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CONFERENCE PROGRAMME

Thursday, June 02	Friday, June 03	Saturday, June 04
	Breakfast	Breakfast
15.00-16.00 Registration of participants	08.30-09.30 Registration of participants	09.00-12.00 Networking
16.00-16.30 Opening ceremony	09.30-11.00 Oral presentations "Section 1"	12.00 Participants departure
16.30-18.30 Plenary session	11.00-11.30 Coffee break	
	11.30-13.00 Oral presentations "Section 1"	
	13.00-14.30 Lunch	
	14.30-16.30 Oral presentations "Section 2"	
	16.30-17.00 Coffee break	
	17.00-18.30 Workshop:”Conceptual models of energy recovery from waste industry”	
	19.30-22.00 Conference dinner	

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SECTION 2: RURAL DEVELOPMENT AND RENEWABLE ENERGY

SECTION 3: ENERGY RECOVERY FROM INDUSTRY WASTE

REDUCE OF ENVIRONMENT IMPACT FROM POWER GENERATING OBJECTS IN KAZAKHSTAN

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Environment impact is an inescapable constituent element of a technological cycle of power generation. In this article an analysis of methods and technologies on reduction of power industry's environment impact is done. In this prospect an observation of alternative Renewable Energy Resources of Kazakhstan is made. The current usage of renewable energy resources in country is shown, and prospects of them in the frame of state and legislative support are observed. It is proven that development of new technologic solutions in the power generating sector is an only path to sustainable development of economics and to the energy and environmental security of the country.

1. INTRODUCTION

Environment impact is an inescapable constituent element of a technological cycle of power generation. It comes from flue gasses emissions to atmosphere, derives from power plants liquid wastes, it appears in the form of the degradation of the land or change of landscape of the area. It might affect the whole ecosystem of the region as it happens in case of Hydro Power Plant Dam Construction. It causes the change of a river flow, or turns up to a waste storages etc.

Obviously, that environment impact from generating installations exists equally as for Kazakhstan, as well as for developed countries with the best practice and their developed technology and technique. . It has to be mentioned that in countries of Former Soviet Union the concentration of polluting substances in flue gases of most generating installations is considerably higher than level of emissions from generating equipment of western developed countries.

2. METHODOLOGY

In Kazakhstan there is a system of continuous monitoring of emissions from stationary sources, which are so-called “organized” sources. Only at the beginning of the new millennium the assessment and inventory of emissions and waste in the extraction of fossil fuels have to be carried out, and they are called "fugitive emissions". According to an expert assessment of the results it is found that the emissions from the "un-managed" sources can be comparable to emissions from stationary sources.

The analysis of the level of various emissions and the impact of energy facilities on the environment [4], (taking into account the emission of fugitive sources) showed that the average level of impact on the environment in the republic is reasonable, it follows from an actual state of the electric power industry of the country:

- Relatively low average density of energy production correlative to the total territory of Kazakhstan (about 6 kW per square kilometer);
- widespread use of co-generation energy production mode, in which as it is known, the energy efficiency is much higher than in just electricity production;
- relatively low sulfur content in the fuel source;
- relatively low level of output of nitrogen oxides, which is associated with the presence of a sufficiently large number of sources with layer mode of fuel combustion; prevalence of furnaces with solid slag removal at a relatively low temperature in the core of burning, etc..

However, it should be noted that the concentration of pollutants in the flue gases of many specific fuel burning and energy producing devices in the most countries of Former Soviet Union is significantly higher than the levels of emissions from generating plants in western countries. At the same time, estimates show that the average estimated dust fallout volumes, and nitrogen and sulfur compounds emissions in Kazakhstan are significantly lower ratios given in various literary sources, as the calculation is per unit area of the country. [4]

Composition and structure of the mineral part of coal mined in the country and burned on heat power plants (HPP) or in large boiler houses, accepts the use of well-known and widely applied devices for cleaning of flue gases from solid and gaseous constituents.

The experience of successful use of electric filters of the latest production of the "ALSTOM" company on Aksu – GRES (one of the biggest heat power plants) shows that these features might be accepted as a good technical solutions.

The use of wet ash catching methods (in intensive irrigation mode) provides flue gas flying ash purification degree, which meets current standards requirements. Problems with over-cooling of cleaned gases that appears during irrigation process, can be solved by technical means. As noted above, there is a relatively low sulfur content in Kazakhstani coals and there is a widely used method of solid ash removal coal combustion on HPPs, that allow to apply relatively simple and not very costly methods for reducing NO_x concentration and SO_2 in flue gases.

In considering the problems of the flue gas cleaning, it is necessary to note some specifics of Kazakhstan. In particular, sometime the rules which are implemented for estimations of emissions from devices burning coal in Kazakhstan are even more "demanding" comparing to some rules in this are in developed countries

From economic and environmental point of view it is obvious, that there is a reasonable or acceptable level of flue gas treatment, taking into account that the power plants and boiler houses are only the part of the total number of air pollution participants. From proposed points of view this level of treatment in Kazakhstan should not be too high, given the fact that fall-outs of electric and heat power plants are relatively small values (≤ 6 kW / km^2).

As it is known, ultimately costs for the flue gas purification are included into the price of production, which definitely has a negative impact on the competitiveness of products of Kazakhstani enterprises of industrial and other sectors. Besides, taking into account the some technological backwardness in the field of modernization of flue gas cleaning system operating in Kazakhstan, a tool to meet the level set by the new regulations should have to be split in two stages. As a first stage it could be preserved the achievement of the "technological" level of norms which could be done under the relatively "light" reconstruction and equipment modernization, which allows enhancing the current situation. And as a second stage, which could be implemented under the deep renovation of the operating equipment of flue gases cleaning, or under the implementation of a new technology.

The country has adopted a state program on reduction of the impact of industries on the environment, in what the energy industry has got one of the leading places.

In this regard, the new technical regulations for the power facilities is adopted, which preserves a significant reduction of the permissible level of emissions into the atmosphere. Significant economic growth of the republic, which is observed in recent years, which allowed to increase investments in equipment and technology for reduction of the energy industry impact on the environment. The payback period of such environment protection and energy efficient measures can be relatively short (for power industry it last from 2 to 7 years). Currently in this direction for energy facilities the transfer of the latest technology for flue gas purification is going on in Kazakhstan. New technologies which comes from the experience of wastern countries and international companies, including those entities which operate in Kazakhstan energy sector.

State support in the field of renewable energy plays an important leading role in reduction of the harmful effects on the environment as well as in reducing of greenhouse gas emissions. It puts way to one of the main directions in the energy security of Kazakhstan as a country, and as a participant of the global energy security.

Kazakh President Nursultan Nazarbayev in his book "Global Energy and Sustainable Development Strategy in the 21st Century" appreciated the basic necessary parameters of the global economic development, based on the analysis of the current situation and trends. In this connection, the need is to develop a program of actions to achieve a balance of "Economy - Energy - Environment". The global community needs a scientifically based reliable program of actions for ensuring energy and environment sustainability of the world in the 21st century. This step is to formulate the basic principles and methods of constructing the trajectories to achieve the triple balance "the economy - energy - environment". [5]

Environmental protection and rational use of resources plays an important role when considering the prospects of the electric power industry of Kazakhstan, at the same time taking into account the global trends in the development of alternative and renewable energy sources.

According to the experts estimates, the potential of renewable energy resources (hydro, wind and solar energy) in Kazakhstan is very significant and is estimated at over 1 trillion. kW • h. [1]

The total kinetic energy of the wind in the world is estimated at about $0{,}7 \cdot 10^{21}$ J. [3]. The country has a huge wind energy potential. Using only a small portion of these resources (1-2%) can provide a environment friendly clean energy, the amount of which could compare to the annual power needs of the whole country.

On the wind map [6] (Figure 1) of there are the natural conditions for the development of wind energy in the country, especially in mountainous areas, where wind speed reaches 5-9 m/s (Jungar Gates, Chilik corridor, etc.).

In addition, the wind in such areas is more stable, which is particularly important for setting wind power installation(WPI).

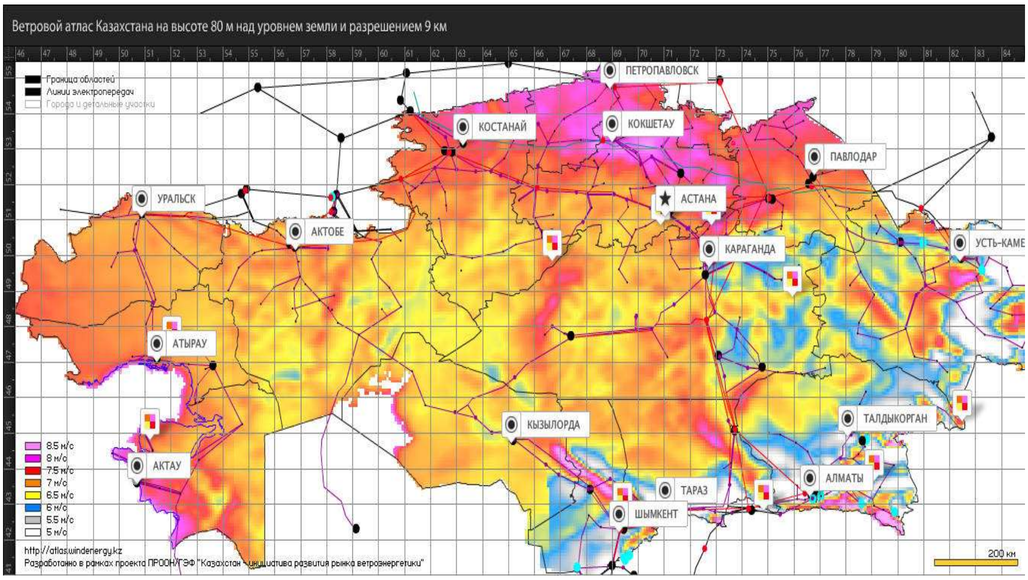

Figure 1. Wind intensity by the regions of Kazakhstan [6]

The use of *solar* energy in Kazakhstan also has great potential. Annual duration of sunlight is 2200-3000 hours, with an annual capacity of one square meter of 1300-1800 kW [2]. When using only from 1.0 to 1.5% of the solar energy, the country can get clean energy which is equivalent to the annual burning of 1.2-1.8 bln. tons of oil equivalent [2], but in practice is barely used and only for getting a heat water.

Experience in technological use of *geothermal* energy in Kazakhstan is actually absent. There are only a few examples of the use of this energy for needs of heating and hot water supply. Two geothermal wells near Zharkent (Almaty region) have a relatively high temperature capabilities. The other sources are concentrated in the regions of Arys and Irtysh rivers.

Bioenergy currently is used mainly as non-commercial biomass fuels.

3. CONCLUSIONS

Kazakhstan has real opportunities to reduce the harmful effects on the environment from the objects of large and small power generating installations. The flue gas cleaning technologies can be improving, the combustion of solid fuels at power plants and boiler houses can be enhanced, and the country has a huge potential in the field of renewable energy. These measures can ensure the reduction of emissions of pollutants in the environment.

Massive amounts of development projects of generating capacities are based on best energy-efficient and environmentally friendly technologies, use of advantages of new approaches to energy and resource saving are proposing a complex program of development of unified energy system of the country, which will provide in the future the following benefits:

· reduction of CO_2 greenhouses emissions and energy industry impact on environment, bringing benefits through clean technologies;

· improving the competitiveness through energy and resource saving and energy efficiency;

· maximum use of the advantages of geopolitical location of the country, transit and export potential of different types of energy, including production of traditional and renewable energy resources;

· large-scale involvement of the renewable energy sources in the energy balance;

· energy and environmental security of the country.

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WATER DESALINATING ENERGY EFFICIENT TECHNOLOGY

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The water desalinating installation with energy efficient heat pump is proposed. It use the hea energy of processes in a heat pump device (HPD) for production of purified water. The energy to drive the HPD has significantly lower level than the level of consumption of energy for production of distillate. The topic is tighten with development of improved energy efficient technologies and combined natural water treatment in terms of growing anthropogenic load on water of natural source. At present that is arising priority in the field of water treatment for use in power generating devices.

4. INTRODUCTION

At present time water resources are on second place after oil and gas resources by the significance for development of world economy. At this point the role of technically fresh (sweet) water is very important for agriculture, for hydro energy, for production of bio-fuel and other water consuming industrial fields.

An issue of desalination of sea water, waste and mineralized waters is topical and urgent for industrial areas with hot and dry climate of Aral sea region with limited natural resources of sweet water.

The performed overview of current situation in technogenic zone of Aral Sea region illustrates a critical need of promotion of modern methods and technologies of water preparation.

It is shown the current ways of water treatment, which are recommended by Classifyer of ground water purification and their disadavnatages with considerable operational cost. For instance, in membarne distillers, which are based on reverse osmosis, mineralized water is pumped through semipermeable membranes, which are made of cellulose acetate or polyamide tar. In this case energy consumption is lying in diaposone of 5-15 kWt h/ $м^3$. With increase of salinity the pumping pressure through membrane is increasing too as well as energy consumption. In the pressure range, when the operation of analyzed equipment is possible, the phase properties of water are preserved. The common disadvantage of these installations is high energy consumption for production of one unit of distillate. That is why a decrease of energy consumption in such installations is still an issue.

The main disadvantage of such desalination devices is a relatively high energy consumption for production of distillate mass unit. That is why the issue of an essential reduction of energy consumption in the given types of devices is hard to get.

5. METHODOLOGY

Due to the fact that for receiving of de-mineralized water under circumstances of all possible varieties of water compositions in water source, the main goal of water treatment system is production of water with permanently high quality. It requires the constant monitoring of water quality source and correction of mode of water preparation installation on industrial enterprises and heat power plants. Especially it applies to the impurities coagulation process of the water in the flood period, when it requires the use of chemical reagents in large volumes, which leads to significant grows of operational costs, costs of shipping and services, because of complexity and bulkiness of main and auxiliary equipment and the needs of defining the dose of coagulant, and the degree of alkalizing of source water and permanent control of the treated water pH indicator.

The other problem, which appears with treatment of surface water in conventional Water Treatment Device (WTD), is processing and recovery of sum residuum and filters rinse waters. The volume of residuum on such installations is about 3 – 4 %, the amount of reverse water is up to 10 – 15 % of the whole power plant output.

The scrutiny of results and data of different researchers does not always lead to indisputable conclusion of applicability of one or another proposed circuit particular case.

In the process of the water preconditioning the rear e series of water quality indexes, that directly affect desalination process, which determine the operation mode of installations and materials as well as their operation time.

In the designing of water preparation processes it should be taken into consideration the purpose of the water, requirements to its composition on the subsequent purification steps, that are matching the physical, chemical and bacteriological indicators, as well as water quality of the water supply source in different seasons of the year, the degree and potential possibility of contamination of it by the municipal and industrial wastewater etc.

A continuous complication and the range of the objects of scientific research require the development of new efficient methods and techniques of water treatment. Existing schemes of water preparation, which are used on many boiler houses and Industrial enterprises, use chemicals and subsequent chlorine disinfection. These methods have a number of drawbacks such as: low efficiency of purification of water comparing to membrane technology, high capital expenditures of the construction of new and reconstruction of old WPD , the high net cost of water due to a significant volume increase of the reagents (flocculants, coagulants, acids, alkalis), consumption of energy and the amount of water consumed during the regeneration of ionite filters, the inability to fully automate and monitor the effectiveness of the filtering process, large size layout and equipment of chemical manufactory.

In connection with the above-mentioned problems with demineralized water, it is necessary to use new technological methods and settings, because the old installations proposed by Natural Waters Purification Classifier are out of date and practically do not refine water of specific and anthropogenic pollution of Aral Sea region territory. At present time in domestic practice a paradoxical situation appeared, the widely spread application of ultra filtrating membrane and heat pump installations requires an operational experience working on such devices. At the same time to gain an experience it requires implementation of them on a number of kinds of natural waters.

A promising experience in this direction might be the use of membrane installations, followed by distillation desalinating system which are supposed to be based on the large and small boiler houses, heat power plants and industrial enterprises for the environment of the Aral Sea region.

The highest quality of desalinated water can be achieved in the distillation distillers. Within them a mineralized water must be supplied with significant volume of heat to proceed an evaporation process and then practically the same amount of heat must be withdrawn. In this case the degree of recuperation depends on the principle and structure of a particular desalter. In a single-stage desalter the consumption of heat in a way to get 1 kg of fresh water is about 2400 kJ . In the case of multistage desalter the heat consumption for preparation of 1 kg of fresh water falls to 250-300 kJ due to heat recuperation of the water phase transition[4].

Below we propose an energy efficient combined installation of desalter and heat pump, which supposed to provide the evaporation-condensation processes heat recovery of the water in the distillation process. The heat pump water desalter presented here is a tool for evaporation. Within it generation and heat recovery of the phase transformation of water performed by reverse thermodynamic cycle heat pump. Reverse thermodynamic cycle performed by the working fluid of the heat pump, in this certain case, by R-134A refrigerant.

The technological scheme includes: a block pre-treatment in the form of filtration module which consists of ultra filtrating installation - UFI; Heat pump water desalter – HPD.

The proposed water desalination installation's scheme is in figures 1, 2.

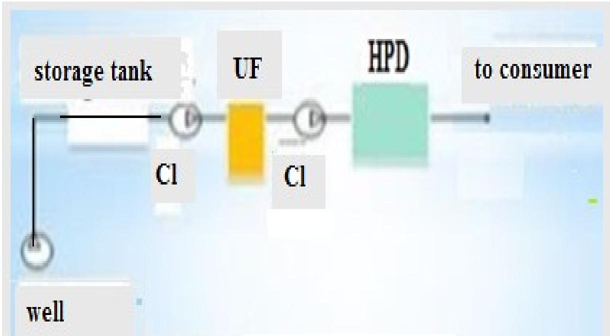

Figure 1 – Technologic scheme of Water treatment installation.

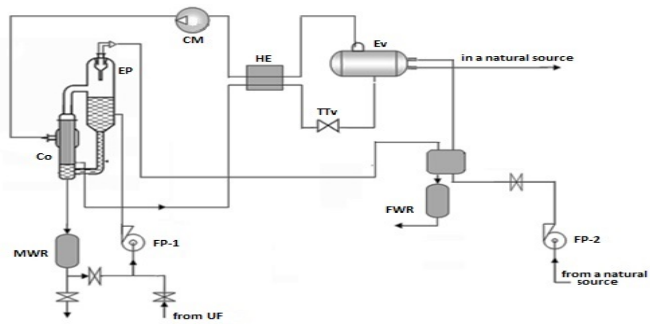

Fig. 2 –Heat pump desalter of water-HPD.

Equipment of the heat pump distiller (figure 2) consists of : a single-stage vapor compression heat pump (HP) with its mandatory elements - condenser - Cr ; evaporator - Ev, regenerative heat exchanger HE; Compressor - CM ; built- in throttle valve – TTv of evaporator condenser - EP . As well as an auxiliary equipment : feeding water pumps FP- 1 , FP- 2, receivers for receiving of fresh water FWR and mineralized water MWR , pipes and valves .

After the pre-cleaning unit UFI natural water pumped by feeding device FP-1 to the condenser of the heat pump. Evaporation tubular unit EU which is a part of a condenser, is configured with external heating chamber and the boiling zone. In the evaporator as a result of the effortless circulation and heat absorption of the heating medium (working substance of the heat pump - the refrigerant R-134A) the mineralized water starts boiling and then a vapor-liquid mixture enters the separator, where the steam and liquid are separated - vapor goes into the steam line, further it moves to tube bundled heat exchanger, where steam condenses giving out its heat to warm raw water from natural water source. The condensate in the form of fresh water is diverted into the receiver of freshwater FWR. Condenser's heating chambers Ch of heat pump has a special tube for boiling process that connects the upper part of the chamber and the middle part of the separator.

The heat pump in desalter installation 1 provides the heat regeneration of mineralized water evaporation – condensing process under atmospheric pressure in the heating chamber of the evaporator. Thus, the energy consumption is carried out only on the heat pump and on drive of other pumps. Energy drive of the heat pump is much lower than "carried" heat of water condensation - evaporation, which defines the energy efficiency in the production of distillate. Calculation of performance, operational parameters and sizes of the technological equipment are performed according to standard methodic.

Pre-treatment of water ultra-filtration installation is required to ensure a deeper concentration of salts in the heat pump desalination device UFI.

According to results received in the experiment with installation performance values up to 100 dm^3/h the TDS Maximum Allowed Concentrations (MAC) are exceeded, and the other inference that an increase of performance values leads to proportional increases of TDS concentration in desalinated water, which brings to the necessity of conducting of desalination process on the heat pump installation (HPI) in two stages.

Thus, the results of experiments proves the need of conducting of desalination process on Heat Pump Desalination Installations in two stages, since under the performance more than 50 dm^3/h the TDS AMCs are exceeded. Due to this fact in the proposed technological scheme we developed desalination on HPI which carried out in two stages.

6. CONCLUSION

On the basis of a complex assessment of reagent-free methods of water treatment and quality indicators of raw water, which are to be treated at the Water Treatment Installation using the membrane and heat pump desalination methods, we got the results of an experimental study of the quality of freshened distillate.

The received results confirm HPI desalter industrial applicability and show the water desalination efficiency on such installations for object of small-scale power engineering enterprises and power industry and for objects of heat supplying systems.

The main advantage of this technological scheme is a low specific energy consumption and relatively low specific capital costs, as well as simple, convenient and cost-effective installation, which does not require the use of reagents and subsequent after-treatment technologies to produce high quality water preventing the formation of corrosion processes of pipes in the heating system and heat energy installations (HEI).

This developed by us combined water treatment installation could be manufactured locally, autonomously or assembled in container design, because of its lowenergy consumption, compactness and small sizes.

It is recommended to use it in the locations of heat power engineering industrial enterprises, where there is no direct access to purified technological, and especially drinking sweet water. To determine the control water quality after a certain stage of its treatment there are sampling devices for water tests and as well as devices and systems of an automatic control.

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WATER LIFTING EJECTORS SYSTEM FOR A 320 MW STEAM TURBINE CONDENSER COOLING WATER BOXES

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ABSTRACT

The results of a new solution ensuring the vacuum in a steam turbine condenser cooling water boxes are presented. This system, based on water ejectors, is operating successfully from last year in a 320 MW steam turbine unit.

1. BACKGROUNG

- In the steam turbine condenser with the cooling water circuit in open cycle, (less in closed circuit systems with cooling towers), the Cooling Water Pumps (CWP) are not dimensioned to reach, at rated parameters, the highest level of the top of the condenser using, , a reverse siphon effect which can obtain a full condenser filling. This can save pumping energy consumption.
- In the condenser upper part, where this phenomena occurs “reverse siphon”, will be an under atmospheric pressure, reaching minus 0.20-0.25bar. This pressure is decreasing in the water output boxes when the condenser tubes are dirty.
- The top of the condenser water circuit is like a trap for the dissolved gases and air .
- To solve this issue, there exist a ”Water Boxes Priming System”, provided by manufactures such as [1], [2]. The device consists of a vacuum pump with accessories, connected with pipes at the highest point of water boxes.
- The ”Water Boxes Priming System”, main functions are:

a) To prime the air from the condenser water circuit in the unit start up period.
b) To remove continuously in operating mode air / gases released from water and trapped at the top of water boxes.
c) Maintain the <reverse siphon> in operation.

2. DESCRIPTION OF THE EXISTING SOLUTIONS

We should notice, that between priming duty at start up, removing duty and maintaining the reverse siphon in operation, there are differences.

a) Priming duty is for a short duration, several hours, and required big rated flow and less suction pressure value (-0.1)÷(-0.2)bar which means (0.9÷0.8) bar abs. The reliability and maintenance are not capital.
b) Removing duty required less gases flow capacity but a high reliability and a suction pressure about (- 0.2)÷(-0.4)bar. This regime is when the tubes are clean.
c) Siphon maintaining duty is required when the condenser tubes are fouled, it requires high vacuum (-0.6)÷(-0.75)bar, high reliability, low gases flow but a variable regime.

The vacuum pumps used in “priming system” are Water Ring Pumps (WRP) or Steam ejectors.

This solution has important disadvantages:

- WRP are not reliable for continuously long term service. It required a separate clean and cooled water circuit for water ring and is very sensitive at any fouling coming inside. In spite of a separator tank and a siphon circuit upstream, dirty cooling water, accidentally (at least droplets) could enter the pump, which can damage it. More so,

in the regime II.c) the mechanical dynamic stress can also damage this kind of pumps.
- Steam Ejector needs steam at start up (and that could be a problem), has bigger energy consumption and needs to avoid the cooling water entrance also.

All these considerations led <TURBOEXPERT srl> and <BLACK SEA POWER GENERATING fzco> to adopt a different solution.

In an unit of 320MW electrical power the existing “Priming system” was out of service due to the issues described above. The new solution should take remedy these problems.

In Fig.1 is shown the CW open circuit and solid line <a-a> indicates the CW level in condenser without ‘Priming System” in operation. The water doesn’t fill completely the condenser in output box moving between 60%-65% of condenser height line <a-a>, in spite the suitable water pressure in input box. Due to inside tube fouling (however, the deposits roughness <0.1÷0,2mm only) the pressure drop was twice than the rated one. This reduced the water flow in upper part, were inside tubes deposits was larger. As a result, and the output the water level was at 60% of height.Even this level was possible to maintain with downstream valve open only 40%. This is due , no doubt, to the CW flow less than the rated one.

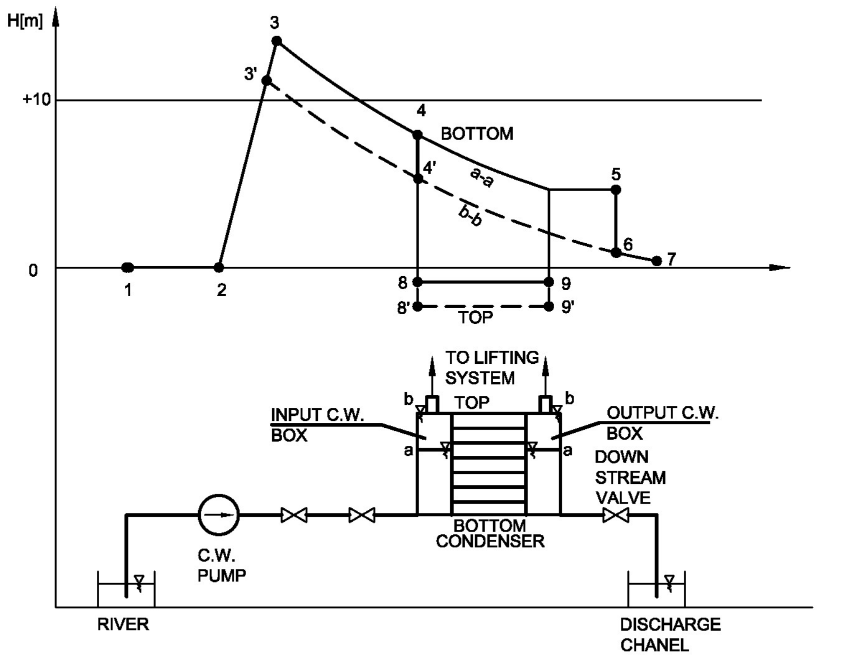

Fig. 1 Cooling water (CW) pressure among the circuit :
a-a without Lifting Ejector and with down stream valve partial closed
b-b with Lifting Ejector in operation and with down stream valve open

3. NEW PRIMING SYSTEM WITH WATER LIFTING EJECTORS

To change this WC flow it was necessary:
- To change the device which maintain the vacuum and,
- To change the operation of the system from priming to priming & continuously operation.

The adopted solution was to use <Lifting Water Ejectors>, the using Cooling Water. That leads to:
- avoid the damages due to accidental CW entrance in vacuum device;
- made possible to have a deep value of vacuum for long term operation;

- ➢ a big flow air rate for priming;
- ➢ to allow the 100% opening of downstream valve:

All these, with a very high reliability and a completely and rather uniformly, filling the condenser with CW.

As is shown in Fig.1 with broken line <b-b> the operating of condenser with new system <Lifting Water Ejector> needs a less initial CWP pressure, meaning that the water flow increased for the benefit of condenser.

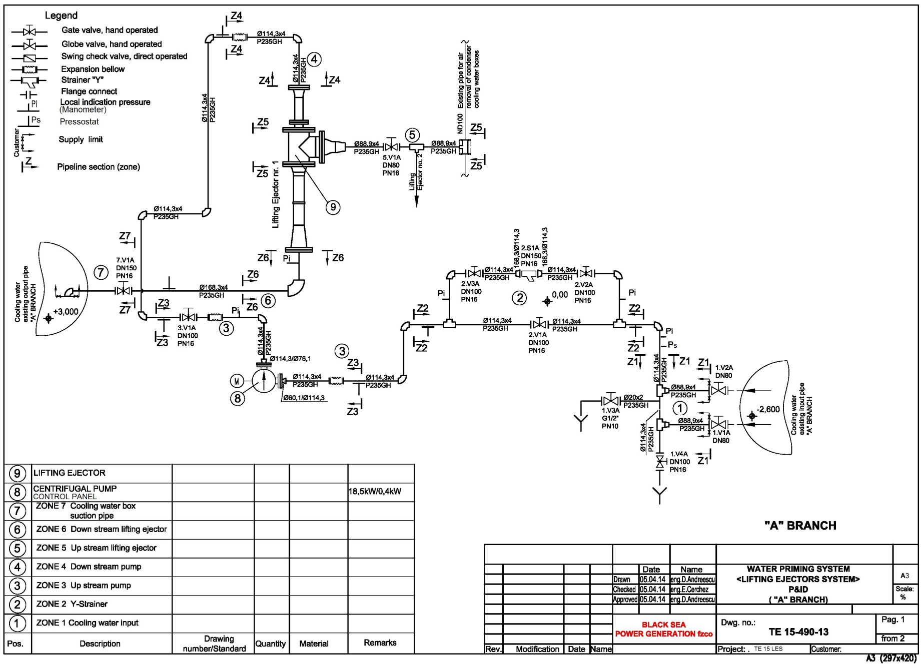

Fig.2 P&ID Water priming system <Lifting ejectors system>

The schematic of Lifting Water Ejectors is shown in Fig.2 .The condenser has two parts on the cooling water part, that for the installation, has a branch for every side (In Fig.1 is only one branch shown) but every system branch can work alone for both condenser water boxes closing / opening suitable vanes. The source water is taken from input of the CW circuit pipe and after a local supplementary filtration is pumped getting to 4.5bar. The source water enters in a Water Ejector, Fig 3, and is suctioning the gases from the highest part of WC boxes through a pipe. The mixture water – air resulting after water ejector is discharged into the downstream cooling water pipe.

The installation has all instruments, valves, elastic supports, corrosion protection etc. required for proper operation.

4. RESULTS

The “Lifting water Ejector System” was instrumented in order to measure its results.

First measurements were made on the Water Ejectors characteristic and the results confirmed the expectations as own experimental and theoretic studies have indicated [3] and [4]. It was possible to reach the limit of vacuum with the air input vane closed when massive source water evaporation occurred accompanied by noises and trepidations.

For <priming duty> at start-up it was sufficient to use only one water ejector due to the add of CW pumped in condenser which pulled up the air.

In normal condenser regime starting up only one branch of Lifting Water Ejectors System was enough to pull up the water level in both condenser output boxes. The water level even exceeded the condenser roof.

Meanwhile the downstream cooling water valves were open near 70%. The static pressure diminished at the top of condenser at (-0.4)÷(-0.45)bar (about 0.55÷0.60bar abs) showing that the <reverse siphon> is working and the CW fills completely and rather uniformly the condenser height. However, the necessary vacuum created by water ejector to keep this regime was (-0.75)÷(-0.78)bar (about 0.25÷0.22bar abs), Fig.4.

With the system in operation the pressure losses in condenser decreased between 30÷35%, due to a <cleaning effect> of bigger CW flow, especially in upper part.

Fig.3 Water Ejectors mounted in site

Fig.4 Air input pressure in Water Ejector in Operation.

5. CONCLUSIONS

1) The Priming System of Cooling Water (in open cycle) steam turbine condenser boxes should work continuously, not at unit start up only, to support the <reverse siphon> to fill all water condenser space.
2) The vacuum pump with <water ring> or any else rotating vacuum pump is not reliable for long term operation in a Power Station real conditions.
3) The new solution adopted <priming system with water ejectors>, with the source water being CW itself, succeeded and the condenser water level returned to normal levels.
4) The CW flow increased due to fully opening of the CW downstream valve, which was partially closed before. That lead to better cleaning of condenser tubes, especially those at the top, The effect which was felt after several days.
5) The solution with water ejector is clear the more reliable. It can be seen after one year of operation.

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MEETING THE ENVIRONMENTAL REQUIREMENTS OF BIOMASS-FIRED EQUIPMENT IN UKRAINE

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ABSTRACT

The paper addresses the problem of satisfying the environmental requirements for biomass energy utilization in Ukraine. Occasionally, equipment performance, production method, fuel quality and properties deviation or operation mode characteristics do not always allow to meet state environmental requirements. In particular, some pieces of equipment that are legal in certain countries could not be applied in other countries without additional measures for reducing environmental impact. The article presents a comparison of the European and Ukrainian regulations relating to pollutant emissions through combustion of biomass. The authors show approaches and methods of ensuring compliance with environmental requirements for biomass-fired installations. Moreover, there is a comparative analysis of existing biomass-fired steam boilers regarding air pollution emissions.

1. INTRODUCTION

Since 2010 Ukraine is a member of Energy Community [1].This means that Ukraine should move towards the improvement of ecology together with the European Union (EU).

According to the Directive 2010/75/EU [2] the EU specifies the requirements for productive activity (including energy production) on environmental pollution. It sets the permitting procedure and requirements on emission for biomass-fired equipment. The main goal is to avoid or diminish air and soil pollution for achieving high quality of environmental protection and health.

2. METHODOLOGY

According to the Law of Ukraine "On alternative fuels" [3], environmental safety regulations and the impact of biomass burning on human health must comply with the laws of Ukraine valid for fossil fuels.

According to the Law of Ukraine "On Air Protection" and the Resolution of the Cabinet of Ministers of Ukraine [4] standards of permissible emissions of pollutants from stationary energy installations are determined.

In addition to the maximum permissible levels of pollutant emissions from stationary sources there are Technological Standards (TS) of permissible emissions. The TS limits mass concentration of pollutants for specific types of equipment. For instance, in case of sunflower husk combustion until 50 MW it is necessary to comply TS acceptable for this type of equipment [5].

To compare norms on pollution we used Ukrainian data presented in [5,6,7,8], as well as data for some EU members published in [9].

Emissions indicators such as of carbon monoxide, nitrogen oxides and particulate matter (PM) are compared. It should be noted that the aforementioned European norms are calculated for 12% of oxygen concentration in flue gases. At the same time, the regulation [6] gives figures for 6%, and [7] – for 11%. For a correct comparison all emission values were transferred to the oxygen concentration of 6%. Detailed calculation method is given in [10].

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The regulations comparison results are shown in Table 1.

Table 1: Regulation of permissible pollutant emissions for of energy equipment when burning biomass.

Standard	The content of harmful substances in the flue gases, mg / nm³			
	Capacity, MW	CO	NO_x	PM
Ministry of Envoironment Protection of Ukraine (MEPU) Resolution №309 from 27.06.2006 [6]	depending on the mass flow	250	500	50-150
MEPU Resolution №309 from 27.06.2006 [6]	< 2,2	–	–	150
	2,2 – 6,5	–	–	50
	6,5 – 13	–	500	50
	> 13	250	500	50
MEPU Order from 13.10.2009 № 540 [5](current TS)	< 50	1125* 3377**	450	150*** 900****
MEPU Order from 13.10.2009 № 540 [5] (prospective TS)	< 5	375	450	150
	5 – 50			75
MEPU Order № 541 from 13.10.2009 [7] (prospective TS)	50 – 100	250	400	50
	100-300	250	300	30
	> 300	250	200	30
GOST 30735–2001 [8] Boiler class 1 wood and peat	0,1 – 0,5	1780	–	–
	0,5 – 1	1570	–	–
	1 – 4	1425	–	–
Directive 2010/75/EU [2](current TS)	50 – 100		300	30
	100 – 300		250	20
	> 300		200	20
Directive 2010/75/EU [2] (prospective TS)	50 – 100		250	20
	100 – 300		200	20
	> 300		150	20
Austrian standard for industrial boilers on wood	0,05 – 0,1	1500	568	284
	0,1 – 0,35	1500	568	284
	0,35 – 2	468	568	284
	2 – 5	468	568	92
	5 – 10	192	568	92
	> 10	192	568	92
German standards for medium and large boilers on clean biomass	< 2,5	225	375	150
	2 – 5	225	375	75
	> 5	225	375	33
Standard «Nordic Swan» – automatic	≤ 1,025	550	470	58
Standard «Nordic Swan» – Manual	≤ 0,34	2740	470	92
	0,34 – 1,025	1370	470	92

* bed firing, ** vortex firing, *** electrostatic precipitator cleaning, **** cyclone cleaning

Comparing the standards presented, one can see that European standards are provided for certain gradations of capacity, not depending on the mass flow rate.

The Ukrainian standards for emissions of oxides of carbon and nitrogen are approximately at the level of European. At the same time, Ukrainian requirements for PM emissions are much stricter than EN 303-5, Austian and German. The Ukrainian PM requirements are at level of the Scandinavian countries which currently possess one of the most advanced biomass conversion technologies.

Therefore, in order to meet the Ukrainian limits a high efficient cleaning system i.e.

electrostatic precipitator or bag filter may be needed. The necessity of high efficient flue gas cleaning system installation affects dramatically on capital expenditures of a biomass project. This impact is especially observed when consider facilities from 2,2 to 6,5 MW_{th}. According to feasibility studies of existing boiler houses in Ukraine performed by authors in 2013-2015, in some cases the costs of flue gas cleaning can make 25 % of total investment, which finally is reflected in feasibility of a biomass project.

Table 2: Required cleaning system specific costs

Capacity level according to [6], MW	Necessity of electrostatic precipitator or bag filter	Cleaning system share cost in CAPEX
< 2,2	No*	-
2,2 – 6,5	Yes	20% - 25%
6,5 – 13	Yes	6% - 11%
> 13	Yes	< 6%

* The requirement on PM could be achieved with cyclones and combustion optimization

At the same time, boilers using sunflower husk as a fuel have special envoironmental requirements. The Ukrainian TS requirements for sunflower husk are not so strict relatively to PM emission, especially when using cyclone flue gas cleaning.

In order to define emission performance of existing biomass-fired facilities a survey has been conducted. Actual emissions of running biomass-fired boilers and relative flue gas purification are shown in Table 3.

Table 3: Actual emission performance of biomass-fired facilities in Ukraine

	Uniplyt furniture plant	Bandurskyy oil extraction plant	Poltavskyy oil extraction plant
Boiler	Vyncke	Vyncke JNO/SAS 173	Vyncke JNOSAS-HD
Fuel	Wood chips	Sunflower husk	Sunflower husk
Burning technology	Grate	Slope moving grate	Slope moving grate
Capacity, MW	12,6	15,5	14,3
Steam, tph	NA	23,77	21,87
Pressure, bar	NA	12	12,5
Fuel consumption, kg/h	5690	4650	3640
Content in the flue gases under normal conditions and O_2=6%, mg/m^3			
NO_x	493	89	134
CO	246	38	3
SO_2	27	83	NA
PM	121	NA	NA
Specific emission, g/Gcal			
NO_x	753	478	579,7
CO	376	204	7,6
SO_2	40,9	442	NA
PM	NA	NA	NA
Cleaning method	Multi cyclone	Cyclone, electrostatic precipitator	Cyclone, electrostatic precipitator

Presented boilers do not exceed emissions limits. Modern high-quality boiler equipment and flue gas purification systems secured the high quality of emissions. Typically, a two-stage system based on a combination of inertial and filtration systems is used. This allows increasing of a cleaning efficiency. This combination allows extention of the lifetime of the filter material and to reduction of load on the cleaning system.

However, selected energy technology, specification of equipment, mode of operation, deflection of its characteristics and fuel quality do not always ensure the necessary environmental requirements. Operation of facility, pollution from which exceed the permissible value is forbidden.

3. CONCLUSIONS

1. The Ukrainian standards of permissible emissions of pollutants from stationary energy installations do not distinguish fossil-fired and biomass-fired boilers.
2. The limits on suspended particulate matter concentration are much stricter in Ukraine than similar requirements of European countries that are far ahead from Ukraine by the degree of development and dissemination of biomass conversion technology.
3. The necessity of high-efficient cleaning equipment, especially for medium capacity boilers from 2,2 to 6,5 MW_{th} seriously affects feasibility of projects. Currently, the strict limits for this capacity range is an obstacle for bioenergy development in Ukraine.
4. The special technological standards for sunflower husk combustion are less strict than the standard limits of permissible emissions of pollutants from stationary energy installations in Ukraine.
5. In Ukraine there are several examples of successful biomass-fired boilers operation equipped with modern flue gas purification systems, indicating the practical feasibility of the requirements for air emissions.

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INVESTIGATION OF BIOMASS FAST PYROLYSIS IN THE ABLATIVE SCREW REACTOR

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ABSTRACT

In the article, a scheme and technical peculiarities of operation of a modified laboratory fast ablative pyrolysis installation with a screw type reactor are given. The results of the experiments of fast pyrolysis of biomass with the purpose to obtain bio-oil, carbonaceous residue and pyrolysis gas in the ablative reactor are presented. The comparative analysis with foreign similar experimental data was carried out. The process of ablative pyrolysis of biomass was investigated in detail and the measures to further improving of the technology were proposed. It was discovered that the effective ablative pyrolysis process should be carried out under the following conditions: 1) providing of high heat flux in the reactor; 2) effective and fast removal of the primary pyrolysis products from the reactor surface; 3) the absence of oxygen in the reaction zone.

3. INTRODUCTION

The latest energy policies of the EU-28 and OECD countries are aimed on setting the ambitious targets on development of renewable energy and bioenergy. As for Ukraine, the main feature of energy supply is that approximately half of energy resources (mainly natural gas for heating and industrial purposes) is imported. The price of natural gas has increased significantly over the last 5 years and is expected to grow further. A real alternative to natural gas is the utilization of renewable energy sources, including biomass. There are various commercialized technologies of raw biomass utilization, out of which the most widespread and economically feasible is direct combustion in boilers. Despite its cheapness and comparative simplicity, in some cases the direct biomass combustion is not an appropriate technology for specific industrial sites, for example, if it is not technically feasible to install new biomass boiler or in case of separate energy generation and consumption. In such specific cases, the technologies of biomass gasification and pyrolysis can make sense. Fast pyrolysis is one of the most cost effective ways to use biomass residues for energy purposes. According to the International Energy Agency, "bio-oil is the cheapest liquid which can be produced from biomass nowadays". Despite many advantages and good prospects, fast pyrolysis technology is not yet as commercial as direct combustion and has some unresolved technical features. There is a number of technical and process organization issues to be addressed and this work is aimed to contribute to this [1, 2, 3].

4. METHODOLOGY

The aim of this research is to improve the experimental installation of ablative fast pyrolysis of biomass, which was developed in the Institute of Engineering Thermophysics of NASU and to compare the experimental data with the data of foreign researchers [4, 5].

The results of the experiments on the fast pyrolysis installation were presented in the scientific work [6]. That installation had a number of design defects, and characteristics of obtained pyrolysis products were quite low. To eliminate the identified defects, the previous design of installation was modified (Figure 1). The main modification consisted in changing of the ablative reactor design to provide the necessary temperature distribution for different zones of the reactor, namely:

1) zone of biomass preheating to achieve the necessary temperature;
2) zone of the pyrolysis process;
3) zone of pyrolysis products removal.

Experiments have shown that the installation worked steadily for 180 minutes, and constant yields of bio-oil at the level of about 50% by weight was achieved due to the determination of optimal operating conditions of the laboratory installation.

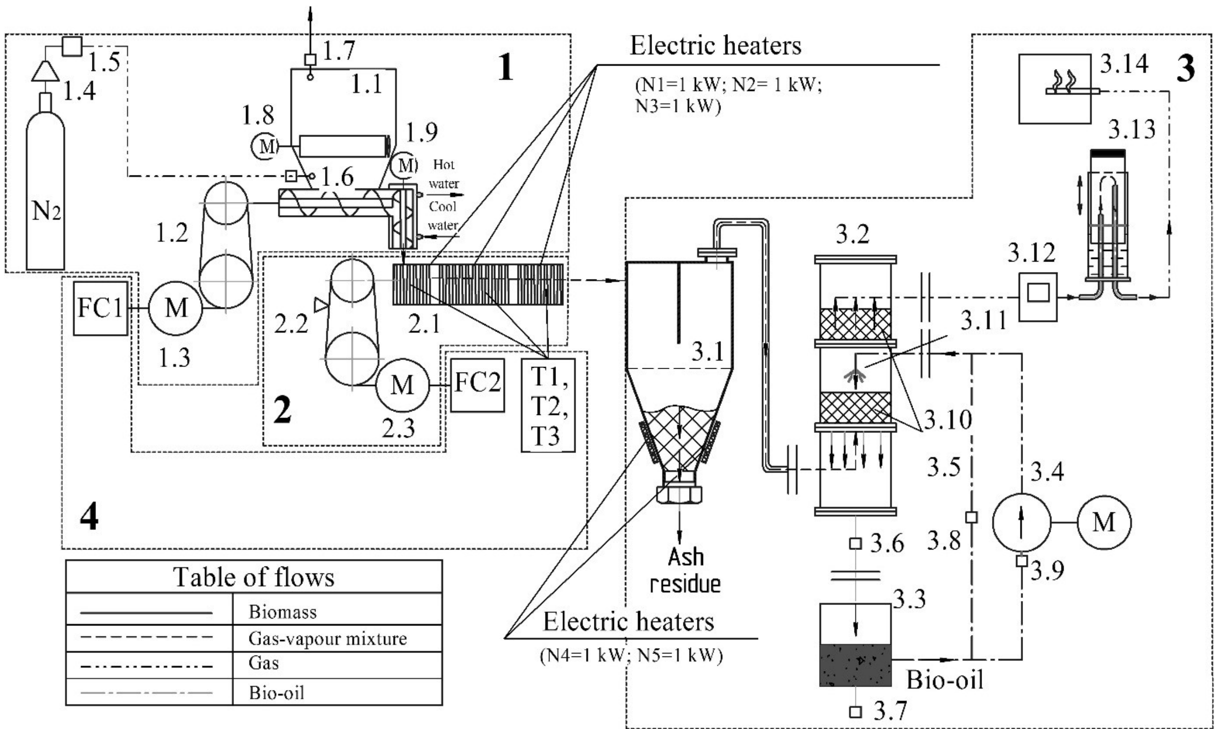

Figure 1: Principal scheme of the experimental installation of fast pyrolysis of biomass:

1 – raw material feeding system*, 1.1 – screw feeder of raw materials with hopper; 1.2 – V-belt drive transmission of screw feeder, 1.3 – gear motor, 1.4 – gas reducer, 1.5 – gas regulator, 1.6, 1.7 – valves; 1.8 – gear motor of hopper agitator drive; 1.9 – gear motor of vertical pipe screw drive;*

2 – reactor block, 2.1 – reactor with screw, 2.2 – V-belt drive transmission of reactor screw, 2.3 – motor;

3 – system of steam-and-gas cleaning and pyrolysis gases utilization, 3.1 – settling chamber, 3.2 – scrubber, 3.3 – tank for bio-oil collecting, 3.4 – pump, 3.5 – bypass (pump regulation of cooling liquid feed velocity) 3.6 - 3.9 – stop valves, 3.10 – Raschig rings; 3.11 – flow nozzle; 3.12 – pyrolysis gas flowmeter, 3.13 – gasholder, 3.14 – burner for pyrolysis gas combustion;

4 – power supply and control unit.

Analysis of [5, 7, 8] showed that designs of ablative fast pyrolysis reactors for laboratory tests are quite similar, but the main differences are in the design, automation systems and application of measure devices.

Schematic diagram of the experimental installation, which was developed in the Institute of Engineering Thermophysics NASU, is shown in Fig. 1. This installation does not differ from foreign analogues that was mentioned earlier. There are three electric heaters with 1 kW_{el} capacity each on the external surface of the reactor. A microprocessor temperature controller controls heaters using signals from thermocouples that are fixed on the external surface of the reactor body. The maximum reactor temperature, which can provide the heater, is 650 ºC. The reactor body is covered with insulating materials to prevent heat loss to the environment.

Different samples of wood sawdust with moisture content of 4% by weight and with particle sizes of 0.5...0.7 mm, 0.5…1.0 mm and 0.5...5 mm and bulk density of 160 kg/m^3, 138 kg/m^3 and 120 kg/m^3 correspondingly are used as raw material. The hopper and the vertical pipe of the feeder were equipped by the agitator and screw, which are driven by gear motors, to avoid hovering of raw material.

The order of experiments was as follows. Samples of biomass of 3…3.5 kg weight were loaded into the hopper, which was sealed to prevent leakage of pyrolysis gas in the opposite direction and to prevent high gas concentration in the laboratory. Before the experiment, nitrogen was injected in the lower pipe of the hopper for 20...25 minutes at a constant flowrate of 0.117 m^3/h for purging of hopper and the path from the reactor to the scrubber of the bio-oil condensation system. The air is forced out from the hopper by nitrogen and taken out through the upper pipe and the burner to the environment. Then diesel oil (3 liters) was measured out and poured into the storage tank.

After putting the fuel in the hopper, the installation sealing and its purging by nitrogen, the electric heaters of the reactor and the settling chamber were turned on and the installation components were heated up to the required operating temperatures in the experiment. Regulation of the reactor temperature was carried out by signals of thermocouples fixed on the external surface of the reactor, taking into account the temperature difference between the outer and inner surfaces, depending on the estimated installation productivity. Temperature fixed by the controller equals to the sum of the required raw material temperature in the reactor and the calculated thermal gradient in the reactor wall. During the experiments, the temperature of the external wall of the reactor was maintained at 550...650 ºC, the settling chamber temperature at 50 ºC. Simultaneously, the system of temperatures measuring and recording system, which includes multi-gauge and PC, was turned on.

The circulating pump was turned on to supply diesel for the scrubber spraying after installation desired temperatures stabilization.

Drives of the hopper agitator and screw of feeder vertical pipe were turned on to ensure stable operation of the feeding system. Current frequencies, which are matched the corresponding screw rotation speed, were set by the frequency converters, which power the electric motors of the reactor and the feeding screw, on the control panel.

Conditions of the experiments and their results are presented in Tables 1, 2.

The experimental results shows, that the share of combustible gases is about 80% of all volume of the pyrolysis gas obtained during the experiment. Due to the high content of CO_2, H_2, CH_4, that is more than 50% of the all gases volume, so the caloric value of pyrolysis gas is high enough. Pyrolysis gas can be used, for example, for the reactor heating instead of electricity.

Table 1: Conditions and results of experimental studies of the biomass ablative pyrolysis on the laboratory installation

Characteristic	Number of experiment				
	#1	#2	#3	#4	#5
Temperature of the reactor external surface [°C]	550	600	550	550	650
Temperature of the settling chamber [°C]	50				
Flow rate of nitrogen for purging [m^3/h]	0.117				
Moving velocity of the raw material particles in the reactor [m/s]	1.0				
Size of raw material particles [mm]	0.5…1	0.5…1	0.5…0.7	0.5…5	0.5…5
Residence time of biomass particles in the reactor [s]	1.0				
Moisture of raw material [%]	4				
Experiment time [min]	180	130	45	120	180
Temperature of cooling liquid [°C]	12	14	10	12	13
Flow rate of cooling liquid [m^3/h]	0.18				
Weight of processed biomass [kg]	2.88	2.57	3.49	2.68	3.13
Weight of carbon residue [kg]	0.7	0.432	1.47	0.998	0.78
Yield of carbon residue [% wt.]	24.3	16.8	42	37	24.9
Weight of bio-oil [kg]	1.408	1.262	1.38	1.18	1.21
Yield of bio-oil [% wt.]	48.9	49.1	39	44	38.6
Density of bio-oil [kg/m^3]	1110	1190	1140	1020	1105
Higher calorific value of bio-oil [MJ/kg]	not determined	13.77	not determined		
Gases yield and losses (on balance) [% wt.]	26.8	34.1	18	19	36.5
Installation productivity of biomass processing [kg/h]	0.96	1.186	4.65	1.338	1.044

Table 2: Component analysis of the pyrolysis gas of experiment #2

Component	H_2	CO	CH_4	CO_2	C_2H_4	C_2H_6	C_3H_6	C_3H_8	iC_4H_{10}	H_2O	N_2	Total	Low calorific value, [MJ/m^3]
[% wt.]	9.51	34.03	11.65	24.35	1.43	1.38	0.19	0.71	0.55	1.72	14.19	100	12.67

Comparison of characteristics of bio-oils, which were obtained on the experimental installations of the Institute of Engineering Thermophysics and the University of Florence, are shown in the Table 3 [5]. Based on the results, we can conclude that characteristics of the obtained bio-oil do not differ significantly from the main characteristics of bio-oil obtained by foreign researchers.

Table 3: Characteristics of bio-oil from IET and Florence University installations

Item name	Analysis result of IET	Analysis result of Florence University
Weight fraction of moisture [%]	47.2	20…30
Weight fraction of sulfur [%]	0.028	0.02…0.05
High heat value [MJ/kg]	16.03	16.6…19.4
Low heat value on as-fired fuel basis [MJ/kg]	13.77	13…18

As seen, the moisture content of obtained bio-oil is 47.2%, which is a relativity high indicator compared with data from University of Florence. Literary and scientific sources [7, 9] shows that the bio-oil yield from dry and low-ash biomass can be up to 65% by weight. Water is always formed during the pyrolysis process from the biomass elements even if dry biomass is used, and the total yield of liquid products from dry and low-ash biomass can reach 75%. The natural moisture content of raw material also obviously effect on H_2O content in bio-oil. In case of very high moisture content (over 30%), bio-oil is separated in two phases with different properties [5, 6, 9].

Carbon residue was collected for carrying out of appropriate tests, which results are presented in Table 4.

As it is shown in the table, the carbon residue has a very high calorific value (~30 MJ/kg), so it can be used as fuel for domestic needs and for the technological needs in industry. There are many different applications of this product, for example, it is used for the charcoal briquettes production, as well as pure fuel or mixed with coal. Products of carbon residue combustion contain less sulfur and nitrogen oxides than the products of coal combustion. Carbon residue can also be used for the production of activated carbon [7].

Table 4: Characteristics of carbon residue of experiment #2

Items	Value	Regulations on the test method
Total moisture of laboratory sample on as-fired fuel basis [%]	3.8	GOST 27314
Ash [%] - on as-fired fuel basis - on dry fuel basis	 3.1 3.2	 GOST 11022 GOST 27313
High heat value on as-fired fuel basis [MJ/kg]	30.4	DSTU ISO 1928: 2006
Low heat value on as-fired fuel basis [MJ/kg]	28.2	DSTU ISO 1928: 2006
Weight part of sulfur [%] - on as-fired fuel basis - on dry fuel basis	 Less than 0.016 Less than 0.017	 DSTU ISO 1928: 2006

A series of experiments showed that the design of the screw needed further upgrading with the purpose of efficient conducting of sawdust pyrolysis process. It is likely that wood particle is not completely decomposed during passing through the reactor. At the same time, the existence time of tar vapors is sufficiently high and, as a result, they are affected by secondary reactions. This explains the smaller proportion of bio-oil yield and its high moisture content in comparison with foreign counterparts.

Particles of raw material pass the reactor with almost the same speed. In the first zone of the reactor, particles are heated to the required temperature for pyrolysis decomposition, in the second zone they are broke down on gas-vapor mixture and solid particles of the carbon residue. The obtained pyrolysis products remain in this state longer than necessary to prevent secondary reactions before they are removed from the reactor. According data from thermocouples fixed on the reactor body, there was a temperature drop on 50...100 °C at the reactor inlet during the loading of fresh raw materials depending on productivity of the feeding system. One to this fact, that if the zone, in which there was the temperature drop, is extended on almost one-third of the reactor length, the bio-oil yield will increase. It is expected that biomass after passing 1/3 of the reactor length does not absorb heat from the reactor body and, therefore, is heated enough to the required pyrolysis process temperature and can overheat due to the work of transporting in the reactor.

4. CONCLUSIONS

The research results of foreign authors [3, 5, 6, 9] and obtained results of experiments show that an effective ablative pyrolysis process should be carried out under the following conditions:

- High heat flux density from the heaters to fuel particles inside the reactor – up to 5 $MW \cdot m^{-2}$;
- Fast and effective removal of the primary pyrolysis products from the reactor surface to ensure the residence time of pyrolysis products in the vapor state up to 1 sec;
- Absence of oxygen in the reaction zone;
- Speed of the particles moving through the reactor should be 1 m/sec.

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OPPORTUNITIES FOR CHARGING ELECTRIC CARS WITH ENERGY FROM RENEWABLE ENERGY SOURCES

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Abstract: Charging electric cars (EC) with energy from the power system practically does not lead to the reduction of harmful emissions. Much greater reduction of emissions could be achieved in case charging stations, using renewable energy sources (RES) are built with the network of petrol stations in the country. Research was conducted for this purpose, showing the possibility and the extent to which the different RES could provide the energy needed by EC, as an upgrade to the existing system for charging automobiles in our country.

Keywords: renewable energy sources, automobile transport, electric cars, harmful emissions.

1. INTRODUCTION

Opportunities for charging electrically driven automobiles through photovoltaic (PV) sources [1,6,7], as well as the levels of wind sources for energy supply at petrol stations in the country [2] have been researched.

A feasibility study of PV stations for charging electric vehicles in the trans-border region and one particular petrol station, located on a provincial road is proposed in this paper [4,5]. The results from this study are not interconnected and spread through the regions of the country. The purpose of this study is to determine the distribution of the petrol stations by regions throughout the country, and to connect it to the available potential of electric energy production from photovoltaic sources and wind turbines. The levels of specific power generation from photovoltaic and wind energy sources are to be determined separately and in aggregate.

2. OUTCOMES

Density of petrol station distribution in Bulgaria

The total number of petrol stations working on the territory of the country is 1486 [4]. The density of their distribution by regions is illustrated on Fig.1. Their concentration is proportional to the size of the regions. In Table 1 the distribution of petrol stations in the

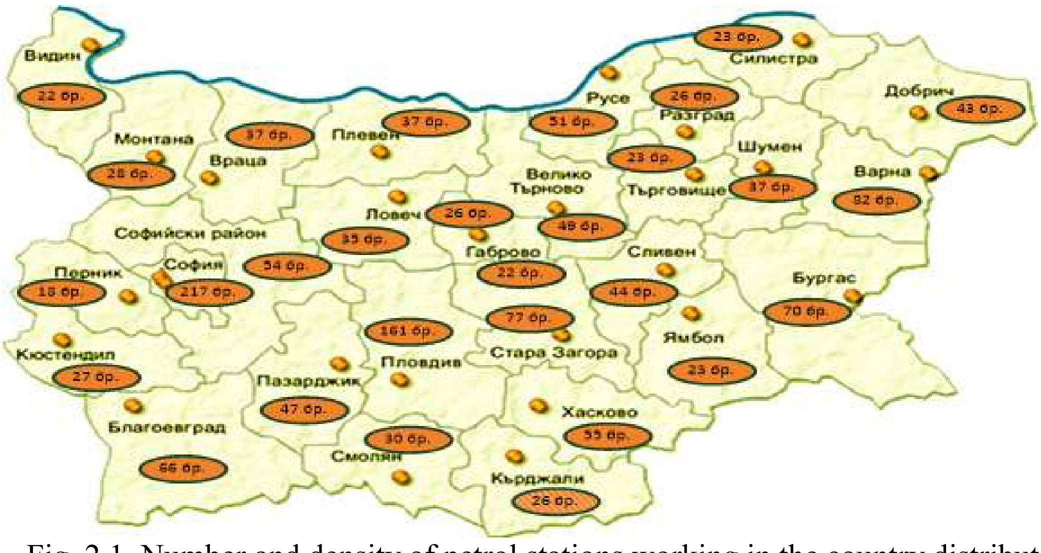

Fig. 2.1. Number and density of petrol stations working in the country distributed throughout the regions in the country

Table 1. Number of petrol stations by regions in the country														
Region	Sof	Pd	Vn	Bur	Ru	VT	Vd	Mn	Vr	Pl	Ss	Db	Lv	Rz	-
Number	313	161	82	66	51	49	22	28	37	37	23	43	35	26	-
Region	Gb	Tar	Shu	Pr	Pz	St Z	Sl	Ya	Hs	Kzh	Sm	Bl	Kyu	-	Total
Number	24	23	37	24	47	87	44	23	55	26	30	66	27	513	1486

regions is shown. In parallel we have the methane stations, whose number is 101. The largest number can be seen in Sofia, incl. Sofia Region -303 (20,3 %), Plovdiv – 161 (10,8 %), Varna – 82 (5,5 %), Stara Zagora – 77 (5,18 %), Burgas – 70 (4,7 %), Blagoevgrad – 66 (4,44 %), Ruse – 51 (3,43 %).

Solar radiation and wind speed are distributed according to the geographical zones and regions in the country [1,3]. The number of petrol stations by region, related to the energy potential of each region, determine the levels of energy potential of each region for providing power for the electric cars from RES.

Specific energy consumption from PV sources

From the previous research conducted [4] resulted electricity production of 1 kWp. The data from a five-year operation period of an active photovoltaic park have been used. Using the Table with data and the data from Table 1, the distribution of the electricity generated to the amount of 1 kWp photovoltaic power over the regions in the country was obtained (kWh/month), according to the concentration of petrol stations and the power potential of the petrol stations zones (Table 2). The density of the estimated specific consumption by month and the regions is in the range of 908 kWh/month for Razgrad to 45072 kWh/month for Sofia. The data have been summed and summarized for one year. The highest influx is

Table 2. Distribution of the generated electricity produced of 1 kWp photovoltaic power throughout the regions in the country (kWh/month)

	Sof	Pd	Vn	Bg	Rus	VT	Vd	Mn	Vr	Pl	Ss	Db	Lv	Rz
IV	37247	22057	11234	8910	6783	6517	3036	3780	4662	4958	3404	5762	4690	3354
V	41629	24472	12464	9900	7548	7252	3366	4200	5180	5513	3772	6407	5215	3733
VI	42255	24955	12710	10032	7650	7350	3432	4256	5254	5624	3841	6536	5320	3783
VII	45072	26565	13530	10758	8160	7840	3652	4536	5624	5994	4094	6966	5670	4035
VIII	42881	25438	12956	10296	7803	7497	3498	4340	5365	5735	3910	6665	5425	3859
IX	33178	19642	10004	7986	6069	5831	2706	3360	4181	4440	3036	5160	4200	3001
X	21284	12558	6396	5082	3876	3724	1738	2156	2664	2849	1932	3311	2695	1917
XI	18467	10948	5576	4422	3366	3234	1496	1876	2331	2479	1679	2881	2345	1665
XII	10642	6279	3198	2508	1938	1862	858	1064	1332	1406	966	1634	1330	958
I	10016	5957	3034	2376	1836	1764	814	1008	1258	1332	920	1548	1260	908
II	17841	10626	5412	4290	3264	3136	1452	1820	2220	2368	1633	2752	2240	1614
III	28483	16744	8528	6798	5151	4949	2310	2884	3552	3774	2576	4386	3570	2547
Sum	348995	206241	105042	83358	63444	60956	28358	35280	43623	46472	31763	54008	43960	31374
	Gb	**Tsht**	**Shu**	**Pr**	**Pz**	**St Z**	**Sl**	**Yb**	**Hs**	**Kzh**	**Sm**	**Bl**	**Kyu**	Sum
IV	3216	3128	4921	2928	6439	11832	5940	3105	7645	3692	4380	8910	3623	
V	3576	3473	5476	3240	7144	13224	6600	3473	8525	4108	4860	9900	4010	
VI	3624	3519	5587	3288	7238	13398	6688	3519	8635	4160	4950	10032	4069	
VII	3888	3772	5957	3528	7755	14355	7128	3749	9240	4446	5280	10758	4366	
VIII	3720	3611	5698	3360	7426	13659	6820	3588	8855	4264	5040	10296	4158	
IX	2880	2783	4403	2616	5734	10614	5280	2783	6820	3302	3900	7920	3237	
X	1848	1794	2812	1680	3666	6786	3388	1771	4400	2106	2520	5082	2079	
XI	1584	1541	2442	1440	3196	5916	2948	1541	3795	1820	2160	4422	1782	
XII	912	897	1406	840	1833	3393	1672	874	2200	1040	1230	2508	1026	
I	864	851	1332	792	1739	3219	1584	828	2035	988	1170	2376	972	

II	1536	1495	2368	1392	3102	5655	2860	1495	3685	1768	2100	4290	1728	
III	2448	2369	3737	2232	4888	9048	4532	2369	5830	2808	3330	6798	2762	
Sum	30096	29233	46139	27336	60160	111099	55440	29095	71665	34502	40920	83292	33812	1835663

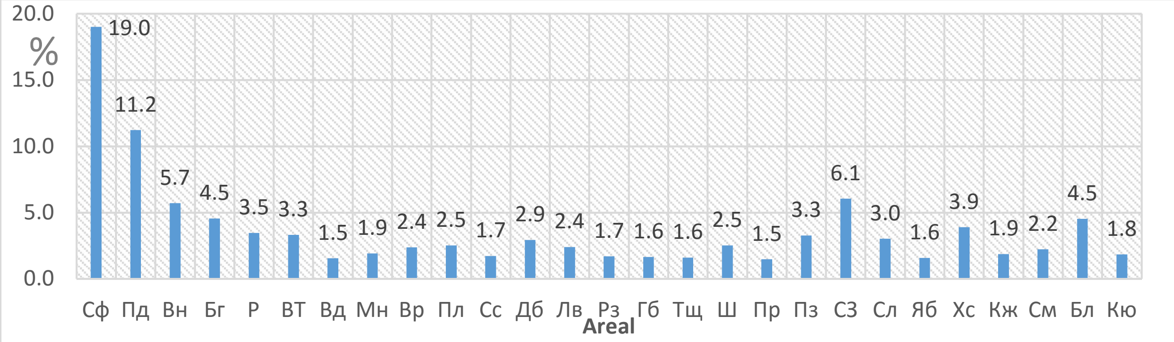

Fig.2. Distribution in % by regions of estimated specific electricity production from photovoltaic sources

expected for Sofia– 348995 kWh/year, the lowest is for Pernik - 27336 kWh/year. The distribution in % by regions of the estimated specific electricity production from photovoltaic sources has been ranked and presented in Fig. 2. As expected, it is the highest in Sofia - 19 %, and the lowest in Pernik and Vidin – 1,5 %.

Specific energy consumption from wind turbines

From the previous research conducted [2] resulted electricity production of 1 kW installed power. The data from a one-year operation period of an active wind turbine park have been used. Using the Table with data and the data from Table 1, the distribution of the electricity generated to the amount of 1 kWp wind generated power over the regions in the

Table 3. Distribution of the generated electricity produced of 1 kWp from wind turbines throughout the regions in the country (kWh/month

	Sof	Pd	Vn	Bg	Rus	VT	Vd	Mn	Vr	Pl	Ss	Db	Lv	Rz
IV	48329	6837	15808	12844	9316	8127	3877	4807	6047	6146	4599	9048	4328	3203
V	50309	7140	16195	13109	9614	8565	4052	5038	6310	6482	4747	9087	4563	3306
VI	48947	7014	15708	12610	9310	8405	3983	4929	6162	6402	4624	8689	4505	3221
VII	55654	7894	18011	14612	10642	9417	4476	5542	6981	7157	5265	10185	5039	3667
VIII	48680	7023	15628	12594	9283	8438	3989	4940	6174	6429	4608	8585	4523	3210
IX	49323	6862	16417	13501	9621	8088	3885	4800	6123	6105	4712	9767	4304	3282
X	35841	4910	12076	9967	7021	5723	2782	3431	4384	4323	3416	7391	3050	2379
XI	33381	4555	11355	9392	6567	5268	2558	3174	4081	3979	3189	7032	2809	2221
XII	38452	4988	13691	11532	7749	5555	2786	3420	4510	4130	3708	9172	2925	2582
I	35379	4606	12607	10609	7138	5134	2573	3157	4158	3817	3421	8425	2703	2383
II	39267	5278	13611	11341	7805	6022	2959	3661	4703	4497	3775	8642	3178	2630
III	48973	6681	16505	13658	9568	7757	3776	4675	5968	5845	4660	10116	4124	3246
	532536	73788	177613	145770	103633	86500	41694	51574	65603	65312	50724	106139	46052	35330
	Gb	**Tsht**	**Shu**	**Pr**	**Pz**	**St Z**	**Sl**	**Yb**	**Hs**	**Kzh**	**Sm**	**Bl**	**Kyu**	Sum
IV	3748	4358	6420	3863	7732	14491	7991	4318	9830,5	4964	5068	10574	4633	
V	4010	4477	6698	4003	8199	15393	8273	4462	10308	5145	5421	11258	4858	
VI	3973	4325	6569	3901	8085	15141	8032	4314	10067	4993	5401	11123	4744	
VII	4409	4977	7425	4444	9022	16960	9137	4937	11381	5692	5954	12389	5364	
VIII	4031	4330	6573	3906	8181	15213	8018	4296	10132	5007	5442	11268	4775	
IX	3626	4508	6504	3927	7547	14342	8156	4483	9884,2	5085	4864	10253	4658	
X	2508	3322	4673	2841	5271	10088	5935	3277	7113,6	3685	3374	7149	3352	
XI	2256	3095	4335	2622	4830	9275,8	5539	3073	6556,2	3427	3029	6525	3090	
XII	2132	3719	4843	2986	4799	9493,2	6377	3656	7213,3	3957	2808	6326	3399	
I	1977	3426	4468	2750	4445	8784,6	5877	3366	6609	3649	2609	5859	3115	
II	2489	3700	5054	3069	5420	10422	6536	3669	7602,4	4047	3333	7273	3583	
III	3375	4514	6350	3863	7143	13685	8109	4484	9641,2	5025	4529	9700	4544	
	38534	48752	69913	42175	80672,9	153289	87979	48335	106338	54675	51831	109697	50114	962814

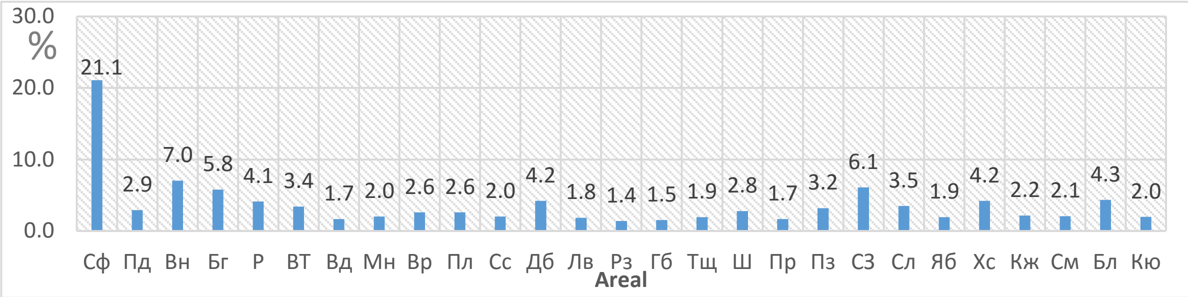

Fig.3. Distribution in % by regions of estimated specific electricity production from wind turbines

country was obtained (kWh/month), according to the concentration of petrol stations and the power potential of the petrol stations zones (Table 3). The density of the estimated specific consumption by month and the regions is in the range of 2132 kWh/month for Gabrovo, up to 55654 kWh/month for Sofia. The data have been summed and summarized for one year. The highest influx is expected for Sofia – 532536 kWh/year, the lowest is for Pernik - 42175 kWh/year. The distribution in % by regions of the estimated specific electricity production from wind turbines has been ranked and presented in Fig. 3. As expected, it is the highest in Sofia - 21,1 %, and the lowest in Razgrad – 1,4 %.

Table 4. Distribution of cumulative electricity generated to the amount of 1 kWp photovoltaic and 1 kW installed wind generated power throughout the regions in the country (kWh/month)

	Sof	Pd	Vn	Bg	Rus	VT	Vd	Mn	Vr	Pl	Ss	Db	Lv	Rz
IV	85576	28894	27042	21754	16099	14644	6913	8587	10709	11104	8003	14810	9018	6558
V	91938	31612	28659	23009	17162	15817	7418	9238	11490	11995	8519	15494	9778	7039
VI	91202	31969	28418	22642	16960	15755	7415	9185	11416	12026	8465	15225	9825	7004
VII	100726	34459	31541	25370	18802	17257	8128	10078	12605	13151	9359	17151	10709	7702
VIII	91561	32461	28584	22890	17086	15935	7487	9280	11539	12164	8518	15250	9948	7068
IX	82501	26504	26421	21487	15690	13919	6591	8160	10304	10545	7748	14927	8504	6283
X	57125	17468	18472	15049	10897	9447	4520	5587	7048	7172	5348	10702	5745	4296
XI	51848	15503	16931	13814	9933	8502	4054	5050	6412	6458	4868	9913	5154	3886
XII	49094	11267	16889	14040	9687	7417	3644	4484	5842	5536	4674	10806	4255	3541
I	45395	10563	15641	12985	8974	6898	3387	4165	5416	5149	4341	9973	3963	3291
II	57108	15904	19023	15631	11069	9158	4411	5481	6923	6865	5408	11394	5418	4244
III	77456	23425	25033	20456	14719	12706	6086	7559	9520	9619	7236	14502	7694	5793
	881531	280029	282655	229128	167077	147456	70052	86854	109226	111784	82487	160147	90012	66704
	Gb	**Tsht**	**Shu**	**Pr**	**Pz**	**StZ**	**Sl**	**Yb**	**Hs**	**Kzh**	**Sm**	**Bl**	**Kyu**	Sum
IV	6964	7486	11341	6791	14171	26323	13931	7423	17476	8656	9448	19484	8256	
V	7586	7950	12174	7243	15343	28617	14873	7935	18833	9253	10281	21158	8867	
VI	7597	7844	12156	7189	15323	28539	14720	7833	18702	9153	10351	21155	8813	
VII	8297	8749	13382	7972	16777	31315	16265	8686	20621	10138	11234	23147	9730	
VIII	7751	7941	12271	7266	15607	28872	14838	7884	18987	9271	10482	21564	8933	
IX	6506	7291	10907	6543	13281	24956	13436	7266	16704	8387	8764	18173	7895	
X	4356	5116	7485	4521	8937	16874	9323	5048	11514	5791	5894	12231	5431	
XI	3840	4636	6777	4062	8026	15192	8487	4614	10351	5247	5189	10947	4872	
XII	3044	4616	6249	3826	6632	12886	8049	4530	9413	4997	4038	8834	4425	
I	2841	4277	5800	3542	6184	12004	7461	4194	8644	4637	3779	8235	4087	
II	4025	5195	7422	4461	8522	16077	9396	5164	11287	5815	5433	11563	5311	
III	5823	6883	10087	6095	12031	22733	12641	6853	15471	7833	7859	16498	7306	
	68630	77985	116052	69511	140833	264388	143419	77430	178003	89177	92751	192989	83926	4360237

Cumulative specific electricity consumption

Using the data from the previous Tables (Table 2 and Table 3), the distribution of the electricity generated to the amount of 1 kW installed power has been done throughout the regions in the country (kWh/month), according to the concentration of petrol stations, photovoltaic and wind turbine potential of the zones of petrol stations (Table 4).

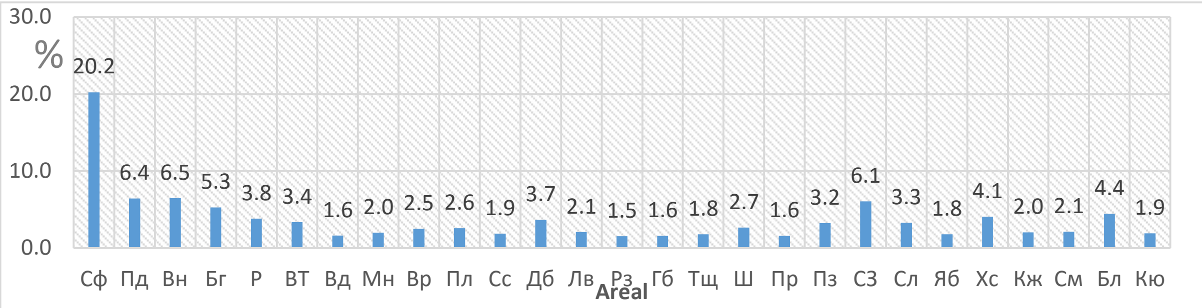

Fig.4. Distribution in % throughout regions of the estimates cumulative specific electricity production from photovoltaic sources and wind turbines

The density of the estimated cumulative specific consumption by months and regions is in the range of 2841 kWh/months for Gabrovo to 100726 kWh/month for Sofia. The data have been summed and summarized for one year. The highest influx is expected for Sofia– 348995 kWh/year, the lowest is for Gabrovo - 27336 kWh/year. The distribution in % by regions of the estimated specific electricity production from photovoltaic sources and wind turbines has been ranked and presented in Fig. 4. As expected, it is the highest in Sofia - 20,2 %, and the lowest in Razgrad – 1,5 %.

Estimated cumulative specific economies from harmful emissions

Using the data for the cumulative electricity production in Table 4, the estimated distribution of specific economies from harmful emissions has been calculated to the amount of 1 kWp photovoltaic and 1 kW installed wind generated power throughout the regions in the country (Table 5). The possible reduction is in the range of 3,6 t/CO_2 to 496 t/CO_2 per year .

Table 5. Distribution of estimated cumulative specific economies from harmful emissions of 1 kWp photovoltaic and 1 kW installed wind generated power throughout the regions in the country (kWh/year)

Region	**Sof**	**Pd**	**Vn**	**Bs**	**Rus**	**VT**	**Vd**	**Mn**	**Vr**	**Pl**	**Sa**	**Db**	**Lv**	**Rz**
t/CO2	496,3	157,7	159,1	129,0	94,1	83,0	39,4	48,9	61,5	62,9	46,4	90,2	50,7	37,6
Region	**Gb**	**Tsht**	**Shu**	**Pr**	**Pz**	**StZ**	**Sl**	**Yb**	**Hs**	**Kzh**	**Sm**	**Bl**	**Kyu**	Sum
t/CO2	38,6	43,9	65,3	39,1	79,3	148,9	80,7	43,6	100,2	50,2	52,2	108,7	47,3	2454,8

3. CONCLUSION:

1. A cumulative indicator – density of specific electricity production has been introduced to the amount of 1 kWp peak photovoltaic power and 1 kW installed wind generated power, related to the density of distribution of petrol stations in the country.

2. The data obtained for the estimated specific electricity production from photovoltaic and wind generating sources separately and cumulatively, which come up to 881531 kWh/year, are the basis for design and construction of electricity charging stations at the existing petrol stations, for charging electric automobiles with energy from renewable energy sources.

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THEORETICAL STUDY THE EFFECT OF INSULATION OF WATER BASIN ON THE PRODUCTIVITY OF TUBULAR SOLAR STILL

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ABSTRACT

The water desalination process using distilled Tubular Solar Still (TSS) is one of the most common ways in drinking water production. The effect of moisture air flow and heat transfer processing is numerically investigated for solar tubular. This article provides numerically study of the two-dimensional by use COMSOL Multiphysics ver. 5.0 programe to analysis two cases: firstly, insulation the outside wall of water basin, secondly, without insulation. The temperature distribution, Streamlines, flow velocity, relative humidity, condensation indictor, and productivity per day, depending on the amount of solar radiation and ambient temperature were measurements and analysis for Najaf city in Iraq. This study indicates that increasing productivity per day up to (30-40%) for water basin wall insulation compare to wall without insulation. The result obtained from this study was analyzed and compared with the literature review, which is in good agreement with the results of the present study.

Keywords: Tubular solar still; Productivity; CFD; Solar radiation.

1. INTRODUCTION

Water, food and air, are the three basic human necessities, and the importance of ensuring a constant supply of potable/fresh water can hardly be overstressed. Shortages of drinking water have long been associated with populations living in arid regions and remote areas. If these regions receive a large amount of direct sunlight, solar distillation may be considered an effective solution in combating the scarcity of water resources [1]. Humans require water for three major fields, namely domestic life, agriculture, and industry. The conventional sources used to supply the water that fills these needs are rivers, lakes and underground water reservoirs. These sources may sometimes be contaminated with large amounts of salts, impurities and harmful organisms, making the water contained in them unfit for use. For that, the use of solar stills as an easy and cheap method for providing clean potable water dates back to the 16th century [1]. There are several studies developed a solar energy applications have been carried out on a Tubular Solar Still (TSS) [2-4].

The past thirty years have seen increasingly rapid advances in the field of Solar distillation. Ref. [5] studied the semi-steady heat and mass transfer model of a Tubular Solar Still (TSS), by taking into account the properties of the humid air passing inside the still. An indoor output experiment on a TSS was carried out in a thermostatic room at the University of Fukui, Japan, in order to validate the suggested model. The researches developed an experimental technique to measure the evaporation flux by balancing the trough, by setting it independently of the other structures of a tubular solar still. In contrast, the authors conclude; that the suggested model can be calculate the water temperature, moist air temperature, tubular air temperature and production at unsteady condition.

Reference [6] attempted to provide a complete group of heat and mass transfer correlations, and to suggest a new heat and mass transfer model for a Tubular Solar Still (TSS) by taking into account the thermal properties of moist air inside the still. They developed a new experimental technique for directly measuring the evaporation rate from the brine surface in the (TSS), and evaluated the setup's evaporative mass transfer coefficient. The model's validity was evaluated by comparison with the field experiments conducted in Fukui, Japan and in Hamuraniyah, UAE.

Reference [7] investigated a new mass and heat transfer model for a TSS, and suggested incorporating various mass and heat transfer coefficients which take into account the properties of moist air inside the still. Ref. [8] provides a detailed comparison carried out by group of scientists between an old and an improved tubular solar still. The comparison included aspects such as design, fabrication, costs and water production. The evaporation mass transfer coefficients and the heat transfer coefficients are higher than the condensation coefficient.

Reference [9] investigated the capabilities of a 2-D CFD simulation to compute mass and heat transfer within a TSS. In addition, it suggested new relations that can be used to estimate water yield, mass and heat transfer coefficients in the TSS. Based on these relations, it proposed characteristic curves to estimate water yield under variable operating conditions.

Several theoretical and experimental studies were carried out in order to investigate what effect varying the parameters will have on the solar still's distillate output. The parameters considered were brine depth, salinity percentage and cover material; the effect of covering the basin with a layer of black rocks was also investigated. Climate parameters, namely solar radiation, wind speed and ambient temperature have been studied as well.

The main objective of the present work is to build a theoretical model to predict water surface temperature, glass cover temperature, average humid air temperature and productivity depending on solar radiation input and on ambient temperature. This paper studies the effect of insulating the basin's outer on the performance of the tubular solar still, depending on the solar irradance input and ambient temperature of Najaf city in Iraq (32° 1' 38.55" N / 44° 19' 59.22" E).

2. THEORETICAL MODEL

The schematic cross-section of a solar still integrated with a tubular solar energy collector and thermal energy balance are shown in Fig. 1. The proposed model used in this theoretical study used the same the dimensions and materials as those used in Islam and Fukuhara (2007) [6].

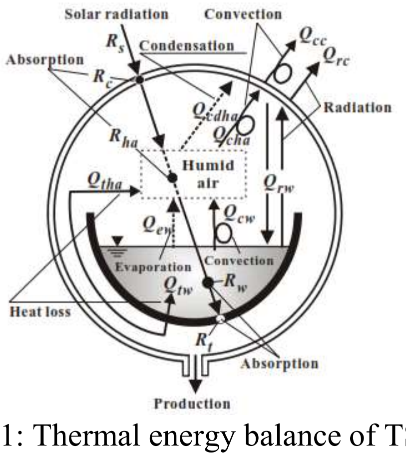

Figure 1: Thermal energy balance of TSS [6].

The following assumptions are used to simplify the proposed model's solution:

1. The Tubular Solar Still (TSS) is cylindrical in shape, placed horizontally and 2-D.
2. The tubular cover does not exhibit any water vapor leakage across its surface.
3. Solar radiation absorption by humid air is negligible.
4. The water vapor on the water surface is saturated.
5. The condensate liquid film exhibits laminar flow and flows only along the tubular cover's interior circumference.
6. The evaporation flux (kg/m^2.hr) is equal to the condensation flux (kg/m^2.hr).

The flow and energy equations are based on the fundamental governing equations of fluid dynamics - the continuity, momentum, energy and mass concentration equations of moisture air are the following:

a. Mass Conservation Equation

The equation for the conservation of mass applied to the air mixture as the carrying fluid is given by:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \tag{1}$$

b. Momentum Conservation Equations

x – direction momentum equation

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+v\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right) \tag{2}$$

y – direction momentum equation

$$u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+v\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)+F \tag{3}$$

$$F=g\left[\beta_T\left(T-T_c\right)+\beta_s\left(c-c_c\right)\right] \tag{3-a}$$

The buoyancy force *F* term arising from density variation is included by means of the Boussinesq approximation based on the assumptions that the variation of fluid density affects only the buoyancy term and the fluid density is a function of temperature only.

c. Energy Conservation Equation

The equation for the conservation of energy is given by:

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha\left(\frac{\partial^2 c}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}\right) \tag{4}$$

d. Concentration Equations

e.

$$u\frac{\partial c}{\partial x}+v\frac{\partial c}{\partial y}=D_{AB}\left(\frac{\partial^2 c}{\partial x^2}+\frac{\partial^2 c}{\partial y^2}\right) \tag{5}$$

Boundary conditions as following;

i. Inner glass cover: u=0, v=0, $T=T_c$, $c=C_c|T=T_c$, Φ=100%

Where:

$$C_c = psat/(R\,T_c) \tag{6}$$

ii. Water surface: u=0, v=0, $T=T_w$, $c=C_w|T=T_w$, Φ=100%

Where:

$$C_w = psat/(R\,T_w) \tag{6}$$

iii. Trough walls: u=0, v=0, $\frac{\partial T}{\partial x}=0$, $\frac{\partial c}{\partial x}=0$ (7)

3. NUMERICAL SOLUTION

It is divided into two parts; 1st Part: - uses the energy balance equation of Islam and Fukuhara (2007) [6] for the tubular cover, moist air, brine water and trough, where equations (7, 8, 9, and 10 of Islam and Fukuhara (2007) [6]) are solved by using Comsol Multiphysics software v5.0 to calculate the water surface temperature T_w, moist air T_{ha}, trough T_t and tubular cover T_c dependent on the solar radiation R_s, and ambient temperature T_a. We have introduced the solar radiation variable with time, and the ambient temperature variable with time of Najaf city in Iraq (32° 1' 38.55" N / 44° 19' 59.22" E).

2nd part: - By using the calculation in the 1st part of numerical solution of T_w, T_{ha}, T_c and T_t, we solve the governing equations (1,2,3,4, and 5) for the moist air to predict the temperature distribution inside the tubular solar still, the moist air concentration, productivity and the streamline of the flow inside the TSS, by using Comsol Multiphysics software v5.0.

4. VERIFICATION MODEL

To verify accuracy of the theoretical results of the present work which was carried out using the program (COMSOL), the results were compared with those of other researchers. A comparison between the experimental results of Islam [6] and CFD results of Rahbar [9] with the present theoretical results was carried out. The comparison results we have obtained show that there is a good agreement between the experimental results of Islam [6], and CFD Rahbar [9] with the theoretical results of the present work, as shown in Fig. 2.

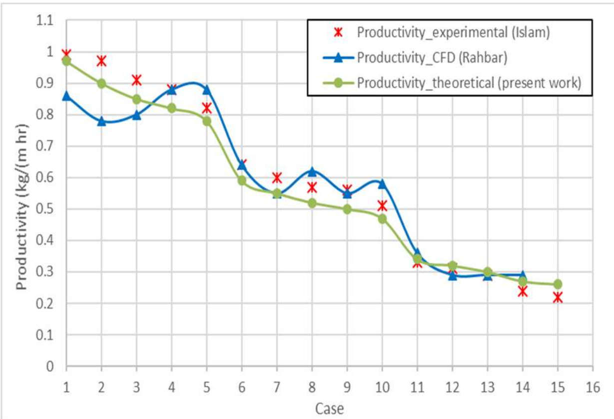

Figure 2: Comparison between experimental results of Islam [6] and CFD results of Rahbar [9] with theoretical results of present work of productivity.

5. RESULTS AND DISCUSSIONS

In this study, the performance of TSS was investigated under real operating conditions in Iraq, Najaf (32° 1' 38.55" N / 44° 19' 59.22" E). Figure 3a shows the variation of water surface temperature T_w, tubular cover temperature T_c, and moist air temperature T_{ha} with time with and without the TSS basin's outer wall insulation, where the temperatures of the water surface, tubular cover, and moist air increased in the case when the basin's outer wall was insulated, and a larger temperature difference between T_w and T_c was obtained compared to the case without insulation, for the same solar radiation input and ambient temperature. The surface temperature of the water in the basin was higher because the solar irradiance absorbed by the trough was transferred to the water.

Figure 3b shows the productivity prediction of TSS by using the present model and equations (5 and 6 of Isalam [6]) with and without the basin's outer wall insulation. The results show that the productivity increases in the case when outer wall insulation is used on the basin, because the temperature difference between the water surface and the tubular cover increased.

The Fig.4a shows the temperature contours at 12:00 am, the measured ambient temperature and solar radiation used in the software is for (25-2-2016). The results indicate that, due to condensation and evaporation phenomena, there are rapid changes in the contours near the water surface and the tubular still cover, where the temperature difference between the water surface and the cover increase when insulation is used on the basin's outer wall. Figure 4b shows the concentration distribution inside the TSS at 12:00 am for (25-2-2016), where the concentration has a maximum value at the water surface and a minimum value at the tubular cover because the maximum amount of water vapor appears at the water surface for a small area compared with the area of the tubular cover where condensation occurs

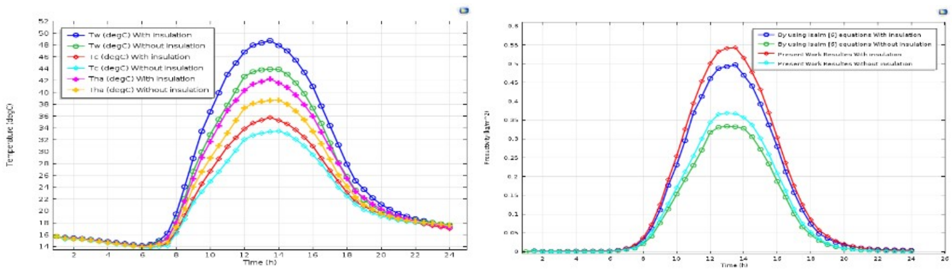

Figure 3: Variation of (a) water surface temperature T_w, tubular cover temperature T_c, and moist air temperature T_{ha}, (b) productivity of TSS with and without insulation of outer wall of basin.

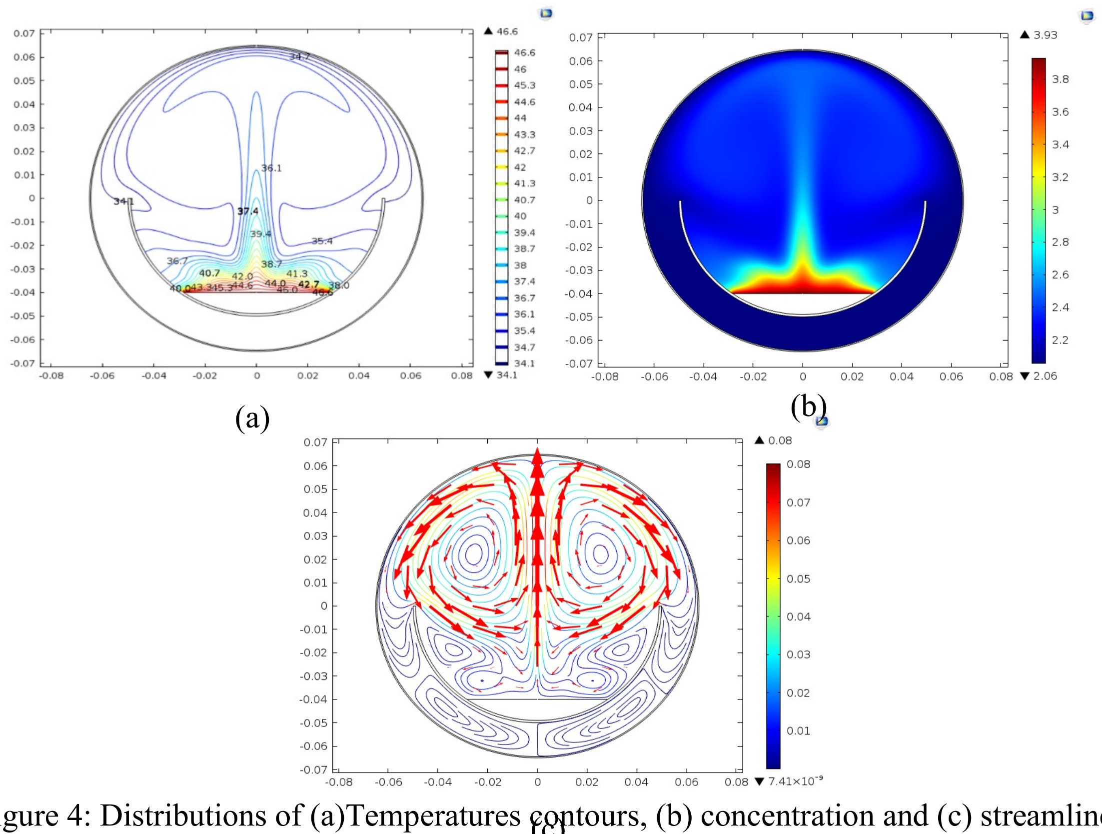

Figure 4: Distributions of (a)Temperatures contours, (b) concentration and (c) streamlines inside the TSS at 12:00 am on 25-2-2016.

Fig.4c show the streamline at 12:00; the measured ambient temperature and the solar radiation used in the software is for (25-6-2015). The figure indicates that there are two recirculating regions, first in a right hand, clockwise direction and the second in a left hand, anticlockwise direction inside the TSS.

The results also indicate that, in the case of using insulation on the basin's outer wall, this leads to an increase in the flow strength inside the enclosure. Moreover, the results show that if the glass cover is divided into two parts, the top and bottom hemisphere, only the upper side of the glass (top hemisphere) participates in vapor condensation. This means that most of the condensation takes place on the upper side of the glass cover.

6. CONCLUSIONS

A simulation model of the Tubular Solar Still TSS was developed, and the performance of the solar collector was simulated with a variable solar radiation value. The following conclusions can be made:

1. The temperatures of water, tubular cover, and moist air increase in the case when insulation was used on the basin's outer wall, and a larger temperature deference was achieved between T_w and T_c when compared to the case without insulation for the same input solar radiation and ambient temperature.

2. Productivity increased when insulation was used on the basin's outer wall, due to an increase in the temperature difference between the water surface and the tubular cover.

3. As a result of the condensation and evaporation phenomena, are rapid changes took place in the contours near the water surface and the tubular still cover, where the temperature difference between the water surface and the cover increased when insulation was used on the basin's outer wall.

4. In the case of using insulation on the basin's outer wall, this leads an increase in the flow strength inside the enclosure.

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NUMERICAL MODELLING OF MIXING FLUIDS AT DIFFERENT TEMPERATURES

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ABSTRACT

The present paper focuses on a rather frequent phenomenon in thermal systems both for nuclear power plants reactor cooling systems and household heating systems. In the present paper numerical modelling was performed for systems where cold and hot fluid streams mix either directly in a T-junction or indirectly in a mixing chamber. The turbulent mixing is investigated numerically using ANSYS FLUENT software, which was also used for model geometry and discretization grid. Numerical modelling clearly shows that the use of the mixing chamber and its positioning eliminate the effects that may be caused by the instability of fluids with different temperatures.

1. INTRODUCTION

Turbulent mixing of fluids at different temperatures has become of significant importance in recent years. Consequently, much research has been carried out on turbulent mixing of hot and cold water in pipes and T-junctions in cooling circuits of nuclear reactors [1]. Random temperature fluctuations or thermal striping in pipe systems, mainly caused due to the instability of fluid jets can induce cyclical thermal stresses and resulting thermal fatigue, which may cause unexpected failure of pipe material. In the available literature, numerous experimental works have been carried out by researchers such as Faidy [2], Hu, et al. [3] and Westin, et al. [4]. Both experimental research and numerical modelling have been carried out by Westin [5] to find the best ways to reduce thermal fatigue and extend the life of cooling systems.

2. METHODOLOGY/EXPERIMENTAL SET UP

Thermal mixing behaviour of two water streams with different temperatures was investigated numerically by computational fluid dynamics (CFD) for 6 different geometries either T-junction or mixing chamber. CFD numerical modelling was performed using the Reynolds Averaged Navier–Stokes equations (RANS) based on k– ε model for turbulent flow.

Numerical modelling of flow and heat transfer has been carried out with the use of the ANSYS Fluent integrated in ANSYS Workbench Platform 16.1. This software solves CFD 3D Navier-Stokes equations using a finite volume meshing method [6]. Model geometry was performed with ANSYS Meshing Design Modeller and the computational grid with ANSYS Meshing, software integrated in ANSYS Workbench Platform 16.1 [7]. Outlet pipe was divided in five cross-sections every 5 cm. Minimum and maximum fluid temperatures were determined for each section. Accurate records of temperature fluctuations of thermal mixing along the outlet were obtained as a result.

3. INPUT DATA

Given that thermal mixing of two fluid streams at different temperatures is a rather challenging process, a 3D discretization grid has been used to ensure accurate results.

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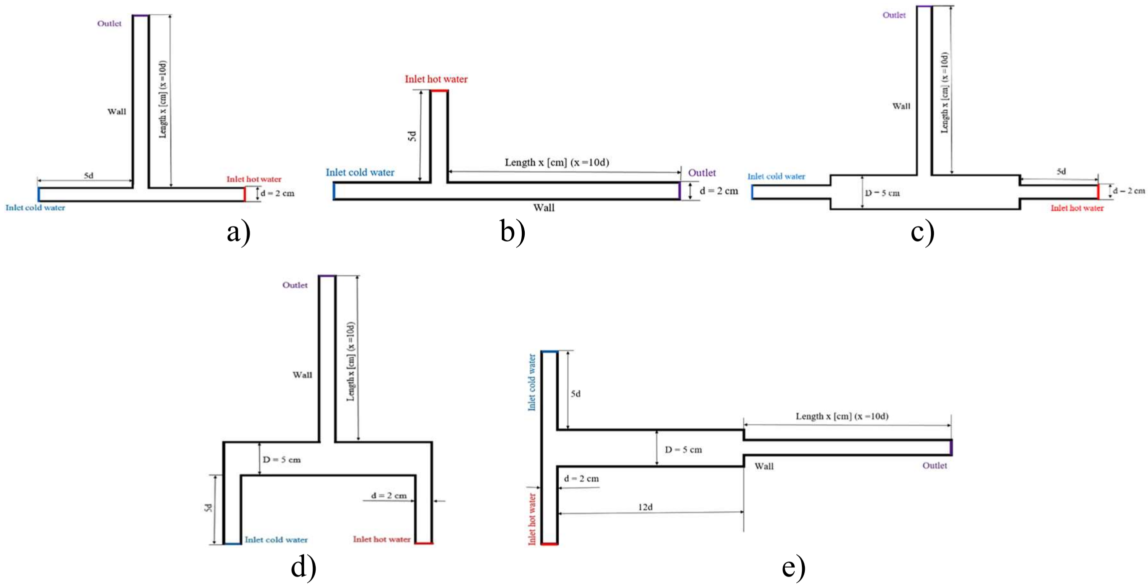

Figure 1: Geometry and discretization domain: a) case 1; b) cases 2 and 3; c) case 4; d) case 5; e) case 6.

As Fig. 1 shows model geometries of the last three test cases present a mixing chamber at the junction of the pipes. The hot inlet temperature was set at 70ºC and cold inlet at 15ºC. The inlet velocity for both flows is 0.5 m/s. Cold and hot inlet pipes used had 2 cm in diameter and the mixing chamber 5 cm. A length of 20 cm was considered for outlet pipe, a length of 10 cm was considered for the inlet pipes, and 24 cm for the mixing chamber. These input data have been used for all six cases under research.

4. RESULTS AND DISCUSSIONS

A CFD model was generated for each geometry using the same input data and the same boundary conditions. The first case shows a T-junction between pipes, with both water flows perpendicular to the outlet pipe. As shown by Fig. 2 and Fig. 3, but especially by the chart in Fig. 4, the degree of thermal mixing is not very effective in the first test case and the use of a T-junction induces a high thermal stress. The second case also shows a T-junction, but in this case hot water flow is perpendicular to the outlet pipe and the cold water flow runs along it.

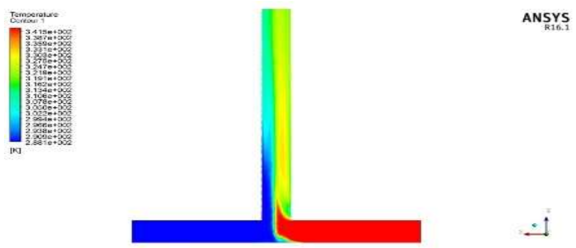

Figure 2: Temperature fluctuation in longitudinal section for test case one.

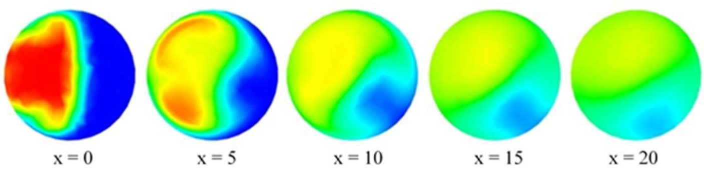

Figure 3: Temperature fluctuation for each outlet cross-section for the first case.

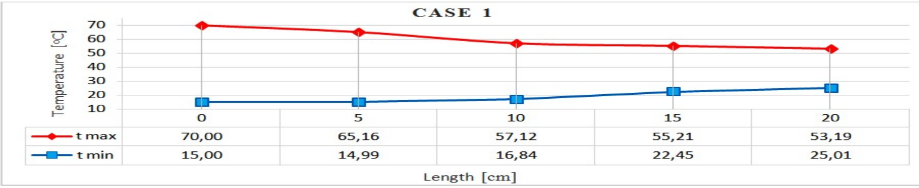

Figure 4: Maximum and minimum temperature fluctuations along the outlet pipe for the first case.

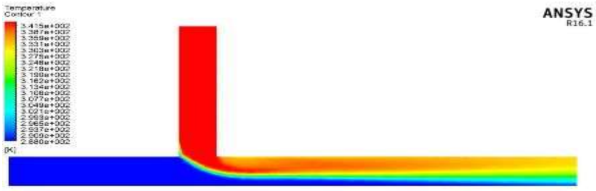

Figure 5: Temperature fluctuations in longitudinal section for case two.

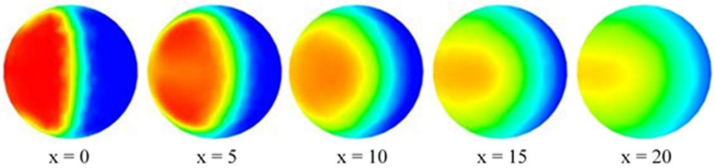

Figure 6: Temperature fluctuations for each outlet pipe cross-section studied for second case.

For second case, as shown by the difference between the maximum and minimum temperatures along the outlet pipe, the temperature gradient in cross section is higher and consequently the mixing process is worse. For the third case model geometry is similar to case two, the difference lies in the fact that in this case the cold water flow is perpendicular to the outlet pipe and the hot water runs along it.

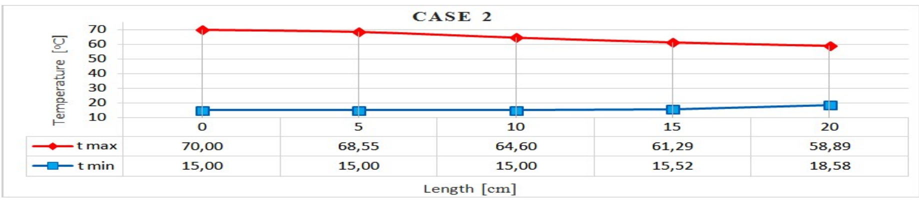

Figure 7: Maximum and minimum temperature fluctuations along the outlet pipe for case two.

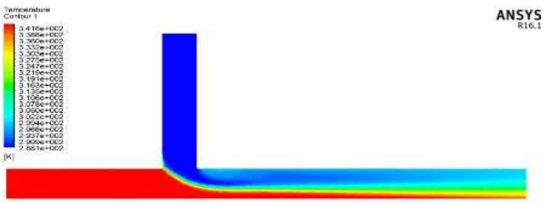

Figure 8: Temperature fluctuations in longitudinal section for case three.

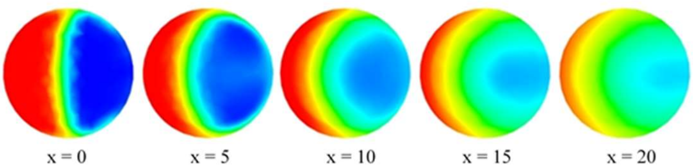

Figure 9: Temperature fluctuations for each outlet pipe cross-section studied for third case.

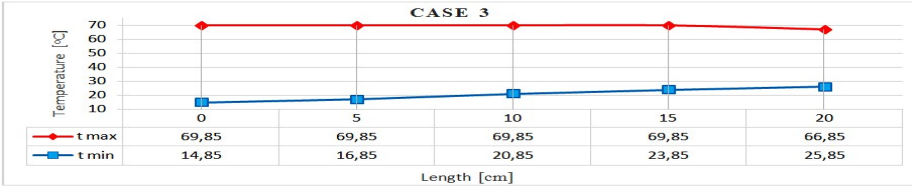

Figure 10: Maximum and minimum temperature fluctuations along the outlet pipe for third case.

Test case 3, as shown in Fig. 9 but especially in the graph in Fig. 10 shows the worst situation of the three previous test cases. Thus, while the minimum water temperature in the last cross-section (*x*=20) increases as compared to previous cases, the maximum water temperature for the same cross-section is very high, the difference between outlet maximum and minimum temperature is 41° C. For a large area of the outlet pipe wall, water reaches a temperature only a quarter of a degree lower than the temperature of hot water inlet.

For the subsequent three test cases model geometries include a 5-cm diameter, 24 cm-long mixing chamber. For case four, the mixing chamber is placed perpendicular to the pipe outlet and hot and cold inlets are located along the mixing chamber, on both sides of it.

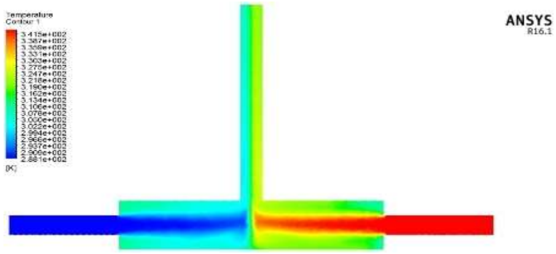

Figure 11: Temperature fluctuations on longitudinal section for case four.

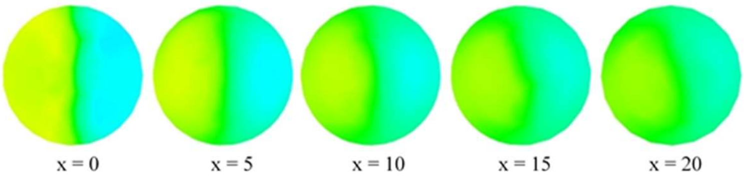

Figure 12: Temperature fluctuations for each outlet pipe cross-section studied for case four.

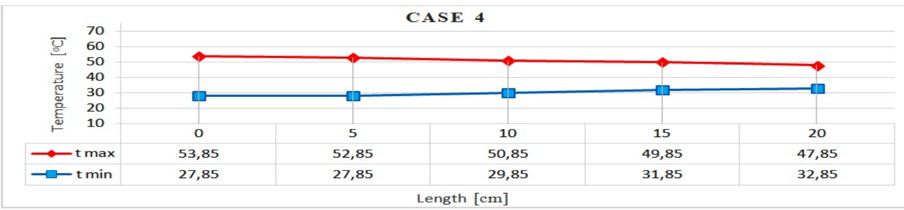

Figure 13: Maximum and minimum temperature fluctuations along the outlet pipe for case four.

This case shows a positive evolution of maximum and minimum temperatures along the five outlet cross-sections. The improvement is obvious even from the first cross-section (x = 0), from the moment water flows out of the mixing chamber along the outlet pipe. Case five model geometry also includes a mixing chamber, different from the previous case in that hot and cold water inlet is perpendicular to the mixing chamber at its ends.

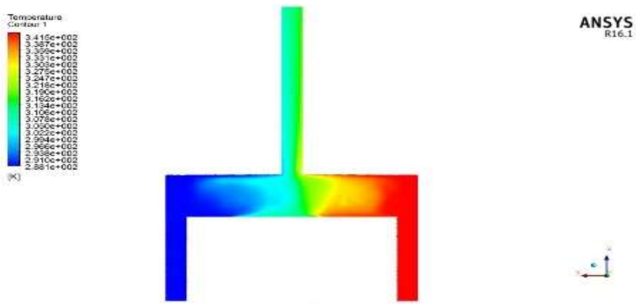

Figure 14: Temperature fluctuation on longitudinal section for case four.

For case five, pipe arrangement of hot and cold water inlet bring a disadvantage compared to the previous case. Even if the maximum water temperature shows a lower value at the outlet, when entering the outlet pipe its value is higher than compared to the previous case.

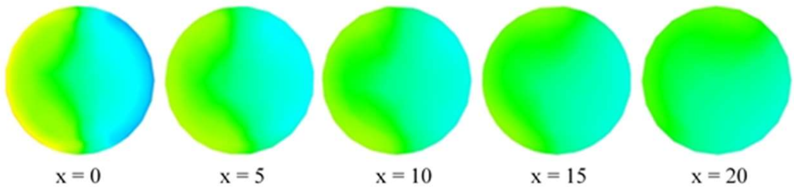

Figure 15: Temperature fluctuations for each outlet pipe cross-section studied for case five.

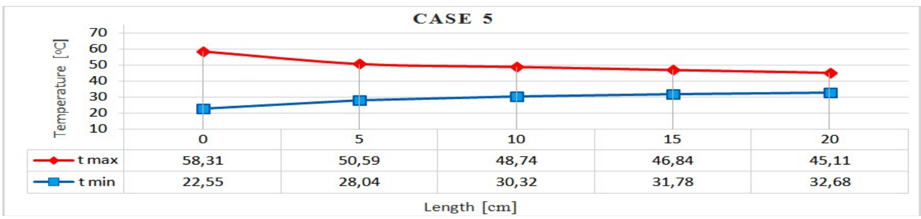

Figure 16: Evolution of the maximum and minimum temperatures along the outlet pipe for case five.

The model geometry for last test case consists of a cold and hot water inlet perpendicular to the mixing chamber on each side at one end, and an outlet pipe placed along the mixing chamber at the other end.

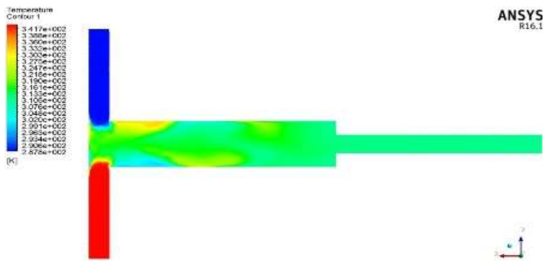

Figure 17: Temperature fluctuation on longitudinal section for case six.

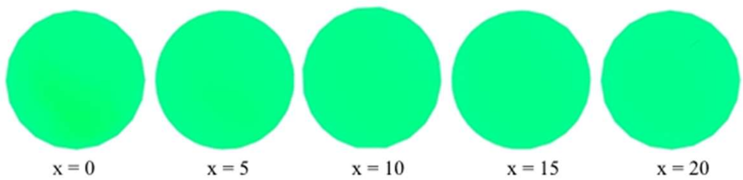

Figure 18: Temperature fluctuations for each outlet pipe cross-section studied for case six.

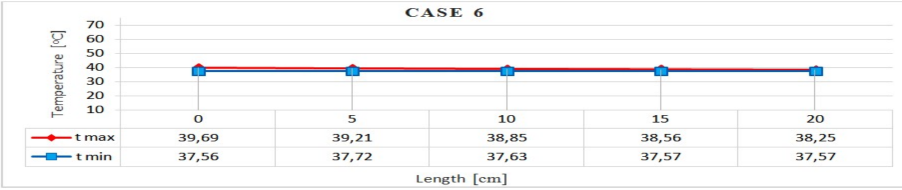

Figure 19: Evolution of the maximum and minimum temperatures along the outlet pipe for case six.

As shown by the figures above, this is the best test case. Fig. 17 clearly shows that turbulent mixing is extremely effective in the mixing chamber, inducing a very effective thermal striping. In this way the difference between minimum and maximum temperature is extremely low even at the mixing chamber outlet, inducing a temperature fluctuation of 0.68ºC at the outlet (x=20). Numerical modelling results were qualitative validated by comparing with experimental and numerical study conducted by Kuczaj A.K et al. [8] for turbulent mixing of fluids with different temperatures in a T-junction.

5. CONCLUSIONS

A comparative view on results yielded by the first three cases clearly shows that case one, where mixing occurs in a T-junction of inlet pipes perpendicular on hot and cold outlet, is the best. When pipe arrangement prevent/does not allow the use of this particular test case and require a model geometry similar to cases two and three, cold water inlet stream must be along the exhaust pipe and hot water stream perpendicular to it to avoid the worst scenario.

Whenever design specifications and pipe arrangement allow and the purpose is to reduce thermal stresses and resulting thermal fatigue of various piping systems, a mixing chamber is the best choice. Numerical modelling results show that the mixing chamber ensures effective thermal mixing and protects pipe walls from thermal fatigue.

Among mixing chamber geometries, the most effective is the last (test case 6), where the mixing chamber is arranged along the pipe outlet and hot and cold water inlet pipe are arranged perpendicular to the mixing chamber at the its opposite end. In this case thermal mixing is almost perfect even from the mixing chamber outlet, the difference between the maximum and minimum temperature being less than two degrees, and maximum water temperature at pipe wall is the lowest from the studied cases.

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BETA TYPE STIRLING ENGINE. THERMODYNAMICS ANALYSIS VERSUS EXPERIMENTS

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ABSTRACT

The paper presents a confrontation of theoretical and experimental results of a beta type Stirling machine. This study is based on two thermodynamic models of first order, Finite Physical Dimensions Thermodynamics (FPDT) and of second order, the isothermal model considering imperfect regeneration. The effect of the piston speed on the heat transfer, wall friction, mechanical power and efficiency of the real operating machine is emphasized. Although the heat losses due to imperfect regeneration are differently evaluated, the two methods give similar performance variation.

1. INTRODUCTION

Nowadays, a particular attention is accorded to the study of Stirling engine which is an excellent mechanism for using solar or recovery energies. The performance of such a machine is strongly dependent on geometrical and physical parameters such as dimensions, heat transfer coefficients, heat source temperatures and regenerator characteristics [1,2].

The Finite Physical Dimensions Thermodynamics method (FPDT) [3-5] is an analytical thermodynamic model which takes into account the finite physical dimensions of a system such as: the temperature pinch between the two fluids of the heat exchangers (finite contact time between the working fluid and the heat source or sink), the finite heat transfer surfaces (or finite conductances), the imperfect regeneration and the finite speed of movement for the mobile elements of the engine which implies a finite speed of the thermodynamic processes. Rochelle et al., [3-5] have shown that thermal engines must be described using physical parameters as maximum pressure (p_{max}) and maximum volume (V_{max}), rather than gas mass, as practical problems are mainly constrained by technical and physical considerations such as material mechanical resistance, material thermal resistance, bulk volume, and heat exchanger conductance and efficiency.

The isothermal model [6] takes into account the pistons movement in addition to the internal and external irreversibilities of the machine. Also, the space and time non-uniformity of the working fluid is taken into consideration by dividing the engine into three volumes.

In this paper, a Beta type Stirling engine was studied. Experimental measurements are confronted to simulation results obtained by the two methods introduced above.

2. THE EXPERIMENTAL DEVICE

The studied β type thermal machine is shown on figure 1. The working piston, the displacer and the two heat exchangers are disposed in a single cylinder of highly resilient glass. It operates as an engine by using an electrical resistance located at the top of the cylinder. This cylinder is surrounded by a double-wall sleeve filled of cool water. The displacer leads the gas from the bottom to the top part of the cylinder and conversely. It also holds a highly conductive material which is used for the heat storage/release, thus playing the regenerator role. The working fluid is air, which is assumed to be a perfect gas.

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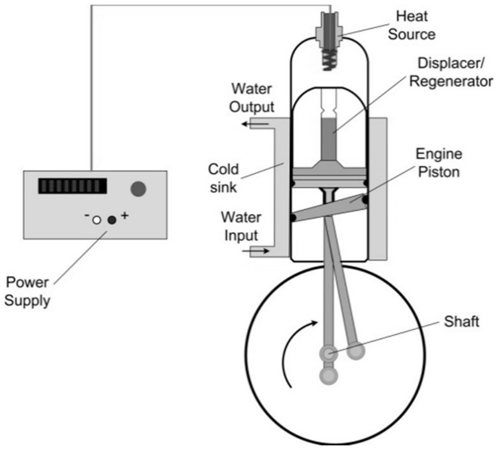

Figure 1: Scheme of the transparent cylinder of the β type Stirling engine.

3. STIRLING ENGINE MODELISATION

a. FPDT method applied to exo-irreversible Stirling cycles with imperfect regeneration.

Stirling cycle with imperfect regeneration is represented in figure 2.

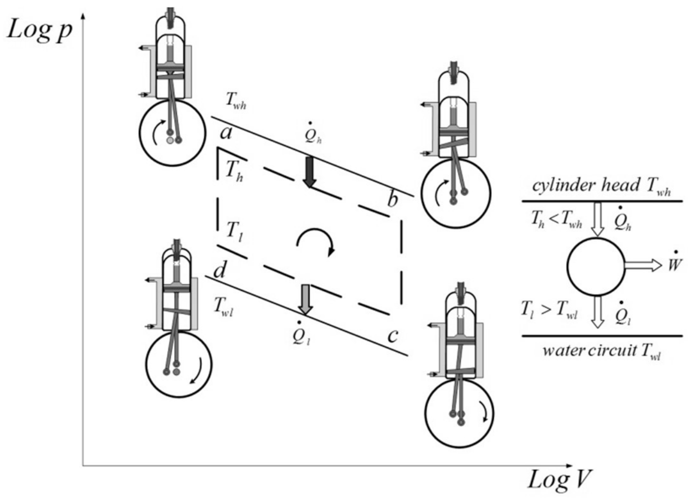

Figure 2: Stirling cycle engine; Energy balance scheme.

The heat transferred during the two isothermal processes are:

$$Q_{h.rev} = Q_{a-b} = p_{\max} V_{\max} \frac{\ln \varepsilon}{\varepsilon} = E_{\varepsilon} \quad (1)$$

$$\left|Q_{l.rev}\right| = \left|Q_{c-d}\right| == p_{\max} V_{\max} \frac{\ln \varepsilon}{\varepsilon} \frac{T_l}{T_h} = E_{\varepsilon} \frac{T_l}{T_h} \quad (2)$$

where ε is the compression ratio.

If the regeneration was perfect, the heat stored on the regenerator during the ***d-a*** transformation and released during the reversible process ***b-c***, will be:

$$Q_{reg\_T} = \frac{p_{\max} V_{\max}}{\varepsilon(\gamma - 1)} \left(1 - \frac{T_l}{T_h}\right) \quad (3)$$

where γ is the adiabatic exponent.

The imperfect regeneration $\eta_{reg} < 1$ implied an additional heat $Q_{p,reg}$ to be assumed by the hot source. The same amount of heat will be transferred to the cold sink.

$$Q_{p,reg} = E_{\varepsilon} k \left(1 - \frac{T_l}{T_h}\right) = \left(1 - \eta_{reg}\right) Q_{reg\_T} \tag{4}$$

where:
$$k = \frac{1 - \eta_{reg}}{\ln \varepsilon (\gamma - 1)} \tag{5}$$

and:
$$\eta_{reg} = \frac{Q_{reg\_T} - Q_{p,reg}}{Q_{reg\_T}} \tag{6}$$

Hence, the heat Q_h and Q_l exchanged by the working gas are:

$$Q_h = Q_{h.rev} + Q_{p.reg} = E_{\varepsilon} \left[1 + k \left(1 - \frac{T_l}{T_h}\right)\right] \tag{7}$$

$$|Q_l| = |Q_{l.rev}| + Q_{p.reg} = E_{\varepsilon} \left[\frac{T_l}{T_h} + k \left(1 - \frac{T_l}{T_h}\right)\right] \tag{8}$$

Thus, the mechanical work W is expressed by:

$$|W| = Q_h - |Q_l| \tag{9}$$

and the cycle efficiency η is:

$$\eta = \frac{|W|}{Q_h} = \frac{\left(1 - \frac{T_l}{T_h}\right)}{1 + k \left(1 - \frac{T_l}{T_h}\right)} \tag{10}$$

b. Isothermal analysis (Schmidt model)

This analysis relies on the division of the Stirling engine into 3 spaces: hot (expansion), cold (compression) and regeneration spaces (figure 3). In this case the hot and expansion volumes are regrouped into the same space which is assumed to be isothermal by compensation of the combined effects (heat transfer and expansion). The cold and compression spaces are combined as well. The imperfect regeneration leads to assumed that the gas temperature history will remain the same and the lost part of regeneration heat will be continuously compensated by a supplement of heat provided by the hot source. Compression and expansion spaces can be expressed according to instantaneous pistons positions by using the engine geometry [5].

The expansion (hot) space instantaneous volume has the following expression:

$$V_E = \frac{V_{E0}}{2} \cdot [1 - \cos(\varphi)] + V_{mE} \tag{11}$$

where φ is the rotation angle of the idealized crankshaft and V_{E0} is the swept expansion volume; which is the displacer swept volume for a β type engines.

The compression (cold) space instantaneous volume is a combination of several volumes and could be expressed as:

$$V_C = \left\{\frac{V_{E0}}{2} \cdot [1 + \cos(\varphi)] + \frac{V_{C0}}{2} [1 - \cos(\varphi - \varphi_0)] - V_{0l}\right\} + V_{mC} \tag{12}$$

where φ_0 is the out-of-phases between the working piston and the displacer movements and V_{C0} is the swept compression volume. V_{ol} is the overlapping volume due to the intrusion of the displacer into the working piston swept volume.

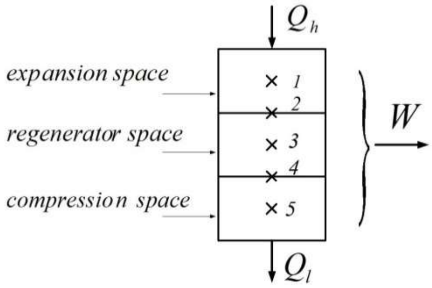

Figure 3: Representation of 3 spaces of the machine with their boundaries

Dead volumes, V_{mE} and V_{mC}, on the heat exchangers are also taken into account. The stored/released heat in the regenerator's material depends on the regeneration efficiency.

$$Q_{reg} = mc_v(T_1 - T_4) = mc_v(T_2 - T_5) = \eta_{reg} \cdot mc_v(T_1 - T_5) \quad (13)$$

Consequently the quantity of heat to be provided additionally by the heat source is $Q_{p,reg}$:

$$Q_{p,reg} = mc_v(T_4 - T_5) = mc_v(T_1 - T_2) = (1 - \eta_{reg}) \cdot mc_v(T_1 - T_5) \quad (14)$$

The displacer reciprocating movement leads the air from the cooling space to the heating space and conversely through its axial section filled with the regenerator material (Fig. 4). The regenerator efficiency is defined by:

$$\eta_{reg} = \frac{T_1 - T_4}{T_1 - T_5} = \frac{T_2 - T_5}{T_1 - T_5} = 1 - \frac{\Delta T_{reg}}{T_1 - T_5} \quad (15)$$

Elementary work in expansion space, $\delta W_h = -pdV_h$, and compression space, $\delta W_l = -pdV_l$, allows to determine, after integration, the provided mechanical work during a cycle:

$$W = W_h + W_l \quad (16)$$

Thus, the cycle efficiency is:

$$\eta = \frac{|W|}{Q_h} \quad (17)$$

4. RESULTS AND DISCUSSION

The main hypotheses of these two thermodynamic analyses were: the expansion and the compression spaces are isothermals, the working gas is a perfect gas and its total mass remains constant throughout the experiment (closed thermodynamic system). The initial data are listed in the following table.

Table 1: Initial Data

n	$\dot{Q}_h$	$\dot{Q}_l$	T_{wk}	T_{wl}	p_{max}	h
$[rot/s]$	$[W]$	$[W]$	$[K]$	$[K]$	$[Pa]$	$[W/m^2K]$
3.86	97.85	56.26	414	299.35	217000	57.22

Table 2: Confrontation of the results obtained by two thermodynamic analysis

n=3.86 [rot/s]					
experimental		*FPDT*		*Schmidt model*	
$\dot{W}_{\exp}$	$\eta_{\exp}$	$\dot{W}_{FPDT}$	η_{FPDT}	$\dot{W}_{0-D}$	η_{0-D}
[W]	[%]	[W]	[%]	[W]	[%]
5.16	5.27	11.29	11.54	9.4	9.6

Nevertheless, the ratio between the experimental mechanical power and the Schmidt model one is about only 55% (table 2). This difference can be illustrated by pV representation using both, experiment and simulation results (figure 4).

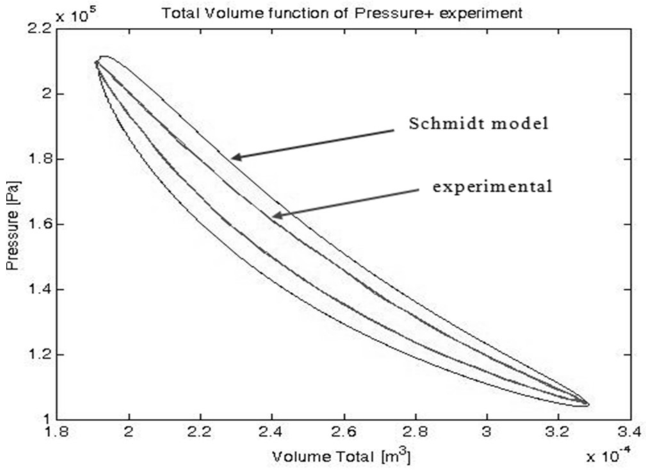

Figure 4: *p-V* diagrams obtained with isothermal analysis (Schmidt model) and the experimental one.

Results obtained by applying the algorithm proposed using the FPDT method are presented in the energetic balance scheme here bellow (figure 5).

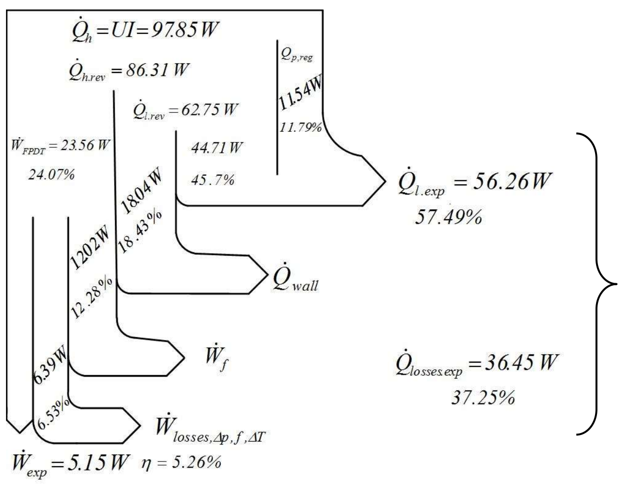

Figure 5. Scheme for the energetic balance (Sankey diagram*)*

where: $\dot{W}_f$ is the lost mechanical power through piston – wall friction, calculated according to the relation $\dot{W}_f = 0.5685 n^{2753}$, obtained on bench test; $\dot{Q}_{wall}$ is the heat flow loss through the wall of the cylinder; $\dot{W}_{losses,\Delta p,f,\Delta T}$ is the mechanical power loss caused by the pressure losses, friction and temperature gap between the working gas and the heat sources, deduced from the energetic balance. The effect of the rotational speed on mechanical power and thermal efficiency is shown in figure 6.

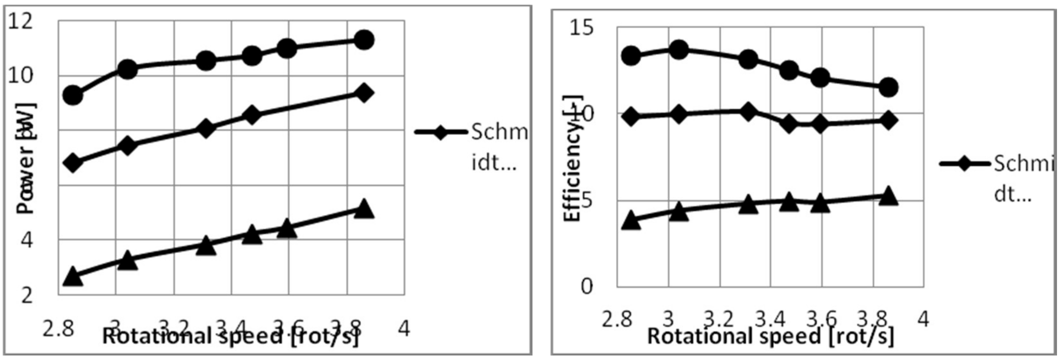

Figure 6: Mechanical power and efficiency versus rotational speed.

The isothermal analysis (Schmidt model) with imperfect heat regeneration, still allows a slightly more judicious estimation of the mechanical power provided by the engine and of the efficiency than the FPDT does. This fact is revealed by confronting the analytical results with the ones obtained experimentally and is due to the the non-uniformity representation of the engine volume and the continuous pistons motion which is more representative comparing with a first order model such as the FPDT method, which assume that the whole gas mass follow the four main evolutions of the cycle.

In addition to this, the Sankey diagram is added in order to indicate several losses of the engine, which were estimated in order to complete this analysis.

5. CONCLUSIONS

In this paper, results of two thermodynamic models have been presented in comparison with experimental ones. The purpose of this study was to compare the two thermodynamic analyses and to determine which of the two is closer to experimental reality. The result is surprising because the two methods give very similar results, with the observation that the isothermal analysis seems slightly more accurate. *pV* diagram and Sankey diagram illustrate different losses of this engine.

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ANALYSIS OF STRAW PELLETS PRODUCTION AND SUPPLY CHAIN: BARRIERS AND OPPORTUNITIES FOR UKRAINE

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ABSTRACT

Straw-to-energy utilization provides wide opportunities to increase added value for business and local communities due to large potential and poor current development of potential biofuel market in Ukraine. In this article we are analyzing straw pellets production and supply chain as one of the inevitable components of sustainable continuation of bioenergy development till 2020 in Ukraine. The key barriers and business opportunities based on the factual production experience for straw pellets production are considered in detail.

5. INTRODUCTION

In 2010-2015 Ukrainian bioenergy sector demonstrates very high indicators of development. The average growth increment of sector for the last 5 years according to official data was 42 %/year (see Figure 1). In 2014 biofuels provided 2.4 million toe (equivalent of replacement of 3 billion m^3 of natural gas) in total primary energy supply. This tendency is likely to be continued in 2015. However, the latest obligations of Ukraine as a member of Energy Community (11 % of RES share in gross final energy consumption in 2020 according to adopted NREAP [1] till 2020) and active participation in new global climate change negotiations (adoption of Paris Agreement) requires even faster development of bioenergy sector till 2020.

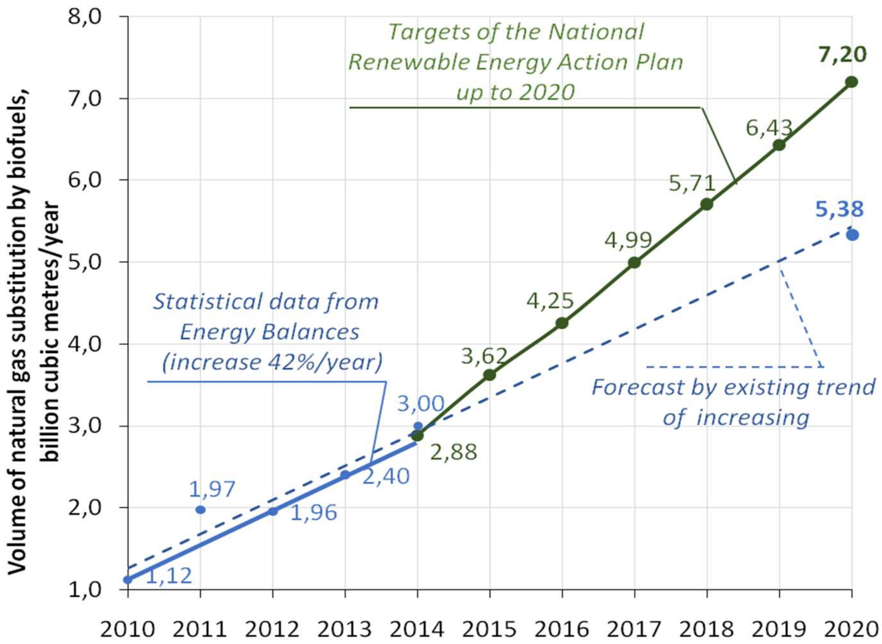

Figure 1: Dynamics of bioenergy sector development and trend till 2020.

Till now bioenergy sector development is based mainly on utilization of woody biomass in heat generation: wood logs and wood pellets mostly for population and district heating, wood chips and residues mostly for industrial purposes, public heating and power production. As a result almost 90% of woody biomass potential is already utilized for energy purposes.

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From the other hand, the largest share of total biomass potential (more than 40%) in Ukraine is represented by agro waste, substantial part of which is comprised by straw pellets. This potential still remains almost unused: only 2 % from total potential of agro waste was used for energy purposes in 2014.

6. WOODY PELLETS AGAINST STRAW PELLETS

The development of pellet market in Ukraine have been started in 2004-2005. The first producers were oriented on the woody pellets and had typically less than 1 t/hour capacity. During the period 2005-2008 the production rises from 40,000 t/year to almost 300,000 t/year (see Figure 2). Since 2008 the production capacities of pellets from sunflower seeds husk started to be introduced. Because the sunflower seeds husk is own waste of oil-extraction plants who acts also as a producers of pellets, the cost of this type of pellets was 30-40% cheaper in comparison with woody pellets, so this market was rapidly growing for the next 5 years. The straw pellets (mainly from sunflower stems, maize rotation waste, barley straw, wheat straw and others) was started in 2009-2010. It was representing by 3 companies accounting in total for approximately 25,000 t/year production capacities. These companies and some other additional small scale producers (installed capacity of 200-300 t/month) dominates the straw pellet market till 2013 when the Vin-Pellet (Smart Energy Holding, LLC) largest straw pellet factory in Europe was commissioned. This pellet factory had 75,000 t/year installed capacity increasing total straw pellets production in 2013 in three times.

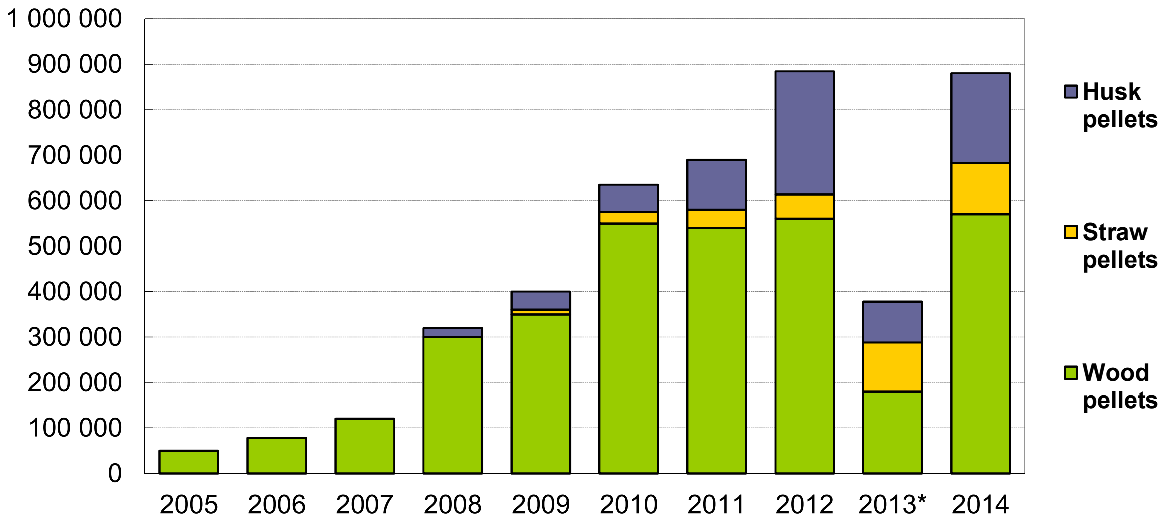

Figure 2: Production of pellets in Ukraine, 2005-2014 (t/year).

** in 2013 Poland suspended co-firing of biomass on large TPPs*

The main sale market for Ukrainian woody pellets and agro pellets is export-oriented market (mainly Poland, Germany, Italy and Great Britain). The average export price FCA for pellets varies a lot depending on quality, batch volume and country of destination. For example, for export to Poland FCA price (2013) could achieve the level of 95 EUR/t and 80 EUR/t for woody and straw pellets respectively and for export to Great Britain FCA price is 280-320 EUR/t for certified woody pellets. The generalization of average price tendencies for both export-oriented and internal markets for three most relevant pellets types are shown on Figure 3. During 2005-2013 the proportion of export/internal woody pellets realization was 90/10 [2]. Regarding agro-pellets, it could be stipulated that during 2010-2013 almost all production capacities were oriented on the export to Poland for co-combustion with coal on the large TPPs. However in 2013 Poland suspended co-firing of pellets with coal and

Ukrainian producers were forced to reorientation on internal market. This situation greatly affects Ukrainian pellet producers decreasing the production rate in 2013 two times in comparison with 2012 (Figure 2). In 2013-2014 woody and especially straw pellets producers started the reorientation on internal market, however this also affects their revenues due to lower FCA price (see Figure 3) and a lot of producers (especially with production capacities 2000-4000 t/year) stopped their activity or were absorbed by larger pellet production companies (usually acting also as vertical integrated biomass energy holdings).

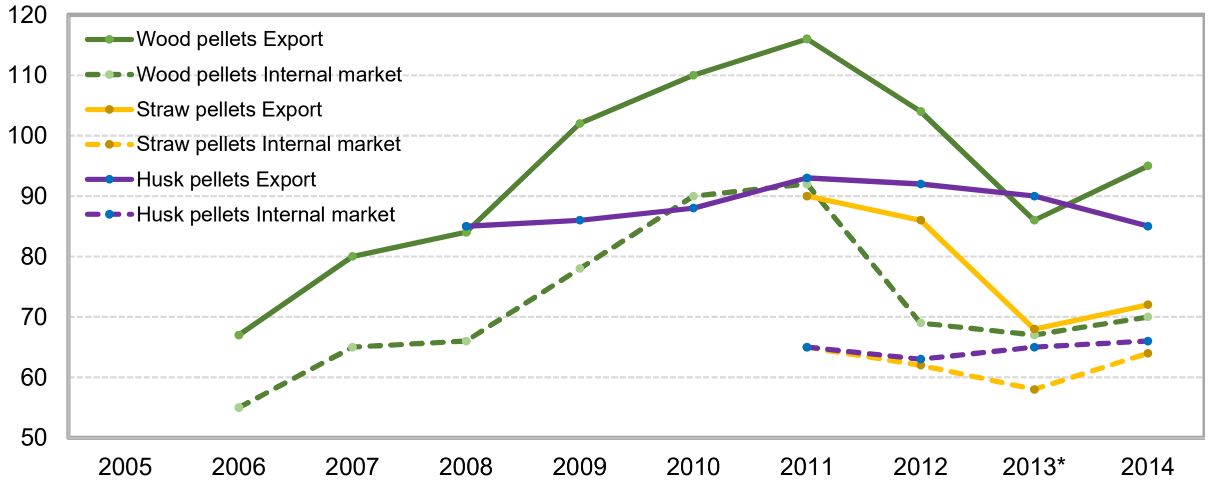

Figure 3: FCA prices of woody and agropellets, 2005-2014 (EUR/t)

It should be noted that agro pellet producers after 2013 pellet market crisis unexpectedly demonstrated more market flexibility for reorientation of their activity from export to internal market while wood pellet producers suffered more. In 2014 however, wood pellets production in Ukraine accounts almost 570 000 t/year, straw pellets up to 113 000 t/year and husk pellets up to 197 000 t/year [3]. Woody pellets still holds the first place on production capacities and agro pellet production is in "frozen" state for last three years. Why such situation occur and what is needed to overwhelm it is explained in the next section.

7. BARRIERS AND OPPORTUNITIES FOR STRAW PELLET MARKET

Current market trend stipulates that since 2013 straw pellet production did not demonstrate the same high development tendencies as woody pellet production during 2006-2010. Despite the elimination of the large group of bottlenecks, mainly in legislation, it is not clear at first glance why such promising market is not so expectedly emerging. The next table summarizes the overall key barriers which considerable decelerate the development of straw pellet market.

Table 1: Main barriers and bottlenecks of straw pellet production in Ukraine

#	**Barrier**	**Short description**
1	Straw pellet is hard fuel with respect to combustion	Higher ash content in comparison with woody pellets, special equipment (usually more expensive and larger in comparison with wood pellets) is needed for production/combustion processes
2	Underdeveloped market of biofuels and especially market of straw	Unclear and unstable internal demand on biomass. Large share of the market is illegal due to general economic field conditions. Potential investors which are planning to produce boilers does not see the perspective of this business because of unclear situation

	pellet combustion boilers	with demand due to low straw pellet production and vise versa. As a result, for 2015 there is zero Ukrainian producers of boilers which can burn straw pellet with guaranteed outlet heating parameters. There are some efforts to burn straw pellets in wood pellet boilers. This approach dramatically decrease efficiency and finally deteriorate boiler equipment.
3	Complicated logistics	1) Raw material bulk density for straw (80-180 kg/m^3) is lower than for wood and/or husk (200-250 kg/m^3): 2) There is no special vehicles for sustainable supply chain organization: only a few types of vehicles are available in Ukraine, most of the special vehicles are needed to be imported which increase the cost; 3) Bad conditions and lack of road network (in forests), especially during heating season; 4) Lack of special construction and design standards for biomass storage facilities. Existing standards and norms are valid all storages without distinguishing biomass storages in separate category and are very strict and complex. As a result, the self-cost of straw raw material increases proportionally (2-3 times higher for straw waste than for wood waste)
4	Seasonal and very short straw collection period	If straw pellet producer still organize all logistics by himself, capital cost of the vehicles (baler, manipulators, trucks, platforms for transportations) are included in the total project cost. The operational time of all this expensive vehicles for medium-scale straw pellet production site is 10-21 days (for 10,000-55,000 t/year production capacities respectively). All other time during year vehicles are not engaged in any operations which decrease economic efficiency of production.
5	Low demand and fluctuations of demand in the EU	In case of internal market failure there is no alternative for straw pellet producers (for example in three hot winters in a row in 2013-2016 harass this market very much)
6	Non-standardized fuel	Straw pellets could only be standardized by voluntary standards (with respect to raw material sustainability and production line certification); no common standard available in EU-28 and in Ukraine; no registry of straw pellet available. As a result – potentially lower price on the good with unclear properties for customer.
7	General impossibility of common certification approach	Extremely high fluctuations of physical and chemical properties depending on place of growth, agro rotation procedures, previous utilization of cropland, fertilization rate, techniques of cultivation, climatic conditions, type of straw species used, and many others. As a result it is impossible to unify the certification for such different conditions which potentially reduce the price of the straw pellets.
8	Absence of strict requirements on biomass quality	Certification procedures are not obligatory in Ukraine. Usually, if the quality is low, the price is reduced, or biomass is not purchased at all.
9	Temporary "protest" of	1) Farms are in private property and have own crop rotation plans and plans for agro waste usage, which usually do not

	agrosector	correspond to logistical operations aimed at collection and supply of straw waste by third party; 2) Agro companies have special vehicles for straw baling in small and average-size (25-100 kg) round bales, however for energy and pellet production purposes typically rectangular average and large scale bales (300-650 kg) are used; 3) No technical capacity and vehicles for harvesting of maize, sunflower stems, stalks which comprise large share of agrobiomass potential (however, in the USA and EU such vehicles exists and successfully operate); 4) Mental problems – agrarian management usually think that all agroresidues are to be returned to the soil despite a number of concrete scientific investigations which prove possibility of collection of some share (20-60%) of agroresidues from field without any harmful effects on soil productivity; 5) Formal prohibition of straw firing at fields, however straw is typically fired on fields by agrarian companies. 6) Agrarian companies usually apply the approach of compensation of fertilization properties of straw which is took away from the fields by additional equivalent mineral (chemical) fertilization. In this case the price of raw dispersed straw (not baled) could be up to 25-30 EUR/t from field. Bearing in mind typical production cost (50-65 EUR/t [4]) the self-cost of straw pellets on the warehouse of factory could achieve 75-95 EUR/t which is too high for Ukrainian market and on the upper limit of EU-28 straw pellet market.

It could be seen, that barriers for development of straw pelletizing technologies are mostly connected with technical and economic part of this core business and adjacent business activities (in agro sector, in transportation and logistics). Meanwhile, let's consider what opportunities could be identified for straw pelletizing.

Table 1: Main opportunities of straw pellet production business in Ukraine

#	**Opportunity**	**Short description**
1	Largest biomass potential among other types of biomass	Straw biomass potential is dependent on annual yield and is assessed on the level of 6…10 Mtoe/year and in 2014 nearly 5% of this potential is used for energy purposes [5]. This potential is likely to increase in the future because of increasing of land productivity, higher yields, engaging abandoned croplands in agriculture, better land management, application of new vehicles and collection approaches, fertilization and special species utilization. At the same time, woody biomass 1.6…2.4 Mtoe/year potential is almost depleted in Ukraine (>90% is already utilized) and could not be increased much (only by increasing of annual fellows and engaging additional resources, for example from recultivation of protection tree lines).
2	Straw pelletizing technology itself is potentially technically easier	Agroresidues usually have lower natural humidity, so drying in some cases is not necessary. Physical and chemical properties of agroresidues are more suitable for pressing and strike technologies application.

3	Economic issues	1) Straw as raw material is potentially cheaper than wood 2) Instantly growing internal demand and price on biomass 3) Pellets are competitive with market price natural gas as a fuel 4) Non-mature market of biofuels production and low competition 5) Potential possibility of export in case of internal market failure
4	High added value of the business	Complex logistics, pre-treatment of raw material, interconnections with agro-companies, construction and design of straw pellet combustion boilers, special vehicles, pelletizing equipment, elaboration of specific rotation approaches creates higher added value for straw pelleting business in comparison with any other pelleting business.
5	Large scale farms in Ukraine	Typical farm as a separate utility in Ukraine accounts 20-30 thousand ha with fields relatively close to each other (max distance is 20-30 km). Such facilities can provide enough biomass feedstock with simple logistics in case of organization of medium-scale straw pellet production closer to them (and by farmers themselves).
6	Agrosector as reliable raw material provider	For the last 10 years agrosector demonstrates constantly growing tendency, it is the most stable and reliable sector in Ukraine and continue to grow, so the raw material supply failure is unlikely.

The opportunities are mainly connected with low competition in the sector because it is still underdeveloped. The main opportunity in Ukrainian conditions is high agro residues potential and large agro companies concentrated in hands of few agro holdings which can provide highly intensive pelletizing business in the nearest future.

8. CONCLUSIONS

As a result of above analysis the key conclusions could be formulated as follow:

The pellet market as part of overall bioenergy market is still one of the emerging markets in Ukraine since 2005.

Woody pellets market is almost in saturation state due to depletion of woody biomass resources, high competition among existing pellet producers, decreasing of demand in EU-28, non-certified of production capacities (inmost cases). At the same time, the future development potential is rather limited, higher added value is unlikely to be achieved.

Straw pellet market is still underdeveloped due to number of technical and economical barriers, mainly connected with specific fuel properties, logistics and production organization, standardization procedures complexity. At the same time, this market has great opportunities in the nearest future in Ukraine due to high agro residues potential, low competition, higher added value and linking to reliable agro-sector business as raw material provider and can demonstrate long-term sustainable growth indicators.

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STUDY OF HEAT EXCHANGER WITH A POROUS STRUCTURE

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ABSTRACT

The proposed heat exchanger implements the effective cooling system, which is a capillary-porous system, has the ability to self-tuning due to capillary forces, and contains a very small amount of liquid, which eliminates the danger of explosion at the burnout of the cooled element, also increasing the reliability of its work and, consequently, the entire installation. The proposed heat exchanger makes mobile the cooling system to the variable thermal loads within a wide range and reliable in operation.

1. INTRODUCTION

Porous heat exchanger refers to highly forced, technical industrial installations, in particular, can be applied to a cooling of metallurgical furnace elements.

On modern industrial technical installations to increase the specific technological productivity of installation and to reduce capital and operational expenses there are high density of heat dissipation, however their service period is reducing.

Well-organized way of cooling thermally loaded elements allows solving this contradiction.

Among the known methods of cooling the most promising is the evaporative cooling which consists in the fact that the cold cooling water is replaced by boiling water to obtain a steam utilized for various purposes.

Evaporative cooling system has a high technical and economic indicators: the consumption of cooling water is reduced, the service life of the cooled components increases, cooling devices, water lines of large-diameter and high-power bulk stations are eliminated, investments are reduced.

The disadvantages of this method are: the danger of furnace destruction by the explosion in case of contact the boiling liquid with the melt; the possibility of crisis onset (transition from nucleate to film boiling) with variable loads, accompanied by a heavy operation conditions of cooled element until its burnout.

2. METHODOLOGY

A heat exchanger with capillary-porous structure is for providing explosion safety, reliability and self -adaptability of cooled system to the variable thermal loads.

In the cooling method of highly forced elements for technical industrial installations by removing heat flows, including removal of steam into the separation node, the cooling of

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systems elements (caissons) is produced by capillary-porous structure, fed by fluid from an external cooling system.

Capillary-porous cooling system has the ability to self-tuning due to capillary forces, and contains a very small quantity of liquid which eliminates the danger of explosion if burnout of the cooled element has taken place, increases the reliability of its operation, and therefore the operation of entire installation.

For example, if the reduced heat flow $q_п$ be higher than heat flow q_o withdrawn from the system, this will lead to liquid penetration in the capillary-porous structure, to a decrease in the radius of the liquid meniscus and increasing of capillary pressure. In this case, the consumption of a feed liquid increases to the establishment of dynamic balance. At reducing the heat load $q_п$ the thickness of fluid in the capillaries and, hence, the meniscus radius of fluid, increases. Capillary forces will start to decrease, reducing the flow of fluid to equilibrium condition.

3. THE OPERATING PRINCIPLE OF THE POROUS HEAT EXCHANGER

Porous heat exchanger contains a cooling element (caisson) on the inner surface of which from the removal side of heat flows, the element with a capillary-porous structure is mounted. Close contact of this capillary-porous structure with the wall of the cooled device is provided by a spring element insertion and is connected to the external nodes of feeding cooling liquid and steam removal (Fig.1).

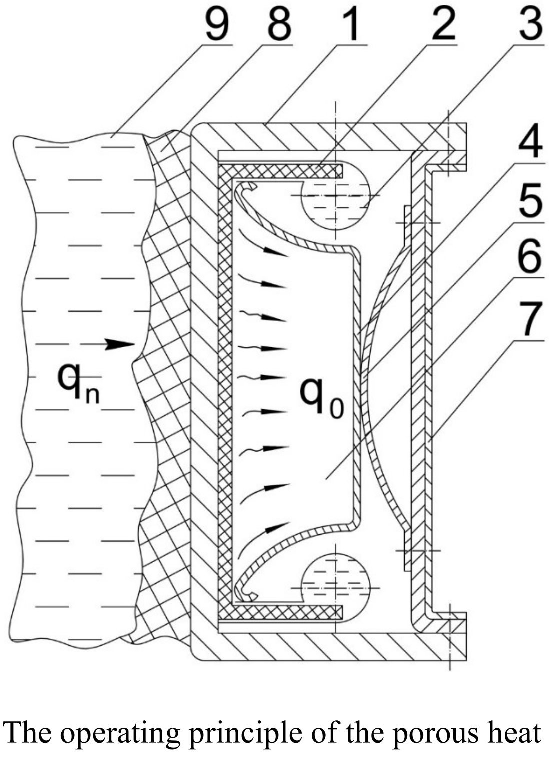

Figure 1: The operating principle of the porous heat exchanger

1 - wall of the caisson; 2- capillary-porous structure; 3 - external feed nodes;
4 - insert for pressing; 5 - spring element; 6 - steam channel; 7- thermal insulation;
8- film of garnissazh; 9- the melt.

The device is designed as the caisson 1, the element having a capillary-porous structure adjoins to its inner surface, from the side of the heat removal. This element having a capillary-porous structure 2, is connected to external feed supply nodes 3, is pressed by the insert 4 with spring element 5 of the steam channel 6 and the thermal insulation 7. During the operation of installation to the outer wall of the caisson 1 adjoins film of garnissazh 8 wetted by the melt 9.

The heat flow with density $q_п$ supplied by melt 9, passing through garnissazh 8 and the wall of the caisson 1 is perceived by the liquid saturating the capillary-porous body 2, which is in close contact with the inner wall of the caisson 1, on the side of heat removal, is provided by the insert 4 with a spring element 5. In addition, the capillary-porous body can be sintered (glued or welded) to the wall of the caisson 1. If at this moment of time specific heat flow $q_п$ will be higher than the heat flow q_o withdrawn from the system, the liquid will evaporate more than supplied from an external feed node 3. This will lead to liquid penetration in the capillary-porous structure 2, to a decrease in the radius of the liquid meniscus and increasing of capillary pressure. Consequently, fluid flow through cross-sectional structure 2 will increase until equilibrium is established. This situation remains valid until it reaches the maximum possible value of the specific heat flow.

If the withdrawn heat flow q_o exceeds the value $q_п$ of supplied heat flow, the thickness of liquid in the capillaries and, hence, the radius of the fluid meniscus is increased. Capillary forces will start to decrease, reducing the flow of fluid to the establishment of dynamic equilibrium.

External feed node 3 is composed of two independent supply lines. The device is operational even when using one of them. Duplicating increases the stability and efficiency of capillary- porous system and the reliability of the installation. The generated steam is removed on a channel to the separation node.

The capillary-porous system 2 contains a very small amount of liquid, which eliminates the risk of explosion in the case of burning the cooling element and thus increases the reliability of the installation work, increasing its operational time, and the ability to self-tuning due to capillary forces makes the system mobile to a variable thermal loads. Heat of produced steam as in conventional circuits may be disposed. To reduce the heat losses to the environment outside wall of the caisson 1 is covered with thermal insulation 7.

Thus, the heat exchanger provides explosion safety due to a very small amount of liquid in the capillary-porous cooling system, increases the reliability of installations, it increases the duration of working operation, and the ability to self-tuning due to capillary forces makes the cooling system to be mobile for variable thermal loads over a wide range, as well as reliable in operation.

The proposed highly forced cooling system by its technical and economic indicators is not inferior to the evaporative cooling system, but exceeds it in terms of security.

4. RESULTS AND DISCUSSION

To investigate the heat transfer capability of the capillary-porous structures experiments were carried out for the structures, which were collected from a metal mesh stainless steel 12X18H10T with different sizes of cells (Table 1). The minimum mesh size was $0{,}08\times10^{-3}$ m as mesh with the smaller size does not allow to organize the developed nucleate boiling, as mesh is corked by the steam bubbles. The largest cell size was chosen 1×10^{-3} m, since for large scale cells a value of capillary potential is close to zero, which leads to an uneven distribution of liquid through the pores of the structure. The boiling crisis was determined by burnout of the wall. Crisis phenomenon has been studied by optical methods involving holographic interferometry, and high-speed filming by camera SCS -1M. Mesh structure was formed from multiple layers of mesh [1].

The best results are achieved for capillary-porous structure of the type 2×0,55, which allows to remove the greatest heat flows at the combined effect of mass and capillary forces. Structure composed of a single mesh layer $0{,}55\times10^{-3}$ m, forms a less stable liquid film on the surface, and when the number is equal to more than two grids, the wall superheat substantially increases relative to the steam temperature, which leads to an earlier onset of the crisis. In addition, the increased size of the cells does not require a high degree of cleaning, as it takes place in the heat pipes and thin-film evaporators [2].

Table 1: The heat transfer capabilities of studied capillary-porous structures, heat pipes and thin-film evaporators

Type of capillary-porous mesh structure	The heat load, $\times10^4$ W/m^2					
	2	4	10	20	40	60
The considered structure						
0,08×0,14×0,14	5,2	13,4	20,5	37,1	50	Burnout of the wall
0,55	6,5	16,4	22,7	53,3	61	Burnout of the wall
2×0,55	7,4	18,2	23,4	50,3	57	Burnout of the wall
2×1	8,1	19,3	24,7	55,6	62,4	Burnout of the wall
Heat pipes						
0,08×0,14×0,14	2,5	10	40	Burnout of the wall		
2×0,55	does not operate					
Thin-film evaporators (without capillary-porous structure)						
-	3,7	5,7	8	Burnout of the wall		

The burnout of the wall in heat pipes is due to blockage of mesh cells by steam bubbles, which stops the inflow of fresh portions of liquid to the heated surface of the pipe.

If the tube wall doesn't contain a capillary-porous covering, and cooling is produced by the steam-water mixture when a thin liquid film is formed on the wall, then at the heat flow about 1×10^5 W/m^2 a decomposition of the liquid film into separate streams and droplets is observed, leading to burnout of the wall. The liquid from the core of the moving steam flow does not leak to the heated surface of the pipe on the inner surface of which is formed a continuous vapor film, the heat transfer rate sharply reduces, the sharply variable cyclic thermal stresses, the temperature distortions are taken place in the tube wall, which substantially deteriorates the operation of the heating surfaces including their destruction [3].

The investigated capillary-porous mesh structure of the type 2×0,55 removes the largest heat flows due to the joint action of capillary and mass forces in a volume of the structure, which facilitates the destruction of the steam conglomerates in the pores. Process of visualization showed in the cell structure the existence of supply by cold liquid portions, aimed to the areas of the collapsing and coming-off vapor bubbles. There is a turbulization of two-phase boiling steady pulsing boundary layer. Presence in the inner space of channel the partitions contributes to additional inflow of liquid to the surface of the structure due to the action on the core flow of centrifugal forces at its going round the transverse porous walls [4].

5. CONCLUSION

The proposed heat exchanger with a capillary-porous structure allows to extend the limits of removal of heat flows in six times in comparison with such the efficient heat exchangers as heat pipes and thin-film evaporators. And also in six times to reduce the heat transfer surface, and for the given surface to increase the reliability and service life, stabilize the temperature field in the pipe wall, thus facilitating the operation conditions of the heating surface in the flame core of burning pulverized coal particles.

The use of mesh with large cells simplifies the requirements for the cooling fluid, which can be used as feed water of boilers. If necessary, such mesh is easily washed from possible contamination and salt deposits, even during operation of the boiler.

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ANNOTATION

Proposed capillary-porous system for cooling of caissons improves the reliability of the devices, intensifies the heat transfer in a porous system and provides explosion safety of highly forced technical installations operation.

It is experimentally defined the type of porous structure (2×0,55), which has increased to six times the heat transfer capacity of the cooling system. Heat transfer mechanism has been studied with the assistance of holographic interference and high-speed filming. A comparison of the studied system with heat pipes and thin-film evaporators is given. The use of mesh with large cells simplifies the requirements for cooling liquid.

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INSTALLATIONS FOR HEAT TRANSFER RATE STUDY IN CAPILLARY-POROUS SYSTEMS OF POWER EQUIPMENT

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ABSTRACT

Various installations for heat transfer rate study in capillary-porous systems through their integral characteristics are presented. A chart of the system operation and flow measurement, temperature and heat flux is provided. Developed is a transpiration cooling device for joint action of capillary and body forces, flat experimental setup, coolant supply knot to the capillary-porous structure and fluid supply system for ten combinations of actions of different forces, allowing the installation to use heat transfer installations with increased height and high specific heat flows diverters.

INTRODUCTION

The experimental setups allow to measure the characteristics of the integrated heat transfer (heat flux, wall-side temperature, vapour, liquid, insulation, liquid flow).

For the construction of heat transfer models and the clarification of the processes' mechanisms the following methods have been used: holography, photoelasticity [1], thermoelasticity and speed filming [2.3].

Heat transfer and hydrodynamics management is performed by applying combined action of capillary and body forces [4], including internal (thermodynamic) boiling properties [5,6], which allow to sort and generalize (accumulate) experimental data [7-9].

1. Measuring circuit

Figure 1 shows a measurement circuit in evaporation-condensation cooling system. The system can work under pressure, when the pump is into operation 4. Needle valves (NV) allow organizing upper (m_1), lower (m_2) and joint fluid supplies.

The cooling system is open, if the capacitor 2 is disconnected, and the vapour is released into the atmosphere.

Constructive implementation of test stand elements

Figure 2 shows a porous cooling device. Coolant is supplied through pipe artery 3. Insert 4 organizes a vapour stream and a perforated pressure plate 10 with microarteries 11 provide the necessary degree of structure pressure 5 and its uniform fluid makeup.

To identify the influence of heated surface height, there was mounted an installation (Figure 3), a cross-section of which is presented in Figure 4.

Figure 5 shows the coolant supply knot configured as a pipe artery 1, the pressure forming insert 7, a perforated pressure plate 9 and a microartery 10

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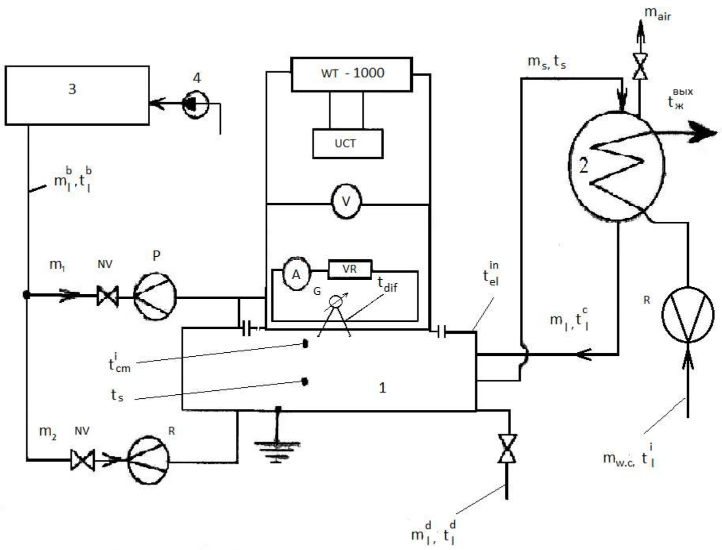

Figure 1: Measurements chart in evaporation - condensation cooling system.
1 – evaporator; 2 – condenser; 3 – tank; 4 – pump:
m_l^b, t_l^b - flow and temperature entering from the tank of fluid; m_1, m_2 - fluid flow entering upper and lower artery; t_{cm}^i - wall side temperature measured by the heater height, t_s - steam temperature; t_{dif} - differential temperature; t_{el}^{in} - electrical insulation temperature; m_s - steam flow; m_l, t_l^c - flow and temperature of liquid (condensate); $m_{air}, m_{w.c}$ - air and water circulation flow; m_l^d, t_l^d - flow and temperature of liquid (drain); t_l^i, t_l^o - fluid temperature at inlet and outlet; NV – needle valve; FM – flow meter; A – ammeter; G – galvanometer; VR – voltage regulator; UCT – universal current transformer; WT – 1000 – welded transformer.

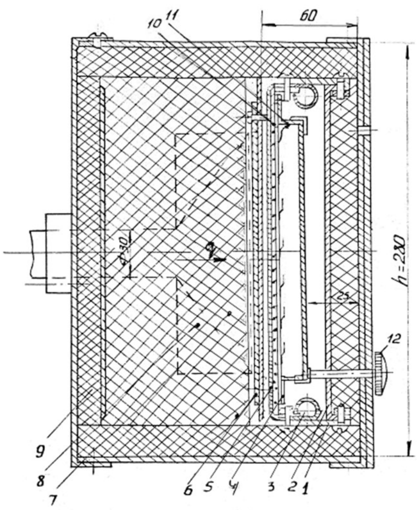

Figure 2: Transpiration cooling installation (of the element) (transverse section): 1 – frame; 2 – lid; 3 – pipe artery; 4 – insert; 5 – void structure; 6 – insulation (mica); 7 – main heater; 8 – guarding heater; 9 – heat insulation; 10 – perforated pressure plate; 11 – microartery

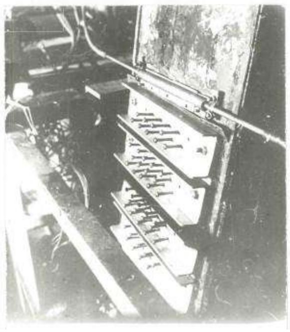

Figure 3: Flat experimental setup to study the influence of heater height and capillary-porous structure pressure degree. Cross-section of the installation is shown in Figure 4.

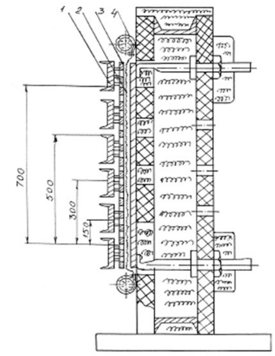

Figure 4: Experimental facility:
1 – pressure bar; 2 – grid structure; 3 –pressure plate; 4 – pipe artery

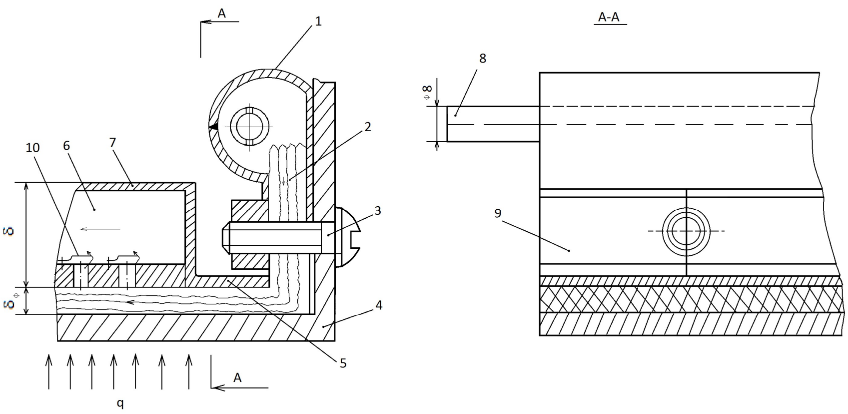

Figure 5: Fluid supply unit: 1 – pipe artery; 2 – platelet structure; 3 – fastening screw; 4 – heated wall-side; 5 - pressure turn-away; 6 – steam channel; 7 – pressure forming insert; 8 – fluid supply pipe; 9 – perforated pressure plate; 10 – microartery

2. The charts of cooler supply

Fluid supply options (Figure 6) a), b), c) are recommended for heat transfer surfaces of moderate height (until h=1 m), heat flux rate ($\approx(1\div2)\cdot10^6$ watt/m^2), up to critical sizes, and more preferable is considered to the option a).

At low supply or artery fluid supply the options are given for heating surfaces not higher than $h\leq0{,}15$ m (except for option e), also at heat flux rate (until $1\cdot10^5$ watt/m^2). Option e) can be investigated in those cases as for options a), b), c).

Joint fluid supply (g, h, i, j) is recommended in the case of heating surface from big height, functioning in highly forced modes, and the best results are taken for an option g).

Hereby are studied a measurement chart, a transpiration cooling installation, a flat installation, a cooler supply knot and a fluid supply chart.

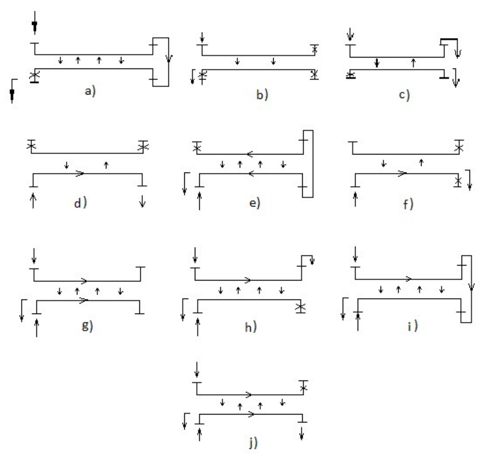

Figure 6: Fluid supply charts:
a), b), c) –upper fluid supply;
d), e), f) – lower fluid supply;
g), h), i), j) – joint fluid supply.

3. Experimental design

To select the necessary and sufficient conditions for the experiments, in order to ensure the required degree of accuracy for engineering calculations, an experimental design has been carried out. It minimizes the number of experiments, ranging all the variables included in the criterial equation of heat transfer [7] and on the basis of mathematical statistics a confidence interval of experimental points is determined. First, there is determined the highest number of important factors that are included in criterial equation of heat transfer, and then there are eliminated factors, the significance of which is low. Quantitative assessment of individual factors effect and their interaction is made on the target function of Stanton number St: $St=\eta_i+E_i$. The quantity η_i- is a real value of an outlet at I experiment; E_i- the additive noise, conforming to i experiment, formed by the action of the total uncontrolled variables.

The search for optimal conditions comes to the definition of regime factors of specific heat flow, the optimal excess of fluid, pressure (q, $m_{опт}$, P), geometrical characteristics of the structure, cell widths and thickness of the wick (b_{ri}, δ_{fi}), heat transfer surface L_i, h_i, slope angle of the β surface, the material of wall-side and structure.

On the basis of relevant factors of optimization, a mathematical model of heat and mass transfer in porous structures is formed. In addition, a constant factor in a formalized criterial equation [7] and in theoretical models is selected [3-6], so that it can generally describe the mechanism of heat transfer processes and also allow to obtain engineering rated functional connections.

4. Conditions for experiments

Before any experiments are carried out, the cooled wall-side and structure are cleaned and degreased. The wall-side is washed with acetone, and the grids are maintained for an hour in 5% acetic acid solution heated to 60 ... 700 ° C, rinsed with water and degreased for 20 minutes in acetone.

The study of heat and mass transfer processes is carried out for heat load equal to $(1\ldots60)\cdot10^4$ watt/m^2, at quantities $\Delta T=T_c-T_n=(1\ldots80)$ K. There are implemented experiments to identify critical heat fluxes up to the value $2\cdot10^6$ watt/m^2 and experiences for moderate loads – $(1\ldots3)\cdot10^4$ watt/m^2, when we study the beginning of boiling liquid. The fluid velocity in the cross section of porous structures has values within $(1{,}1\cdot10^{-3}\ldots0{,}1)$ m/s, fluid underheating (0…20) K, fluid surpass – $(1\ldots14)m_n$, m_n – steam flow. The system pressure may vary within (0,01…10) mPas.

Boiling moment is fixed in several ways:

- by means of visual observation with the use of filming and photo recording equipment;
- by changing the nature of the curve $q = f[\Delta T]$, i.e. by changing the evaporative heat transfer mode;
- by the appearance of salt deposits.

Certain measures are taken, so that to allow test data to be obtained repeatedly: bedding and surface deaeration are carried out for two hours at a pressure of about 5 MPa and heat load - $2\cdot10^5$ watt/m^2. Then it follows pressure suppression and electrical voltage reduction up to its disconnection.

To investigate the critical heat fluxes there are used recommendations [9], according to which the coolant fluid flow is gradually reduced step by step. At a sharp increase in the wall-side temperature, fluid flow increases as long as a stable mode is fixed. This method allows a little electric power, which matters in installations for visualization of processes and minimizes the risk of surface burnout.

The effect of surface orientation in gravitational forces on the rate of heat transfer is also studied. The slope angle is measured from a vertical line ($\beta=0$) and takes both arbitrary and next fixed values: $\beta_1=0$; $\beta_2=\pm45$; $\beta_3=\pm75$; $\beta_4=\pm90$ degrees. The angle is considered positive if the steam moves against the direction of gravitational forces and, respectively, negative - in the opposite case.

CONCLUSIONS

Experiments were carried out to cool the heat transfer surface without structure. Feeding arteries with slit width of $(0{,}5\ldots1)\cdot10^{-3}$ m and length of 0,09 m are used as distributive devices.

During experiments the invariability of the fluid flow entering the evaporator and the condenser as well as the differential thermocouple readings are controlled, whilst the temperature and barometric pressure in the room are specified.

For each of the thermal operations of the system a fixed optimum fluid coolant flow can be obtained by adjusting the needle valve as long as it reaches a uniform temperature distribution of the wall-side at a minimum discharge flow. Experiments are carried out at a zero discharge (heat pipe mode) and at a large excess of fluid. Facility's readings record is made after installation in a stationary thermal mode, which is fixed with a zero reading of a differential thermocouple.

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ASSESSMENT OF WASTE HEAT AVAILABLE IN A PASSENGER CAR-BASED INTERNAL COMBUSTION ENGINE

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ABSTRACT

Within the scope of new environmental standards, it becomes more difficult to reach the objectives of CO2 emissions and pollutants by the solely optimization of the thermal engine (HCCI, double supercharging, low-pressure EGR, downsizing). A thermal engine converts 30 % of the fuel energy into mechanical shaft work; the rest of energy is wasted through the cooling liquid and the exhaust gases. Thus, it would be possible to convert this wasted heat in order to improve the engine overall efficiency and reduce the fuel consumption of the vehicle.

In this article, the characteristics of a passenger car-based internal combustion engine are analyzed. From exhaust gas temperatures and exhaust gas mass flows, the characteristic of available waste heat over load and speed is estimated. Finally, the expected waste heat recovery at typical passenger car operation conditions is determined by weighting the waste heat recovery characteristics with the operation conditions of the New European Driving Cycle (NEDC).

1. INTRODUCTION

Huge amounts of energy are consumed by internal combustion engines in all types of vehicles, but much of this energy is wasted through the exhaust and the cooling system. Exacerbating this problem is the fact that these combustion products also cause serious environmental issues. Engine waste heat recovery could improve the fuel thermal efficiency, minimize fuel consumption, and reduce engine emissions. Using an organic Rankine cycle (ORC) to recover the low-grade wasted heat from these systems is the technology that is the closest to being suitable for mass production.

The efficiency of an internal combustion engine refers to the percentage of the energy resulting from the combustion that actually is applied to moving the car or running the accessories. For current ICEs, the proportion of fuel energy converted into effective work at medium and high loads is about 30% - 45% for the diesel engine or 20% - 30% for the gasoline engine, and the rest is mainly brought into the environment by the exhaust gas and cooling system.

2. CHARACTERISTIC ANALYSIS OF THE DIESEL ENGINE WASTE HEAT

To design a reasonable system to utilize various waste heats from the diesel engine with high efficiency, studying the energy distribution in the running process of the diesel engine is necessary. When an engine is running, the energy and exergy quantities of the exhaust and the coolant are significantly different. Because of this, it is very difficult to design a system that

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can comprehensively recover waste heat from both the exhaust and the coolant of that system. A four-cylinder in-line diesel engine is used as the object of analysis. The main technical performance parameters are listed in Table 1.

When a vehicle is running, the engine speed and load can vary through a wide range. Therefore, the engine performance test was conducted in an engine test cell in order to obtain the thermodynamic parameters of the exhaust and coolant systems overall possible engine operating regions as defined by the engine speed and output torque. For our measurements, the minimal and maximal engine speeds were set to 1000 rot/min and 4500 rot/min, respectively. The intermediate speeds were selected using a step increment of 250 rot/min, starting from the minimum engine speed. At each selected engine speed, different load values were selected, ranging from a 100% load to a minimal stable load value. The values for the output torque, the output power, the engine speed, the mass flow rate of the intake air, the injected fuel quantity, the exhaust gas temperature, and the coolant temperatures at the outlet of the engine's water jacket were all recorded for each load and speed configuration.

Table 1: The main technical performance parameters of the diesel engine [3]

Items	Parameters	Units
Model	Diesel	[-]
Cylinder number	4	[-]
Stroke and cylinder bore	88.3x75	[mm]
Displacement	1560	[cm$^{3]}$
Compression ratio	18:1	[-]
Air intake type	Turbocharged and Intercooled	[-]
Fuel injection system	High pressure common rail	[-]
Rated power	80	[kW]
Rated speed	4000	[rpm]
Maximum torque	240	[Nm]
Speed at maximum torque	1800	[rpm]

To determine the amount of waste heat produced during the transient operation, the vehicle has done experimental tests under the New European Driving Cycle operating conditions. The New European Driving Cycle (NEDC) is a driving cycle, last updated in 1997, designed to assess the emission levels of car engines and fuel economy in passenger cars (which excludes light trucks and commercial vehicles) [4].

The distribution of fuel energy released by combustion under a certain operating condition of the diesel engine is depicted using the first law of thermodynamics, which is:

$$\dot{Q}_{cb} = P + \dot{Q}_r + \dot{Q}_g + \dot{Q}_{rest}[kW] \quad (1)$$

Where: $\dot{Q}_{cb}$ is the heat flux received through fuel combustion; P is the amount of mechanical power produced; $\dot{Q}_r$ is the heat flux rejected through the water cooling system; $\dot{Q}_g$ is the heat rejected through the exhaust gases and $\dot{Q}_{rest}$ is the heat flux rejected through radiation and incomplete combustion that cannot be directly determined in this stage.

The heat flux received through fuel combustion can be computed as:

$$\dot{Q}_{cb} = \dot{m}_{cb} H_{icb} [kW] \quad (2)$$

Where $\dot{m}_{cb}[kg/s]$ is the fuel mass flow rate and $H_{icb} = 4200[kJ/kg]$ is the inferior fuel heat value. The inferior fuel heat value is considered from data available in literature [5,6].

Next, the heat flux rejected through the water cooling system can be computed as follows:

$$\dot{Q}_r = \dot{m}_w c_w (t_e - t_i)[kW] \quad (3)$$

In eq. (3) $\dot{m}_w[kg/s]$ is the water mass flow rate; $c_w = 4.186[kJ/kgK]$ is the water heat capacity; $t_e[°C]$ and $t_i[°C]$ are water temperatures at engine outlet and inlet, respectively.

The heat flux $\dot{Q}_g[kW]$ rejected through exhaust gases is computed as:

$$\dot{Q}_g = \dot{Q}_{eg} - \dot{Q}_{air}[kW] \quad (4)$$

Where, $\dot{Q}_{eg}[kW]$ is the total heat flux available in exhaust gases and $\dot{Q}_{air}[kW]$ is the heat flux due to the fresh load.

The quantity of waste heat contained in exhaust gas is a function of both the temperature and the mass flow rate of the exhaust gas:

$$\dot{Q}_{eg} = \dot{m}_g c_{pg} T_g[kW] \quad (5)$$

In eq. (5) $\dot{m}_g[kg/s]$ is the exhaust gasses mass flow rate; $c_{pg}[kJ/kgK]$ is the heat capacity at constant pressure of exhaust gases and $T_g[K]$ is the temperature of exhaust gases. Heat capacity of exhaust gases is considered from available data in literature according to experimental data [5].

The heat flux due to the fresh load can be determined:

$$\dot{Q}_{air} = \dot{m}_{air} c_{pair} T_{air}[kW] \quad (6)$$

Where, $\dot{m}_{air}[kg/s]$ is the air mass flow rate $c_{pair} = 1.013[kJ/kgK]$ is the heat capacity at constant pressure and its value is considered from data available in literature [7] and $T_{air}[K]$ is the measured ambient air temperature.

6. RESULTS

One common way to present the operating characteristics of an internal combustion engine over its full load and speed range is to plot brake specific fuel consumption contours on a graph of brake mean effective pressure (or engine torque) versus engine speed.

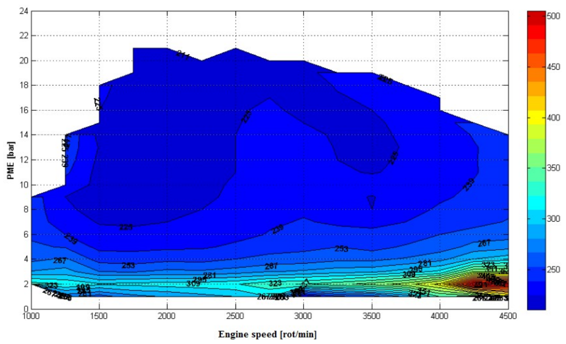

Figure 1: Brake specific fuel consumption [g/kWh]

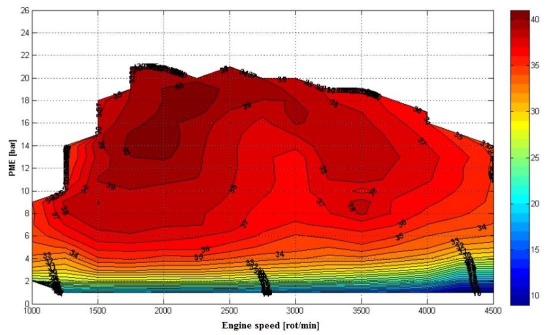

Figure 2: Engine effective thermal efficiency [%]

The measured engine performance map is displayed in Figure 1. The lowest brake specific fuel consumption (b.s.f.c.) zone is situated at the high duty range between 1500 rot/min and 3000 rot/min and the minimum b.s.f.c. value is less than 210 g/kWh.

The effective thermal efficiency is defined as the ratio of the output torque at the flywheel end to the fuel combustion energy, and the results are given in figure 2. The effective thermal efficiency reaches a peak of greater than 40% in the low b.s.f.c. region.

The fuel energy released by combustion is shown in Figure 3. As the engine speed and engine load increases, the fuel energy released by combustion increases gradually. Such phenomenon is primarily caused by the increase in fuel consumption and intake air mass. The combustion energy increases almost linearly with the engine output power, achieving 220 kW at the rated power point. Note that the waste heat quantities of the exhaust and the coolant vary in a similar fashion. The variation of the waste heat quantity carried by the coolant system and exhaust gases over the whole operating range, are shown in figures 4 and 5.

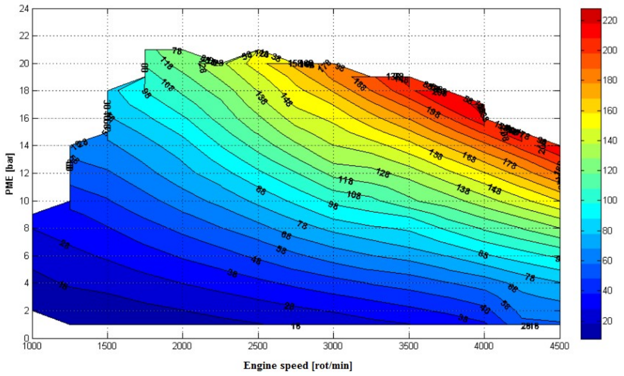

Figure 3: Fuel combustion energy [kW]

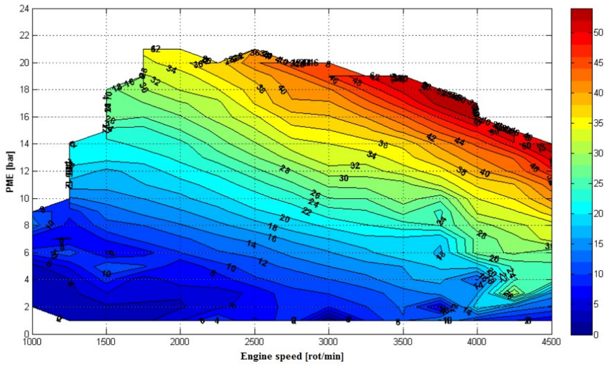

Figure 4: Energy part of cooling system [kW]

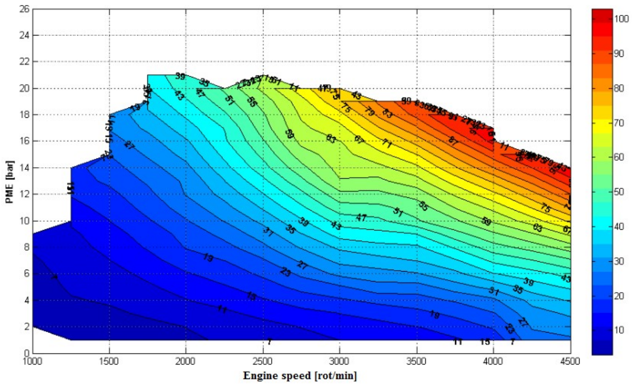

Figure 5: Energy part of exhaust [kW]

Chassis dynamometer measurements were carried out in order to measure the exhaust gas mass flow rate and temperature for the NEDC operating conditions, figures 6 and 7.

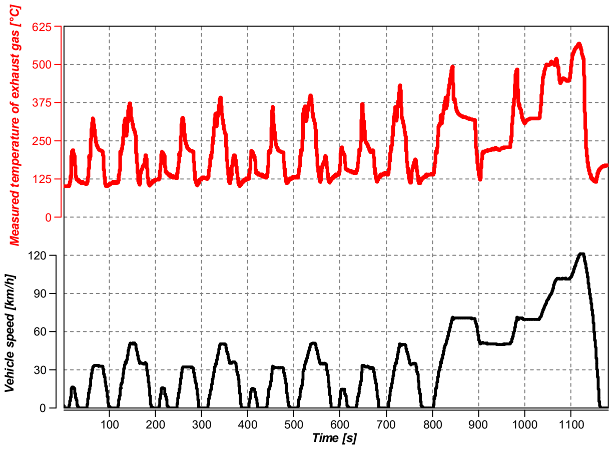

Figure 6: Measured temperature of exhaust gas under NEDC

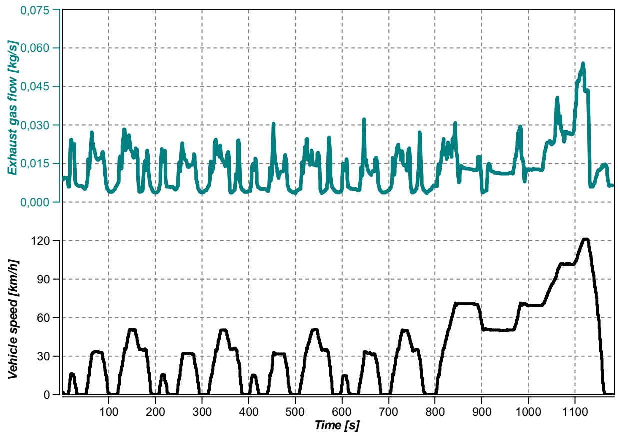

Figure 7: Exhaust gas flow under NEDC

Assessing the waste heat recovery options just by design point performance is only half the truth. As passenger cars are used in transient operation conditions, this influence must also be taken into account, see figure 8.

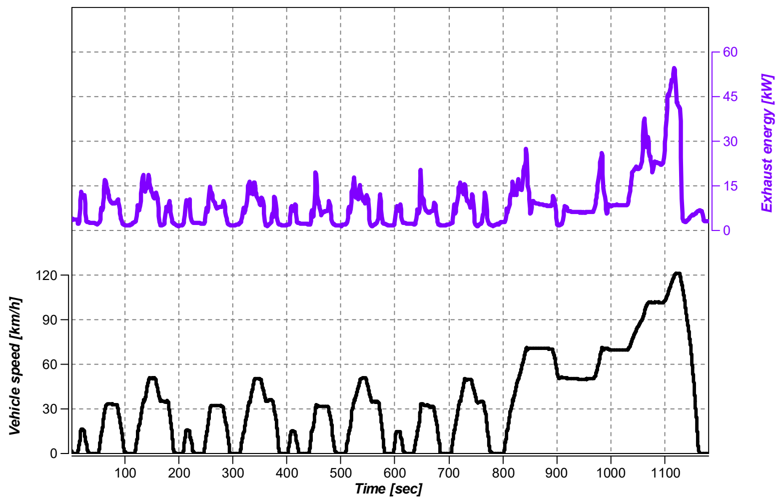

Figure 8: Engine exhaust waste heat under NEDC

7. CONCLUSIONS

In this study, the waste heat from the exhaust, of a passenger car equipped with a diesel engine was analyzed using measured data. The performance map of the diesel engine is evaluated over the engine's entire operating region. Based on this analysis, the following can be concluded:

- Despite all the technological advancements in internal combustion engines, this technology only transforms about 1/3 of fuel energy into mechanical power. It can be seen that the waste heat at the vehicle exhaust is equivalent to the vehicle effective power.
- For passenger cars that are used mostly inside of cities, and therefore operate mostly at idle speed and low part load conditions, the waste heat recovery benefit will be very low, especially if the necessary technical effort is taken into account.
- For passenger cars that are used mostly on countryside highways and motorways, and therefore operate mostly at high part load conditions or even full load conditions, the waste heat recovery benefit will be significant.

Waste heat recovery is an option for passenger cars. However, performance of waste heat recovery depends strongly on operation conditions.

Acknowledgements

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PROBLEMS ASSOCIATED WITH COMBUSTION OF BLAST FURNACE GAS IN BLAST STOVES

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ABSTRACT

Combustion of blast furnace gas in blast stoves raises two problems caused by the humidity content: increase the share of natural gas used for co-combustion and increase of the acid dew temperature that produces corrosion. In the paper are studied the influence of blast furnace gas moisture on the share of natural gas used for co-combustion and on the dew temperature.

1. INTRODUCTION

The air used in blast furnace process is preheated in blast stove (cowper) in order to reduce fuel consumption of blast furnace. The blast stove is a regenerative heat exchanger with a vertical combustion chamber, a vertical chamber filled with bricks and a dom which connects the chambers at the top (Fig. 1). During the heating period (about 50 minutes) the blast furnace gas enriched with natural gas is burnt to heat the refractory brickwork up to 1350°C and then compressed air (5-6 bars, 220°C) is passed in counterblow through the the refractory brickwork to be heated to approximately 1350°C, during the cooling period (about 40 minutes) [1].

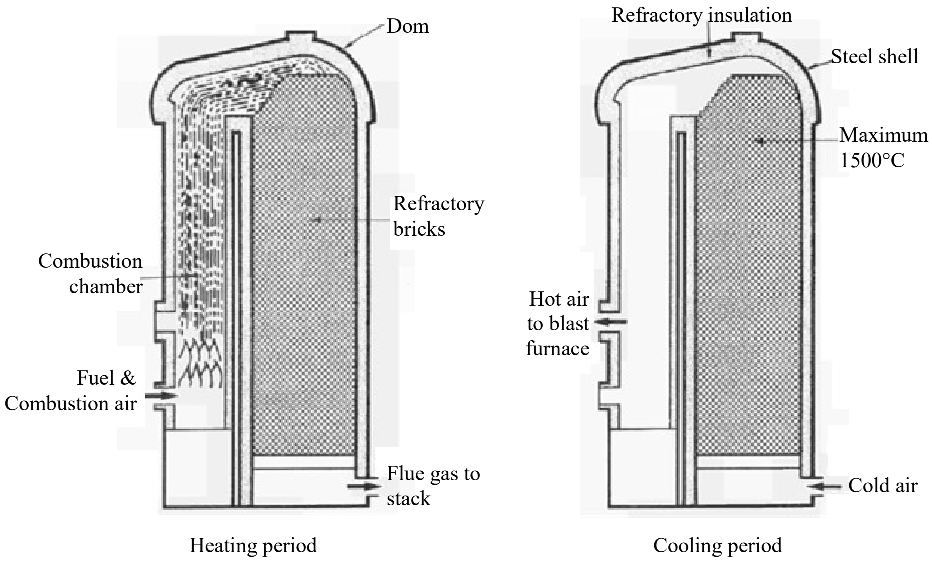

Figure 1: Hot blast stove [3].

The blast furnace gas is generated during the production of hot metal as gaseous by product. The characteristics (composition and heating value) of blast furnace gas are variable and depend on the composition of charged coke and charged flux and on process conditions. Blast furnace gas contains dust, carbon monoxide, carbon dioxide, hydrogen and small amount of sulphur compounds, ammonia, cyanide compounds, hydrocarbons and polycyclic aromatic hydrocarbons. It is purified in order to meet the air quality control criteria in

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electrostatic precipitation and wet scrubber for the removal of dust, SO_2 and cyanide compounds. Passing through the wet scrubber the blast furnace gas enriches in moisture, so that the content of water vapour is about (10-50)g/Nm^3 [2]. The average composition and lower heating value on dry base are given in Table 1.

Due to its low heating value the blast furnace gas should be enriched with natural gas in order to obtain higher combustion temperature and to ensure the combustion of CO. As the characteristics of blast furnace gas are changeable an in-line heating value and humidity measurement are required to adapt the natural gas proportion in order to maintain constant operation conditions of blast stove.

Table 1: Characteristics of blast furnace gas [1].

Gas fuel	Lower heating value (dry base) [kJ/Nm^3]	Methane CH_4 [%]	Ethane C_2H_6 [%]	Propane C_3H_8 [%]	Butane C_4H_{10} [%]	Hydrogen sulfide H_2S [%]	Oxygen O_2 [%]	Nitrogen N_2 [%]	Carbon dioxide CO_2 [%]	Carbon monoxide CO [%]
Blast furnace gas	2600-3500	0.06	-	-	-	1	-	50 - 55	17 - 25	20 - 28
Natural gas	35 872	98.379	0.503	0.164	0.071	-	0.077	0.647	0.011	0.011

2. PROBLEMS ASSOCIATED WITH COMBUSTION OF BLAST FURNACE GAS IN BLAST STOVE

Combustion of blast furnace gas in blast stove raises some issues. The moisture contained in blast furnace gas lowers the heating value leading to the increase of natural gas consumption, which means the increase of costs. The humidity content influence on the lower heating value of blast furnace gas can be seen in Fig. 2.

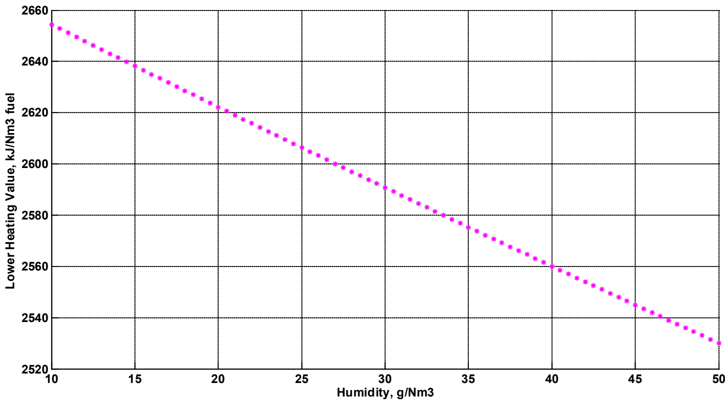

Figure 2: Lower heating value.

The dependence of lower heating value on humidity content is given by the following equation [5]:

$$LHV_w = (12620 \cdot CO + 10784 \cdot H_2 + 35774 \cdot CH_4)\frac{1}{1 + 1.245 \cdot d} \quad \text{[kJ/Nm}^3\text{ wet fuel]} \quad (1)$$

where: d – humidity content of blast furnace gas, kg/Nm^3;

CO, H_2, CH_4 – concentration of CO, H_2 and CH_4 in blast furnace gas, % (Table 1).

To obtain the high temperature of 1550°C inside the blast stove the participation of natural gas is 17% when the humidity content is 20 g/Nm^3. The participation of natural gas increases to 22% when the humidity content increases to 50 g/Nm^3.

The high content of humidity leads also to the increase of dew temperature of flue gas.

Another problem generated by the combustion of blast furnace gas in blast stove is stress corrosion of the upper part (dom) and lower section, near the flue gas outlet [2], [3], [4]. The high content of nitrogen in blast furnace gas and the high temperature inside the blast stove during the heating periods lead to generation of large amount of NO by the thermal (Zeldovich) mechanism [3].

The nitrogen oxides cause under certain conditions formation of an acid environment on the inside of the stove shells [4]. In the presence of oxygen and at low temperatures the NO is converted to NO_2. The formation of nitric acid in the stoves is described in [6] and [7]. It is formed at the beginning of cooling period (pressuring of stove) when remained NO formed during the combustion (heating) period is oxidized to NO_2 due to high concentration of O_2.

Experiments show a concentration of NO_2 in hot blast stove of about 80 ppm [6]. The rate of NO_2 generation increases in the coldest area of stove such as the steel shell. The NO_2 condenses as nitric acid when is cooled below the nitric acid dew point and it dissolves in the condensed water when is below the water dew point to form nitric acid solution. This acid environment causes stress corrosion cracking of the steel shell material [7].

The water dew temperature for different water content of flue gas is given by the following equation [8]:

$$T_d = 1000/\left[2.20732 - 2.117187\cdot10^{-1}\ln m - 2.166605\cdot10^{-3}(\ln m)^2 + \right. \\ \left. +1.619692\cdot10^{-4}(\ln m)^3 + 4.8998\cdot10^{-5}(\ln m)^4 + 3.691725\cdot10^{-6}(\ln m)^5\right] \text{ [K]} \quad (2)$$

where:

$$m = \frac{p_{H_2O}}{10};\ p_{H_2O} = 1.013\cdot10^5\frac{V_{H_2O}}{V_{ga}} \quad (3)$$

The nitric acid dew temperature is [6]:

$$T_{dewNO_2} = 1000/\left(3.6614 - 0.1446\ln p_{H_2O} - 0.0827\ln p_{NO_2} + 0.00756\ln p_{H_2O}\ln p_{NO_2}\right) \text{ [K]} \quad (4)$$

The dew temperature of SO_2 may be estimated by using the equation [6]:

$$T_{dewSO_2} = 1000/\left(3.9526 - 0.1863\ln p_{H_2O} - 0.000867\ln p_{SO_2} + 0.00091\ln p_{H_2O}\cdot\ln p_{SO_2}\right)\text{[K]} \quad (5)$$

In equations (4) and (5) p_{H_2O}, p_{NO_2} and p_{SO_2} are in mm Hg.

Concentrations of NO and NO_2 can be estimated by using the following model [9]:

$$\tfrac{1}{2}O_2 + \tfrac{1}{2}N_2 \Leftrightarrow NO,\quad K_{p,NO} = 4.71e^{-\frac{10900}{T}} = \frac{[NO]}{[N_2]^{\frac{1}{2}}[O_2]^{\frac{1}{2}}} \quad (6)$$

$$NO + \tfrac{1}{2}O_2 \Leftrightarrow NO_2,\quad K_{p,NO_2} = 2.5\cdot10^{-4}e^{-\frac{6923}{T}} = \frac{[NO_2]}{[NO][O_2]^{\frac{1}{2}}} \quad (7)$$

To find out the causes of acid corrosion inside the blast stove there were calculated the dew temperatures for water, NO_2 and SO_2 considering the combustion of wet blast furnace gas with natural gas. The blast furnace and natural gas have the average composition given in Tab. 1. Variation of dew temperature for different value of humidity content in blast furnace gas and constant NO_2 concentration (80 ppm) is shown in Fig. 3. It can be seen that the nitric acid dew temperature is higher than water dew temperature and sulphurous acid dew temperature, confirming that the corrosion of blast stove is caused by the nitric acid.

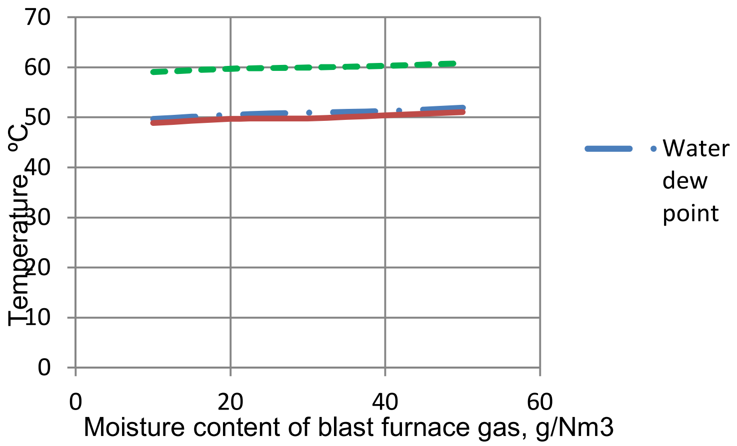

Figure 3: Dew temperature inside the hot blast stove (NO_2 = 80 ppm).

8. CONCLUSIONS

The increase of moisture content of blast furnace gas from 20 g/Nm^3 to 50 g/Nm^3 leads to the increase of natural gas share used for co-combustion from 17% to 22% and the increase of nitric acid dew from 59°C to 61.5°C.

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INVESTIGATION THE INFLUENCE OF THE WATER VOLUME FLOW IN THE CONVECTOR ON THE PARAMETERS OF LABORATORY HEAT PUMP INSTALLATION

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ABSTRACT

The purpose of this work is to investigate the influence of the volume flow of the water, passing through the tubes of “water-air” convector, on the basic parameters of laboratory reversible heat pump installation type "water-water", working in “heating” regime.

1. INTRODUCTION

To achieve energy-efficient performance of the work of heat pump installations used for air conditioning of residential premises, it is necessary to investigate the influence of the adjustable input factors on the parameters of the installation.

The heat pumps "water-water" work at a certain setting of the temperatures of heat pump switch and shutdown in order to support a certain heat power of the heat consumer. Therefore, if there is a regulation the volume flow of the water through the consumer, there is an expectation for change the temperature difference between the input and output water.

The influence of the water volume flow through the convector on the following installation parameters, working in “heating” regime, have been investigated: average heat convection coefficient between the water in the convector tubes and their inner surface (internal heat convection coefficient); average heat convection coefficient between the outer surface of the convector and wrapped it airflow (external heat convection coefficient); average heat transfer coefficient of the convector; average heat flow exchanged between the convector and ambient air; average heat pump coefficient of performance.

2. METHODOLOGY

2.1. PRINCIPAL SCHEME AND DESCRIPTION OF THE INSTALLATION

The principal scheme of the laboratory installation is shown on Figure 1 [1, 5, 6].

The heat pump is “water-water” type, brand CEAT, model Aurea 20.

The convector is “water-air” type, brand BUMYANG, model FVC20MLL2.

When the installation works in "heating" regime, the heat pump heat exchanger in the outer circle is an evaporator, and that the inner circle is a condenser. In the evaporator the refrigerant takes heat energy from the cold water, circulating in the outer circle, and in the condenser the refrigerant gives heat energy to the hot water, circulating in the inner circle. The convector gives heat energy to the ambient air in the room and increases its temperature [1, 2, 3, 5, 6].

In “heating” working regime the water in the buffer represents the heat source, from which the installation draws the heat energy, required to the heat pump work. In order the laboratory installation works for a long time without reducieng considerably the temperature of the buffer water (the laboratory installation simulates work of a heat pump installation, drawing heat energy from an underground water source), it is necessary to achieve a stratification of the water in the buffer. Therefore, as shown in Figure 1, to the heat pump water is drawn from the top of the buffer until the cooled water returns to the buffer bottom.

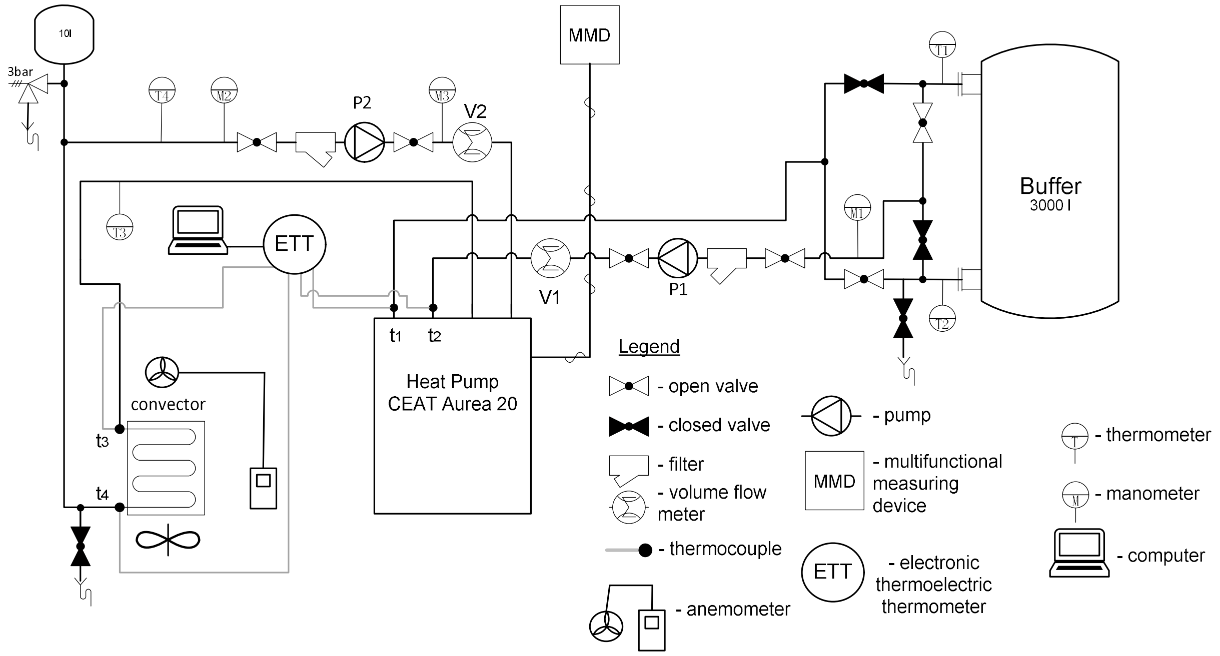

Figure 1: Principal scheme of the laboratory installation, working in "heating" regime

2.2. INPUT PARAMETERS OF THE INSTALLATION

In Table 1 the input parameters of the installation work within the made experimental investigation, are specified.

Table 1: Input parameters of the installation

Settings of the heat pump	Setting of the convector's fan	Setting of the circulating pump in the outer installation circle	Temperature of the ambient air
temperature of heat pump switch t_4 = 42 °C; temperature of heat pump shutdown t_4 = 45 °C	degree "HIGH" ($w_2 = 5{,}06\,m/s$)	$\dot{V}_2 = 3{,}01.10^{-4}\ m^3/s$	$t_{ambientair} = 18{,}8\ ^{\circ}C$

Since, as the laboratory in which is located the installation has a relatively large volume, and because, that experiments haven't been very long, it has been assumed that the ambient temperature $t_{ambient\ air}$ remains constant within the respective experimental investigation.

Because of the same reasons, and due to the provided stratification of the water in the buffer, the average water temperature coming from the buffer to the heat pump remains constant over time and approximately equal to the ambient temperature, within the experimental investigation.

The water volume flow in the inner circle of the installation has been regulated by the valve located at the exit of the circulating pump P_2 (Figure 1).

2.3. INVESTIGATION THE INFLUENCE OF THE WATER VOLUME FLOW ON THE CONVECTOR'S INTERNAL HEAT CONVECTION COEFFICIENT

The heat convection coefficient α_1 has been determined by a criterion equation [1, 4, 5, 6].

The change of the coefficient α_1 when there is a change of the water volume flow $\dot{V}_1$ is shown on Figure 2.

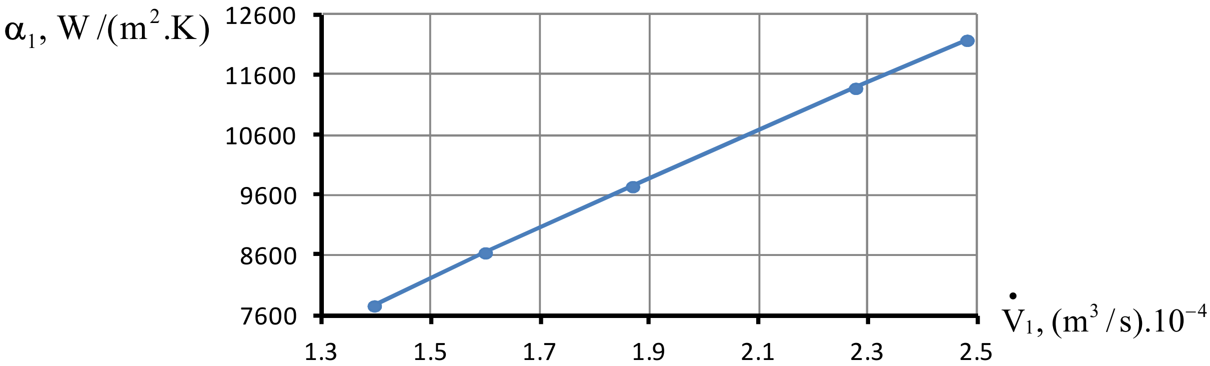

Figure 2: Graphical dependence between α_1 and $\dot{V}_1$

By increasing the water volume flow $\dot{V}_1$ in the inner circle of the installation, the velocity w_1 of the water in the convector tubes has increased according to a linear law. At the same time, the temperature difference (t_3 - t_4) has lowered, that is, has reduced the average temperature of the water $\bar{t}_{water}$ in the tubes of the convector. The change of $\bar{t}_{water}$ has been in very small range over the entire range of variation of the water volume flow (from 44,9 ºC to 43,7 ºC). Therefore, the physical parameters of the water (conductivity coefficient λ_1, kinematic viscosity ν_1 and criterion of Prandtl Pr_1) have changed in very small ranges. It follows that the coefficient α_1 depends primarily on the water velocity w_1. This explains the linear increase in heat convection coefficient α_1 by increasing the water volume flow $\dot{V}_1$ (Figure 2).

2.4. INVESTIGATION THE INFLUENCE OF THE WATER VOLUME FLOW ON THE CONVECTOR'S EXTERNAL HEAT CONVECTION COEFFICIENT

The heat convection coefficient α_2 has been determined by a criterion equation [1, 4, 5, 6].

The change of the coefficient α_2 when there is a change of the water volume flow $\dot{V}_1$ is shown on Figure 3.

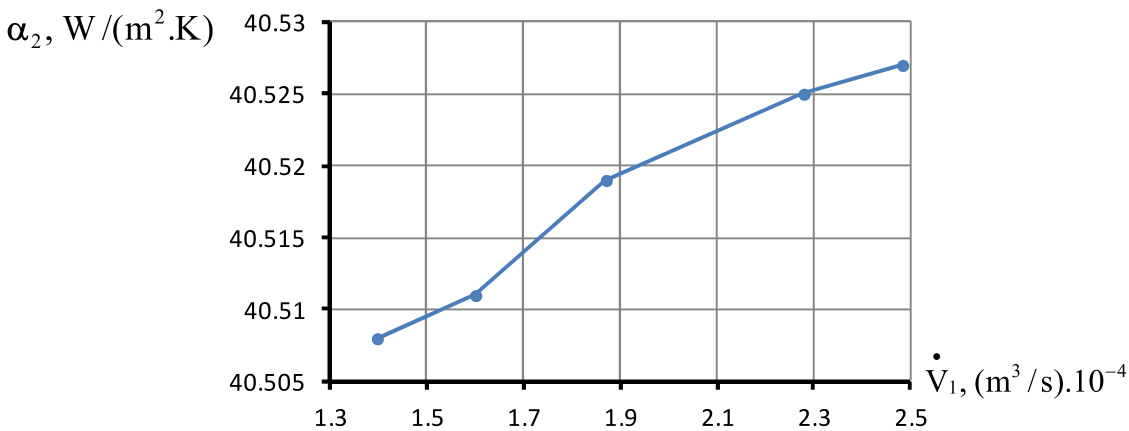

Figure 3: Graphical dependence between α_2 and $\dot{V}_1$

By increasing the water volume flow $\dot{V}_1$, the average temperature of the air $\bar{t}_{air}$ through the convector has lowered in very small range (from 31,9 ºC to 31,3 ºC), which means small range of variation of the air physical parameters. Since, as the air velocity w_2 in the narrowest section the outer surface of the convector's heat exchange apparatus remains constant, the criterion of Reynolds Re_2 depends only on the air kinematic viscosity ν_2, which has lowered. Therefore Re_2 has increased. On the other hand, by lowering of $\bar{t}_{air}$, the criterion of Prantl Pr_2 has increased. Therefore the criterion of Nuselt Nu_2 has increased. By lowering of $\bar{t}_{air}$, the air conductivity coefficient λ_2 has lowered.

From Figure 3 it is seen that by increasing the water volume flow $\dot{V}_1$, the heat convection coefficient α_2 has increased (although in very small range). Therefore greater influence on the change of α_2 has the increase of Nu_2, than the decrease of λ_2.

2.5. INVESTIGATION THE INFLUENCE OF THE WATER VOLUME FLOW ON THE CONVECTOR'S HEAT TRANSFER COEFFICIENT

The heat transfer coefficient U has been determined by the equation for single layer flat wall, ignoring the thermal resistance of the tubes and ribs of the heat exchange apparatus [1, 4, 5, 6].

The change of the coefficient U when there is a change of the water volume flow $\dot{V}_1$ is shown on Figure 4.

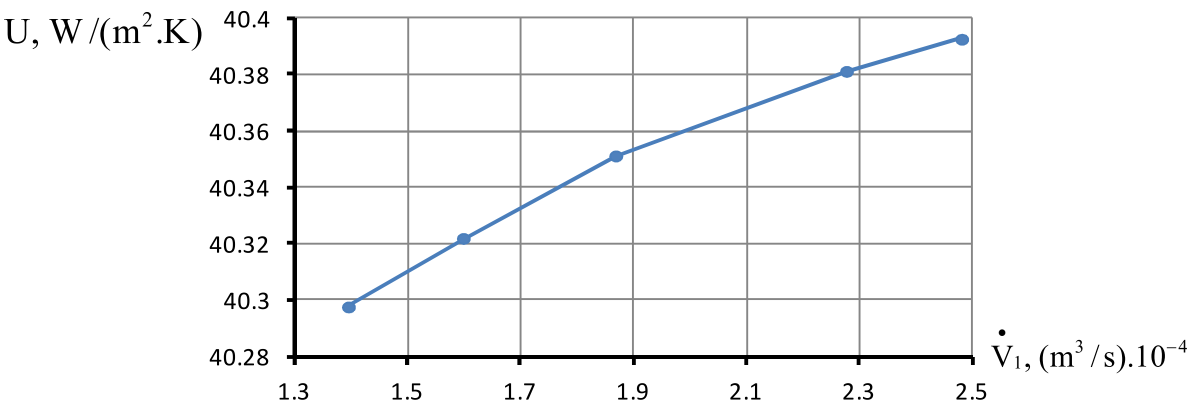

Figure 4: Graphical dependence between U and $\dot{V}_1$

Since the heat convection coefficients α_1 and α_2 have increased by increasing the water volume flow, it follows that the heat transfer coefficient has increased. Because, much greater influence on U has the external heat convection coefficient α_2, the change of U has been in very small range.

2.6. INVESTIGATION THE INFLUENCE OF THE WATER VOLUME FLOW ON THE HEAT FLOW, EXCHANGED IN THE CONVECTOR AND THE HEAT PUMP CONDENSER

The heat flow $\dot{Q}_{con}$, exchanged between the convector and ambient air (in the heat pump condenser) has been determined by the basic calorimetric equation [1].

The change of the heat flow $\dot{Q}_{con}$ (average value determined in the cycles heat pump work) when there is a change of the water volume flow $\dot{V}_1$, is shown on Figure 5.

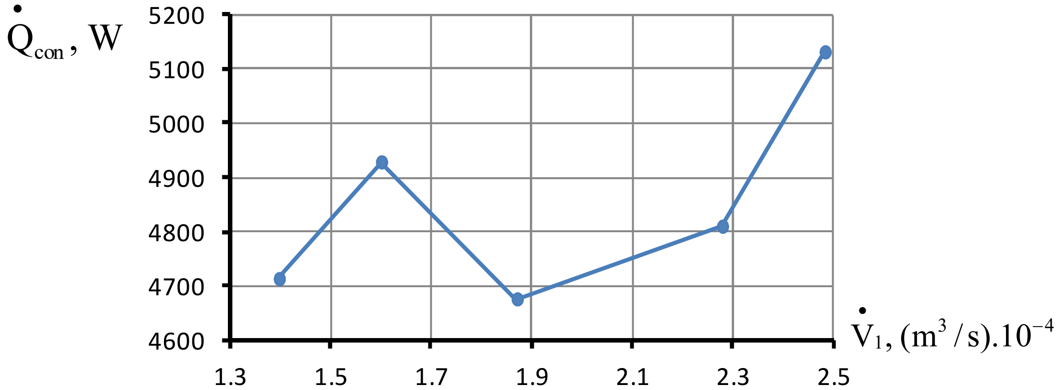

Figure 5: Graphical dependence between $\dot{Q}_{con}$ and $\dot{V}_1$

The raising of $\dot{Q}_{con}$ by increasing of $\dot{V}_1$ (from $1{,}39.10^{-4}$ m^3/s to $1{,}59.10^{-4}$ m^3/s; from $1{,}87.10^{-4}$ m^3/s to $2{,}28.10^{-4}$ m^3/s; from $2{,}28.10^{-4}$ m^3/s to $2{,}48.10^{-4}$ m^3/s), can be explained by the fact that in terms of the basic calorimetric equation, greater influence on the heat flow has the increase of the water volume flow in the tubes of the convector, than the decrease of the temperature difference $(t_3 - t_4)$.

The lowering of $\dot{Q}_{con}$ by increasing of $\dot{V}_1$ (from $1{,}59.10^{-4}$ m^3/s to $1{,}87.10^{-4}$ m^3/s), can be explained by the fact that in terms of the basic calorimetric equation, greater influence on the heat flow has the decrease of the temperature difference $(t_3 - t_4)$, than the increase of the water volume flow in the tubes of the convector.

2.7. INVESTIGATION THE INFLUENCE OF THE WATER VOLUME FLOW ON THE HEAT PUMP COEFFICIENT OF PERFORMANCE

The coefficient of performance $COP|_W$ has been determined on the base of the heat flow $\dot{Q}_{con}$, exchanged in the heat pump condenser and the consumed by the heat pump's compressor electric power W_{comp} [1, 3, 7].

The change of the coefficient of performance $COP|_W$ when there is a change of the water volume flow $\dot{V}_1$ is shown on Figure 6.

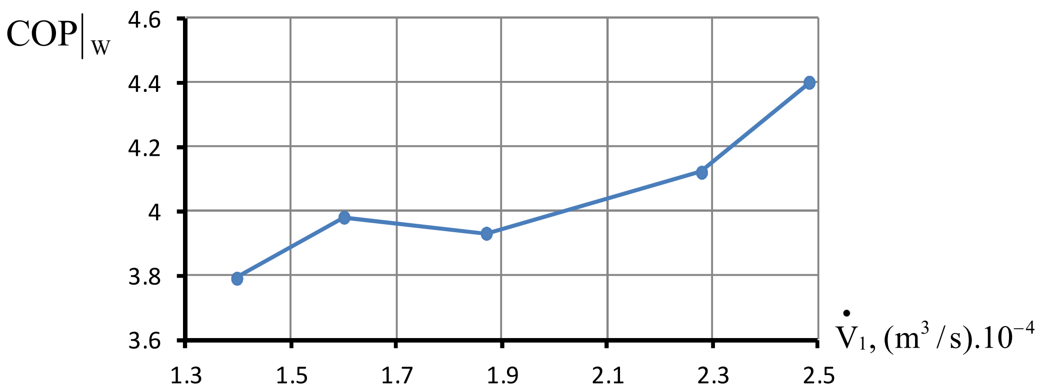

Figure 6: Graphical dependence between $COP|_W$ and $\dot{V}_1$

With increasing of $\dot{V}_1$, the temperature difference (t_3 - t_4) has lowered. Therefore the maximum temperature of the water, supplied from the heat pump to the convector, has lowered. This is the reason for the decrease in average electrical power W_{comp}, consumed by the compressor of heat pump.

The raising of $\dot{Q}_{con}$ by increasing of $\dot{V}_1$ (from 1,39.10^{-4} m^3/s to 1,59.10^{-4} m^3/s; from 1,87.10^{-4} m^3/s to 2,28.10^{-4} m^3/s; from 2,28.10^{-4} m^3/s to 2,48.10^{-4} m^3/s), can be explained by the fact that greater influence on the the coefficient of performance has the increase of $\dot{Q}_{con}$, than the decrease of W_{comp}.

The lowering of $COP|_W$ by increasing of $\dot{V}_1$ (from 1,59.10^{-4} m^3/s to 1,87.10^{-4} m^3/s), can be explained by the fact that greater influence on the the coefficient of performance has the decrease of W_{comp}, than the increase of $\dot{Q}_{con}$.

3. CONCLUSION

The change of the volume flow $\dot{V}_1$ of the water in the internal circle of the installation (through the tubes of the convector), working in "heating" regime, has leaded to:

- relatively large change of the internal heat convection coefficient α_1 of the convector and the heat flow $\dot{Q}_{con}$, exchanged between the convector and the ambient air (in the heat pump condenser);
- relatively little change of the heat pump coefficient of performance $COP|_W$;
- negligible change of the external heat convection coefficient α_2 and the heat transfer coefficient U of the convector.

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SUPPLY INSTALLATION WITH HYDROGEN OR HRG GAS TO THE DISCONTINUOUS OPERATION BOILERS WITH SOLID BIOMASS

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ABSTRACT

This research involves designing a supply installation with hydrogen gas or HRG gas to the discontinuous operation boilers with solid biomass. The introduction of gas was expected to be in the biomass supply pipe, realizing the improvement of the ignition of the biomass in particular for granulation and high humidity situations. The gas is introduced only during supply of biomass and serves to control (reduce) the emission of carbon monoxide (CO).

1. INTRODUCTION

Developing green energy has led to demand in our country for the production of heat boilers operating with biomass (wood, straw, etc.) [1]. Current requirements of environmental protection involves implementing solutions for efficient combustion.

The paper relates to a supply installation with hydrogen gas or HRG gas to the discontinuous operation boilers with solid biomass. Discontinuous operation is to maintain ambient parameters subject to a building biomass heating.

Burning biomass in any technology leads to significant emissions of carbon monoxide. The process is present even if biomass is dried and densified. As a result, creating energy vector hydrogen - biomass, by capitalizing of ignition and combustion superior characteristics of hydrogen, reduce this disadvantage of increased emissions of CO. The gas is introduced only during supply of biomass and serves to control (reduce) the emission of carbon monoxide (CO) [2]. The air barrier upstream gas instilled aims to stop the ingress of gas to bunker fuel.

2. EXPERIMENTAL TESTS

Heat boilers in our country that use solid biomass covers a wide range of powers from 25 kW to 1000 kW. The smallest problems are in the pellets combustion and the highest problems are in wood waste combustion (including energy willow). The use of biomass in the form of chips is the lowest cost on fuel, so the research is to increase combustion efficiency, including the use of gas fuel for thermal support, beginning with hydrogen and ending with natural gas. In this research was developed the concept of energy vector represented by the combination between H_2 (or HRG) and solid biomass.

This research involves designing a supply installation with hydrogen gas or HRG gas to the discontinuous operation boilers with solid biomass. The introduction of gas was expected to be in the biomass supply pipe, realizing the improvement of the ignition of the biomass in particular for granulation and high humidity situations. Meanwhile, the gas used is

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a thermal support for biomass burning, its proportion varies depending on the quality of biomass.

Conventional combustion technologies present the following disadvantages:

- high concentrations of CO becouse of low speed ignition and slowly propagation of flame front;
- reduced control of the finalization combustion process by the burning air injection in one step;
- ensuring stability problems due to the delayed ignition for grained biomass and biomass with high humidity.

This supply installation with gas for co-combustion with solid biomass eliminates the disadvantages above. This research appeared because of the experimental tests of the vector biomass hydrogen using [3]. Figure 1 shows the general design of the installation of introducing gas into solid biomass.

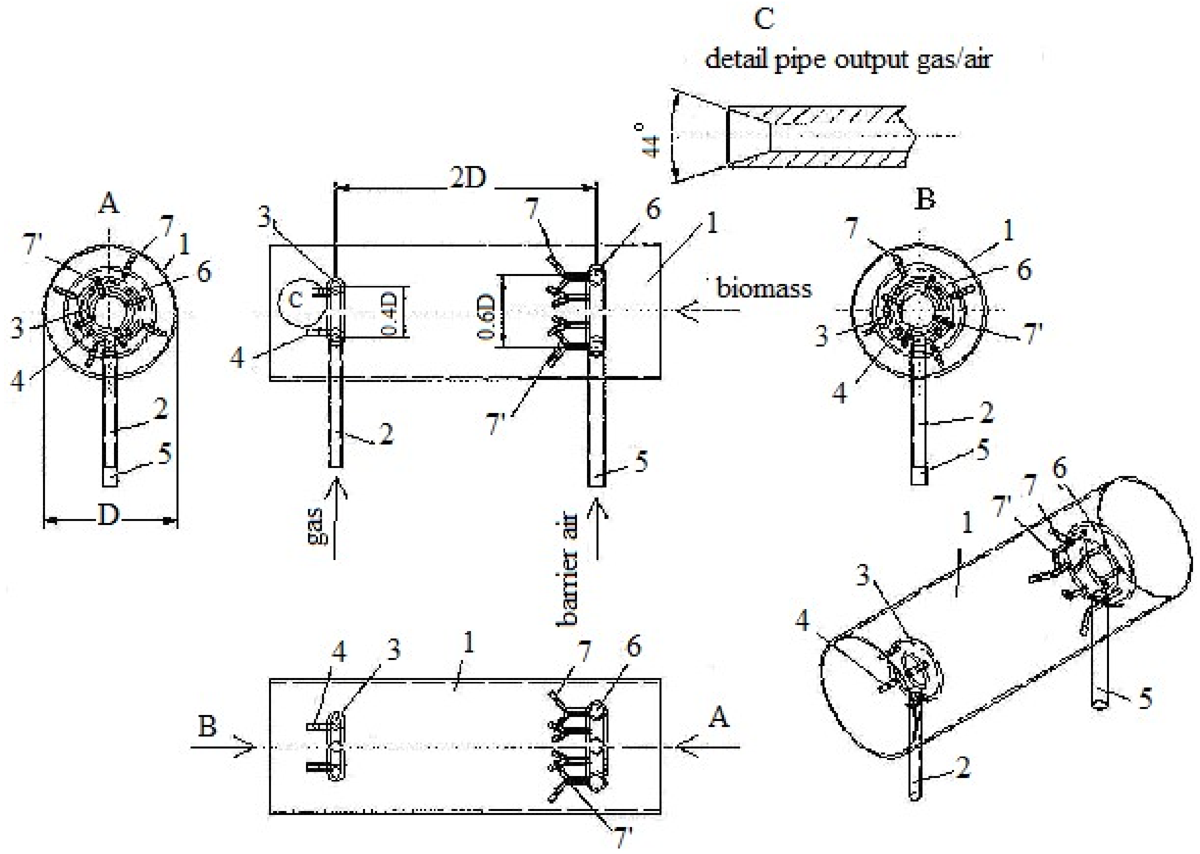

Figure 1. General design of the installation of introducing gas into solid biomass

The gas is introduced into the final section of the feeding duct 1, the duct 2, the tor 3 and lances 4. The air barrier is positioned at the back of the intake gas is being introduced through the pipe 5 in the tor 6 and exits by the lances system 7 and 7 '. This intake system creates an air barrier that directs gas only to furnace, while, avoiding the return of flame. To achieve a continuous barrage of air flow section the lances are spatially offset. Moreover, for the same reasons the lances air flow are mandatory flared to 44° in the output section (respecting natural flare angle for airflows).

The system, according to research overcomes the disadvantages mentioned above, as to:

- overall increase speed of combustion by the presence of hydrogen in the flame front;
- low levels of emissions (NOx, CO) thanks to the separation of air into two streams;
- increase combustion stability and the efficiency plant (about 10 ... 15%) by contribution of the gaseous fuel.

Figure 2. *Gaseous fuel and the air barrier supply system*

Also, in Fig. 1 shows the dimensions of constructive optimal size reference to the channel will be D. If channel section 1, is not circular, the size of reference will be the equivalent hydraulic diameter. To achieve an efficient the flow air barrier will be at least double than the gas flow. Co-combustion gas - biomass will be done taking into account the air barrier. The central channel 1 will be constructed of steel with a thickness of 3 ... 5 mm to resists the erosion of the solid phase.

Such a system was implemented at boiler ERPEK produced in Romania, boiler with a heat output of 35 kW for burning chopped wood [4]. Biomass supply channel is rectangular, having equivalent hydraulic diameter D = 123 mm (160x 100 mm). The boiler operates fully automatically, stopping the combustion while maintaining constant power plants. The experimental tests were carried out with HRG gas, supplied by a generator industry. Figure 2 shows a gaseous fuel and the air barrier supply system.

The air barrier became tertiary air, the boiler having at the level of furnace primary and secondary air division. The experiments were carried out for the rated load of wood chips boiler operation with calorific value of 14,200 kJ / kg and with the HRG gas flow of 1,000 litter / h. For the experimental test used a 30 kW boiler ERPEK, HRG gas supply system is assembled on a rectangular biomass supply channel (Figure 2). It shall be noted that during the experimental tests, there were no problems for the ingress of gas HRG biomass bunker.

3. CONCLUSIONS

- The gas (H_2 or HRG) supply installation is designed to reduce the emission of carbon monoxide and for increasing the efficiency of discontinuous operation boilers with solid biomass.
- The pneumatic system of the barrier air will block the ingress of gas to bunker fuel. Total air necessary for combustion will account for barrier air.
- Conceptually, the supply installation can be used for using natural gas.

ACKNOWLEDGEMENTS

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CHARACTER OF THE ELECTRICITY PRODUCTION OF PHOTOVOLTAIC POWER STATIONS

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Resume: According to the Energy Act the created photovoltaic energy parks (PEP), part of the renewable sources, are adjoined to the electricity power grid. It is necessary to conduct a detailed study on the character of the electricity production from PEP in order to avoid the problems of such adjoining and to develop graphics for a more effective use of the energy produced by PEP. It should be noted that in the circumstances of our country such study is not enough. For this purpose, results from the study are presented for the electricity production of an active photovoltaic energy park for a five-year period in days, hours and months. A triangle for evaluation of the daily production of PEP and comparison with conventional sources is proposed.

Key words: renewable energy sources, photovoltaic energy parks.

1. INTRODUCTION

Over the years until 2013 1425 photovoltaic energy parks have been built and put into operation, namely:

2006	2007	2008	2009	2010	2011	2012	2013	Total
1	0	11	32	47	177	1072	85	1425

There is a huge leap during 2012 when 1 072 photovoltaic centrals (PC) for the production of electricity have been put into operation. In addition, more than 60% (691 units) of those centrals with a total installed power of 487 MWp are put into operation only in the month of June 2012. The size of the preferential price for the produced electricity of PC during 2010 – 2012 in Bulgaria ranges around 35 euro/MWh. The generated amount of electricity from photovoltaic centrals during 2013 is over 1340 GWh out of all the installed photovoltaic power of 1019 MWp. After this period of rapid development of PC, a necessity is created to study the character of their electricity production based on the real results of their exploitation, based upon which the further use of PC as an element of our electricity system should be judged. The conducted research [2,3,4] have a partial character and does not provide enough information for this aim.

2. OBJECT

A photovoltaic central with peak power of 117 kWp built on the roof of workshops of the object Zita – Ruse and put into operation during 2008÷2009 has been chosen for the object of the present study of the character of the electricity production. Data for the period 2009÷2014 have been used out of [5]. The object produces electricity for its own needs. In case of shortage it is charged by the system and in case of excess, the spare electricity is exported into the grid. This is a case of a good practice, when the electricity of the park is mainly targeted for its own needs.

3. RESULTS

Common character of the loads of electricity production

On fig. 1 and fig. 2 the generated loads of electricity production of the studied photovoltaic park are presented. The everyday loads (in the amount of 30) can be seen in the space of the figures. For the winter month (fig. 1) it is seen that there had been only one sunny day. Most of the rest of the days were medium cloudy and the dark days were as many as the medium cloudy days. During the summer month (fig. 2) the sunny days and the medium cloudy days predominated. The loads are high in the space of the high power loads which border with the nominally installed peak power of the object. Irrespective of that, it is visible that there is an irregularity in the loads and their incomparability is too high. If the loads of all the rest of the months are compared, they will have a common character.

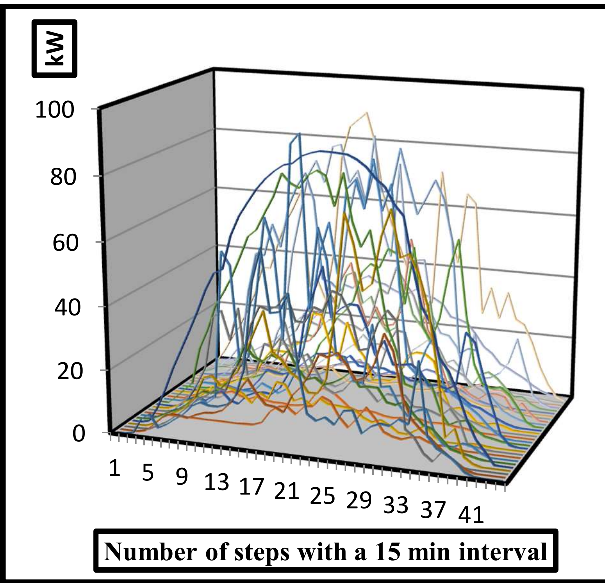

Fig.1. Character of the generated electrical power loads of a photovoltaic park in the winter month

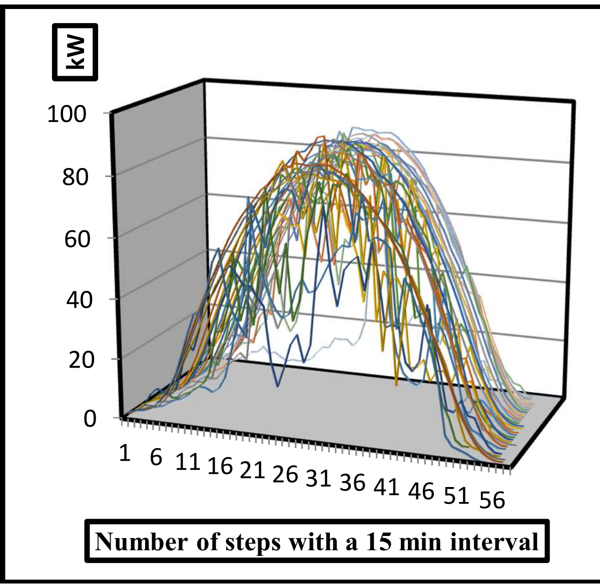

Fig.2. Character of the generated electrical power loads of a photovoltaic park in the summer month

Indicators for the character of the loads and electricity production of the park

The minimal (min), medium (sr) and maximal (max) generated power of loads, their percentage from the peak installed power of the park (117 kWp), as well as the produced electricity – medium day for a given month (I-sr, II-sr, III-sr, IV-sr, V-sr, VI-sr, VII-sr, VIII-sr, IX-sr, X-sr, XI-sr, XII-sr), minimally (I-min, II-min, III-min, IV-min, V-min, VI-min, VII-min, VIII-min, IX-min, X-min, XI-min, XII-min) and maximally (I-max, II-max, III-max, IV-max, V-max, VI-max, VII-max, VIII-max, IX-max, X-max, XI-max, XII-max) produced for a given day of the month (table 1) are defined and summarized for the character of the load indicators. The average day electricity production is in the range between 149 kWh and 594 kWh, minimally between 19 kWh and 284 kWh and maximally between 149 kWh до 594 kWh.

Table 1
Distribution of the medium values by month of the minimal (min), medium (sr) and maximal (max) quantity electricity (kWh), power (kW) and share of the production (%) during the period of 2009÷2014

Month	I-sr	I-min	I-max	II-sr	II-min	II-max	III-sr	III-min	III-max
kWh	164	26	416	244	30	538	404	49	640
kW	18,35	2,62	47,558	19,507	2,76	53,77	21,6	4,3	58,14
%	15,7	2,2	40,6	16,7	2,4	46,0	18,5	3,7	49,7
Month	IV-sr	IV-min	IV-max	V-sr	V-min	V-max	VI-sr	VI-min	VI-max
kWh	503	109	716	561	174	706	594	284	672
kW	31,69	8,06	52,04	30,54	12,4	52,26	18,6	39	45
%	27	7	44	26	11	45	16	33	38
Month	VII-sr	VII-min	VII-max	VIII-sr	VIII-min	VIII-max	IX-sr	IX-min	IX-max
kWh	585	174	673	586	219	643	492	54	646
kW	38,4	11,6	45,6	40,4	15,9	47,7	37,1	4,6	51,7
%	33	10	39	35	14	41	32	4	44
Month	X-sr	X-min	X-max	XI-sr	XI-min	XI-max	XII-sr	XII-min	XII-max
kWh	342	34	540	241	40	418	149	19	416
kW	29,1	3,1	50,2	26	4,24	43,95	15,7	2,15	46,2
%	25	3	43	22	4	38	13	2	39

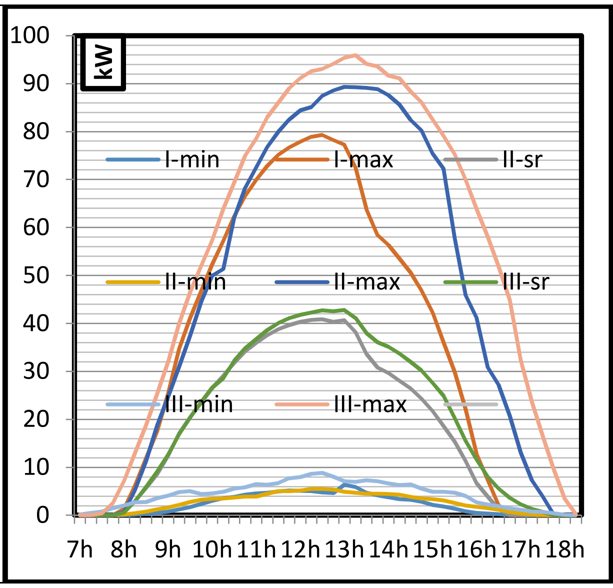

Fig.3. Medium monthly (I-sr, II-sr, III-sr), minimal (I-min, II-min, III-min) and maximal (I-max, II-max, III-max) daily loads during the first quarter

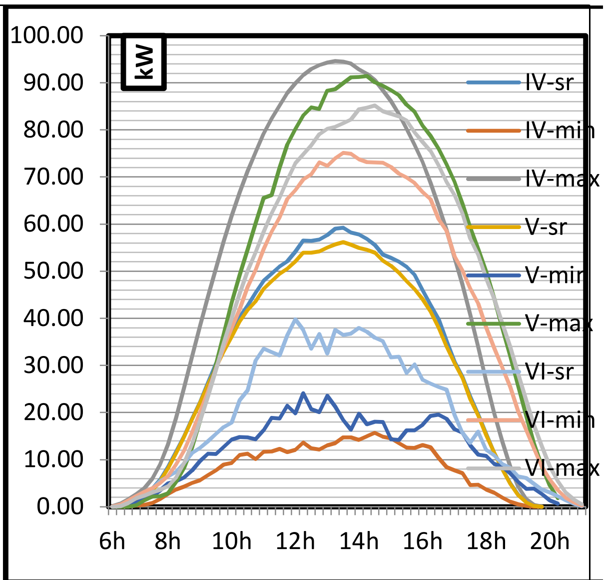

*Fig.4. Medium monthly (*IV-sr, V-sr, VI-sr*), minimal (*III-min, IV-min, V-min*) and maximal (*IV-max, V-max, VI-max*) daily loads during the second quarter*

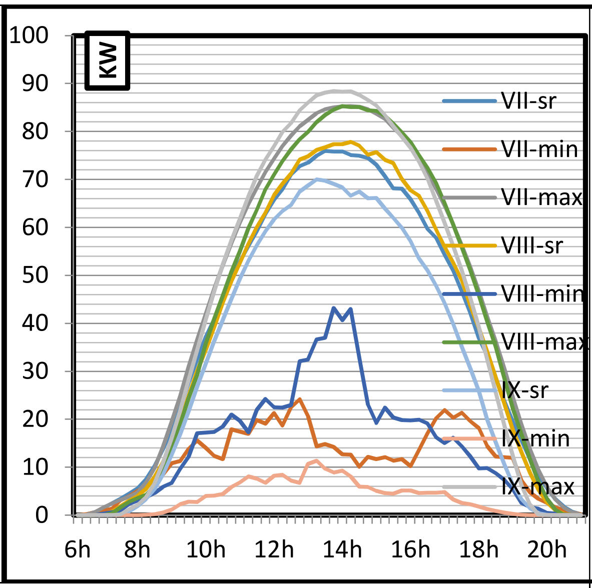

Fig.5. Medium monthly (, VII-sr, VIII-sr, IX-sr***), minimal (***VII-min, VIII-min, IX-min***) and maximal (***VII-max, VIII-max, IX-max***) daily loads during the third quarter***

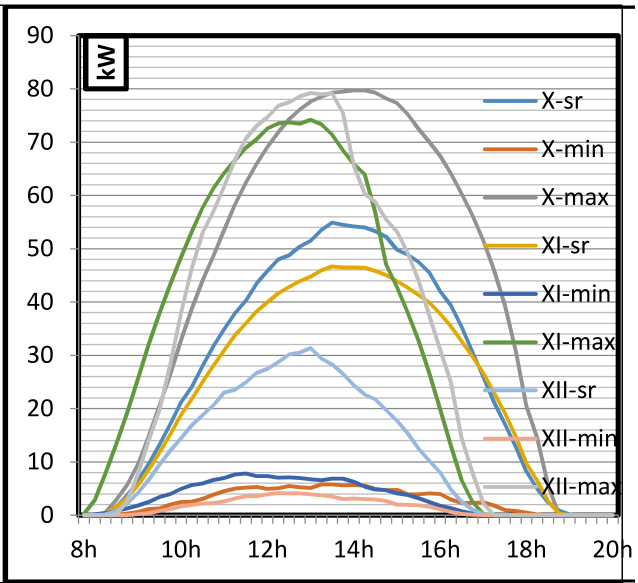

Fig.6. Medium monthly (X-sr, XI-sr, XII-sr***), minimal (***X-min, XI-min, XII-min***) and maximal (***X-max, XI-max, XII-max***) daily loads during the fourth quarter***

The average daily power loads are in the range between 15,7 kW and 40,4 kW, minimally between 2,15 kW and 284 kW, maximally between 43,95 kW and 58,14 kW.

The daily loads during the first quarter – medium monthly (I-sr, II-sr, III-sr), minimal (I-min, II-min, III-min) and maximal (I-max, II-max, III-max) are given in fig.3, for the second quarter - medium monthly (IV-sr, V-sr, VI-sr), minimal (III-min, IV-min, V-min) and maximal (IV-max, V-max, VI-max) in fig. 4, for the third quarter - medium monthly (VII-sr, VIII-sr, IX-sr), minimal (VII-min, VIII-min, IX-min) and maximal (VII-max, VIII-max, IX-max) in fig.5, for the fourth quarter - medium monthly (X-sr, XI-sr, XII-sr), minimal (X-min, XI-min, XII-min) and maximal (X-max, XI-max, XII-max) in fig.6.

Integral curves of electricity production

Integral curves of the average monthly electricity production (fig. 7) have been designed after calculating the average monthly loads according to the five-year period of exploitation of the park data. The expected summary monthly electricity production of the park is compared in terms of day hours by using those curves. The average summary electricity production by months is given in table 1 and fig. 7.

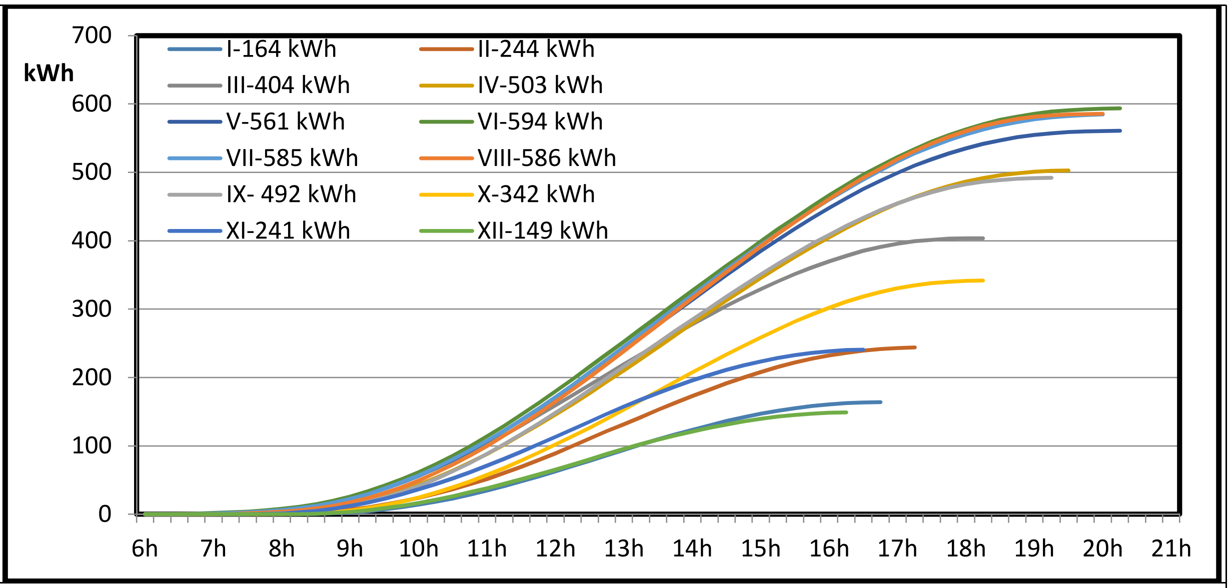

Fig.7. Integral curves of the average monthly electricity production

Table 2.
Modeling of the levels of electricity production of a PES

	Models		Range
I	$y = -7E\text{-}08x^6 + 2E\text{-}05x^5 - 0{,}0011x^4 + 0{,}0263x^3 + 0{,}0406x^2 - 0{,}2271x + 0{,}175$; $R^2 = 1$	(1)	Up to 16,45 h 36 steps
II	$y = 1E\text{-}07x^6 - 7E\text{-}06x^5 - 0{,}0003x^4 + 0{,}0291x^3 - 0{,}387x^2 + 1{,}6221x - 1{,}7366$; $R^2 = 1$	(2)	Up to 17,15 h 38 steps
III	$y = -8E\text{-}08x^6 + 2E\text{-}05x^5 - 0{,}0016x^4 + 0{,}0569x^3 - 0{,}4642x^2 + 1{,}3906x - 1{,}2072$; $R^2 = 1$	(3)	Up to 18,85 h 43 steps
IV	$y = -6E\text{-}08x^6 + 2E\text{-}05x^5 - 0{,}0015x^4 + 0{,}0603x^3 - 0{,}6334x^2 + 2{,}333x - 2{,}2334$; $R^2 = 1$	(4)	Up to 19,30 h 48 steps
V	$y = -5E\text{-}08x^6 + 1E\text{-}05x^5 - 0{,}0015x^4 + 0{,}058x^3 - 0{,}5445x^2 + 2{,}0787x - 2{,}0069$; $R^2 = 1$	(5)	Up to 20,30 h 51 steps
VI	$y = -7E\text{-}08x^6 + 2E\text{-}05x^5 - 0{,}0015x^4 + 0{,}0574x^3 - 0{,}4922x^2 + 1{,}7649x - 1{,}3304$; $R^2 =1$	(6)	Up to 20,30 h 51 steps
VII	$y = -6E\text{-}08x^6 + 2E\text{-}05x^5 - 0{,}0016x^4 + 0{,}0618x^3 - 0{,}5995x^2 + 2{,}3578x - 2{,}3595$; $R^2 = 1$	(7)	Up to 20,15 h 50 steps
VIII	$y = -8E\text{-}08x^6 + 2E\text{-}05x^5 - 0{,}0018x^4 + 0{,}0688x^3 - 0{,}7261x^2 + 2{,}7499x - 2{,}6969$; $R^2 = 1$	(8)	Up to 20,15 h 50 steps
IX	$y = -1E\text{-}07x^6 + 3E\text{-}05x^5 - 0{,}0024x^4 + 0{,}088x^3 - 1{,}0039x^2 + 4{,}0202x - 4{,}1952$; $R^2 = 1$	(9)	Up to 19,30 h 47 steps
X	$y = -3E\text{-}08x^6 + 1E\text{-}05x^5 - 0{,}0012x^4 + 0{,}0547x^3 - 0{,}7034x^2 + 3{,}0249x - 3{,}2839$; $R^2 = 1$	(10)	Up to 18,5 h 43 steps
XI	$y = 6E\text{-}08x^6 + 3E\text{-}06x^5 - 0{,}001x^4 + 0{,}047x^3 - 0{,}4931x^2 + 1{,}6585x - 1{,}4355$; $R^2 = 1$	(11)	Up to 16,30 h 35 steps
XII	$y = 2E\text{-}07x^6 - 1E\text{-}05x^5 - 0{,}0001x^4 + 0{,}024x^3 - 0{,}3626x^2 + 1{,}6175x - 1{,}7591$; $R^2 = 1$	(12)	Up to 16,15 h 34 steps

Each of the integral curves has been extrapolated. The received models are polynomials of sixth degree, where the indicator $R^2 = 1$ for each of the polynomials, i.e. the highest possible level of extrapolation has been achieved. When using the models the number of steps, shown in table 2 is determined.

3. CONCLUSION

1. The daily and monthly electricity production of the photovoltaic central (PC) has a changeable and unstable character (fig. 1 and 2). The main reason is the specifics of the sun shining in the country. The results show the necessity of a study of the electricity production of other PC throughout the country's territory, based on which changes should be introduced in the legal act and the PC's electricity production prices.

2. The level differences by months of electricity production are significant, where the average daily load changes in a range of 4 points, minimally up to 15 points and maximally up to 4 points. The daily loads are distinct also when it comes to their levels – the average monthly are up to 3,5 points, the minimal are up to 7 points when compared to the maximal.

3. A high punctuality of the simulation of the daily electricity production of the PC ($R^2 = 1$) is provided by the derived regression models. Through them the data of the daily production can be transformed via the polynomials in an analytical type and can be used in the planning and management of the PC's electricity production for the design, planning and trade on the electricity market.

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CHARACTER OF THE ELECTRICITY PRODUCTION OF WIND POWER STATIONS

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Resume: According to the Energy Act the created wind energy parks (WEP), part of the renewable sources, are mandatorily adjoined to the electricity power grid. It is necessary to conduct a detailed study on the character of the electricity production from WEP in order to avoid the problems of such adjoining and to develop graphics for a more effective use of the energy produced by WEP. It should be noted that in the circumstances of our country such study is not enough. For this purpose, results from the study are presented for the electricity production of an active wind energy park for a five-year period in days, hours and months. A triangle for evaluation of the daily production of WEP and comparison with conventional sources is proposed.
Key words: renewable energy sources, wind energy parks.

INTRODUCTION

According to art. 31, para. 2 from the Renewable Energy Sources Act (RESA) the electricity from renewable sources is bought out based on long-term contracts for buying for a period of 12 months for electricity, produced by wind energy [2]. According to RESA the preferential price as defined in specific moments is applicable for the whole period of buying and is not changeable. In art. 93a and 94 from the Energy Act (EA) an obligation for the public supplier is posed to buy the electricity that is produced by renewable sources, including by wind generators [4]. Until 2013 174 units of wing energy parks [1] has been built and put into operation in the country. According to the introduced regulation [2, 3] the electricity system and the society are obligated to pay back the produced electricity by those parks. In the same time, a question occurs if the subscribers can rely on such production. To answer that question, it is necessary to have a systematic research and analysis of the character of the electricity production of the active wing energy parks in the country.

RESULTS FROM THE ANALYSIS

Indicators of the load schedules of the wind generator

The evaluation of the indicators is performed based on a wind generator with power of 500 kW. Two characteristic periods are chosen – during the winter (23.12. 2008 – 21.01.2009 г.) and during the summer (25.07-25.08.2008). The load schedules for December-January is given in fig. 1, and for July-August on fig. 2. During the winter the maximum momentary power has twice reached its nominal power of 500 kW (fig.1), the maximum momentary power during the summer has reach 340 kW (fig.2). The processed data and the received values of the main indicators of the loads are according [4]. The average power during the winter has been 113 kW (22,2% from the nominal), and during the summer month it has been 34 kW (6,8% from the nominal).

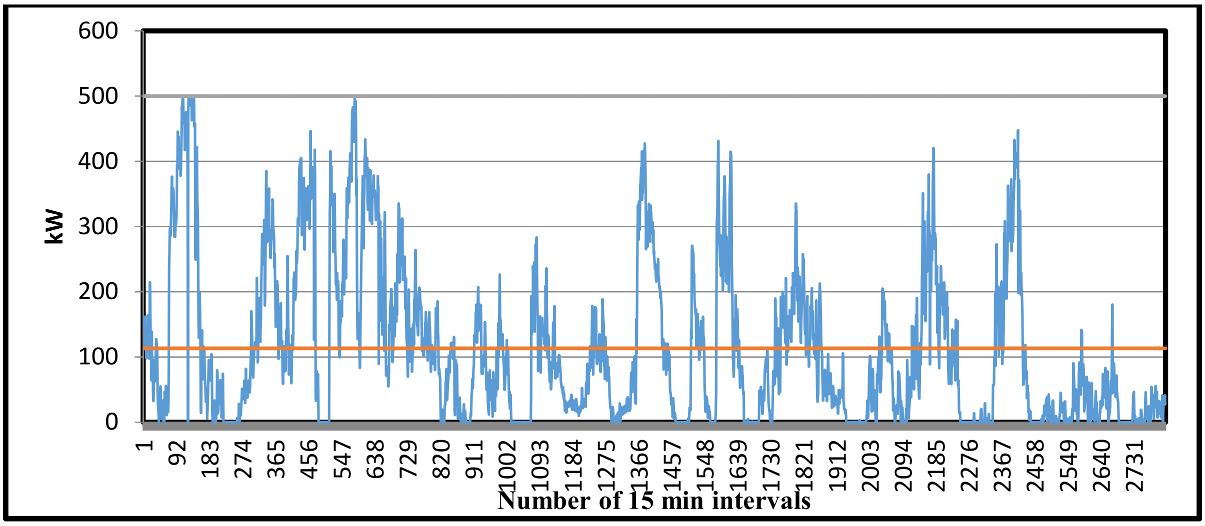


Fig.1. Distribution of electricity production during the month with intensive electricity production

Current power kW   Average power kW   Nominal power kW

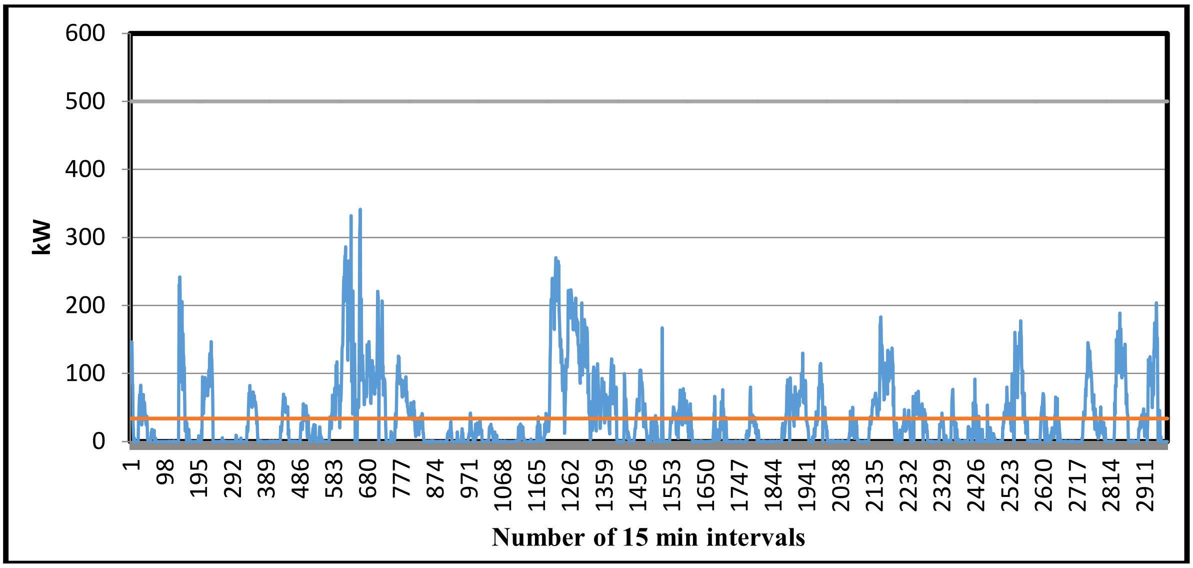


Fig.2. Distribution of electricity production during the month with minimal electricity production

Current power kW   Average power kW   Nominal power kW

The use coefficients $\mathbf{C_u}$ respectively for summer and winter month are 0,068 and 0,226 units, the inclusion coefficients $\mathbf{C_i}$ - 0,57 and 0,785 units, and the load coefficients C_l - 0,119 and 0,289 units. As it can be seen each of the coefficient has low values. Particularly low are the coefficients for the summer schedule, which in comparison with the winter coefficient $\mathbf{C_u}$ is 3,32 times, for $\mathbf{C_i}$ - 1,38 times and for C_l - 2,43 times smaller.

Electricity production indicators

The load schedules from fig. 1 and fig. 2 are additionally processed in which case the daily electricity production has been indicated, the working hours and the pause condition of the wind generator (table 1).

Table 1 **Daily electricity production, pauses and working hours of the studied generator during the month with intensive and minimum electricity production**										
	Month with intensive electricity production					Month with intensive minimum production				
days	kWh /day	%	pauses, hours	Working hours	pauses,%	kWh/day	%	pauses, hours	Working hours	pauses,%
1	2	3	4	5	6	7	8	9	10	11
1	7595	176	0,25	23,75	1	586	-26,9	10,75	13,25	44,8
2	514	-81	11,75	12,25	49	694	-13,3	16,5	7,5	68,8
3	4345	58	0	24	0	702	-12,3	16,25	7,75	67,7
4	5531	101	0	24	0	402	-49,8	16,25	7,75	67,7
5	3899	42	7,5	16,5	31,3	250	-68,8	18	6	75
6	7899	187	0	24	0	298	-62,8	12,5	11,5	52,1
7	4196	52	0	24	0	3006	275,3	1	23	4,2
8	2488	-10	1,75	22,25	7,3	1717	114,3	6,25	17,75	26
9	1664	-40	4,75	19,25	19,8	974	21,5	5,5	18,5	22,9
10	1249	-55	7,5	16,5	31,3	71	-91,1	19,75	4,25	82,3
11	2490	-10	6,25	17,75	26	219	-72,7	12,5	11,5	52,1
12	1050	-62	0	24	0	64	-92,1	20	4	83,3
13	1521	-45	2,5	21,5	10,4	2041	154,8	16,5	7,5	68,8
14	5365	95	0	24	0	3018	276,8	0	24	0
15	1520	-45	9,25	14,75	38,5	937	17	7,5	16,5	31,3
16	3763	37	3,5	20,5	14,6	661	-17,5	9	15	37,5
17	1361	-51	10,25	13,75	42,7	586	-26,8	8	16	33,3
18	3192	16	1,5	22,5	6,3	223	-72,1	17,75	6,25	74
19	2626	-5	0	24	0	216	-73,1	16,25	7,75	67,7
20	381	-86	14,25	9,75	59,4	625	-21,9	11,75	12,25	49
21	1629	-41	3	21	12,5	883	10,2	7,5	16,5	31,3
22	4000	45	0,5	23,5	2,1	133	-83,4	18,5	5,5	77,1
23	1785	-35	9,25	14,75	38,5	1511	88,6	3,5	20,5	14,6
24	2147	-22	10,75	13,25	44,8	627	-21,7	6	18	25
25	3213	17	9	15	37,5	248	-69	16	8	66,7
26	384	-86	9,25	14,75	38,5	231	-71,1	19,75	4,25	82,3
27	992	-64	3,25	20,75	13,5	1180	47,4	6,75	17,25	28,1
28	282	-90	15,25	8,75	63,5	326	-59,3	12,25	11,75	51
Average	2753		5,04	18,9	21	801	0	11,9	12,1	49,4
Total	77083		141,25	530,75		22429		344,15	339,75	

77083 kWh (daily average 2753 kWh) have been produces in total for the month with intense electricity production, and for the month with minimum electricity production - 22429 kWh (daily average 801 kWh), or with 3,44 times less.

A distribution of the daily electricity production (table 1, quantity 2, fig. 3) and for the month with minimum electricity production (table 1, quantity 7, fig. 4) has been presented. For the first month the range of electricity production is in the interval between 282 kWh and 7899 kWh. The difference is of 7617 kWh or with 28 points. During the other month the range of electricity production is in the interval between 71 kWh and 3018 kWh. The difference is of 2947 kWh or with 42,5 points. The data show that in terms of days as well as

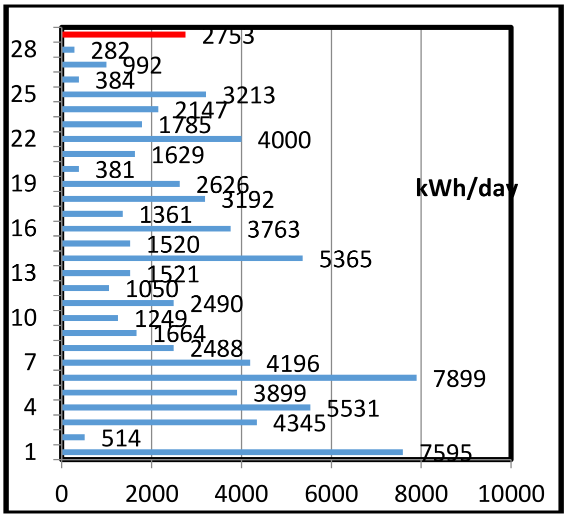


Fig.3. Distribution of the daily electricity production for the month with intensive electricity production

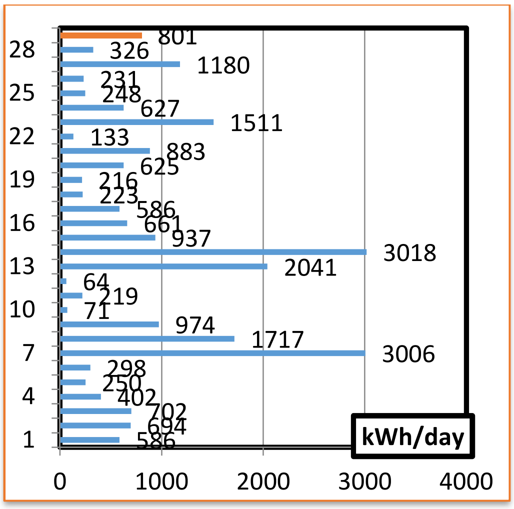


Fig.4. Distribution of the daily electricity production for the month with minimum electricity production

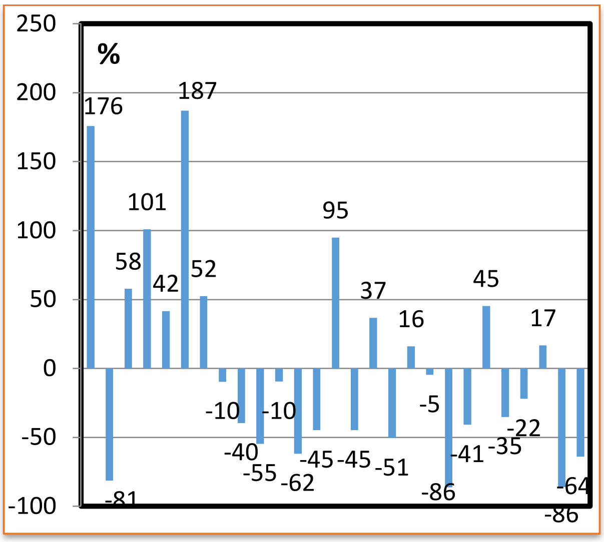


Fig.5. Fluctuation of the daily electricity production for the month with intensive electricity production, %

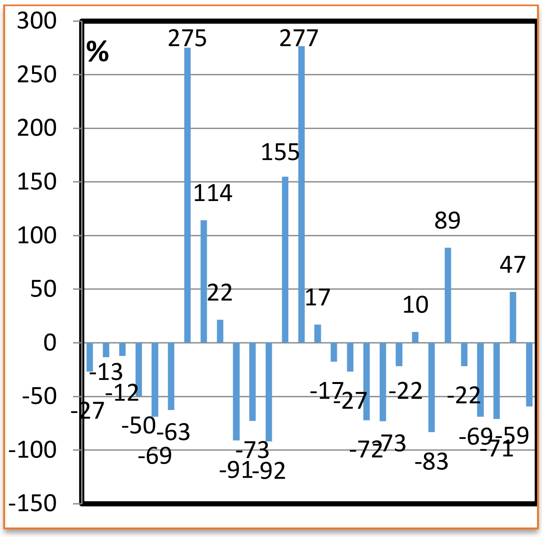
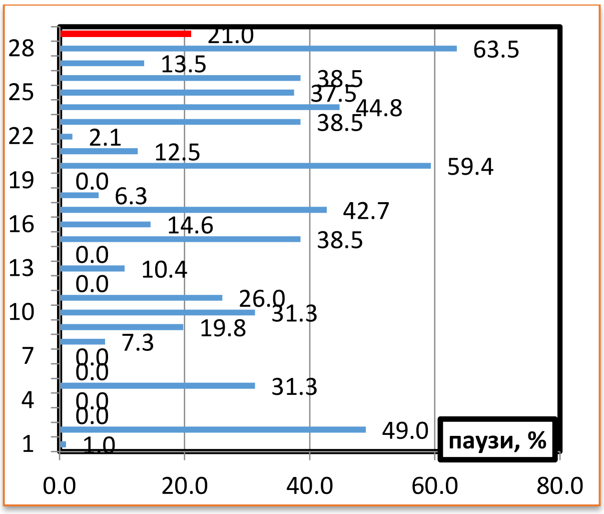


Fig.6. Fluctuation of the daily electricity production for the month with minimum electricity production, %

in months the differences in electricity production are high and unpredictable, which is visible from the data between 28 and 42,5 points. The fluctuations for the months with weak wind are higher.

The fluctuation of the daily electricity production for the month with intensive electricity production in % (fig. 5) and for the month with minimum electricity production in % (fig. 6) has been defined. The fluctuation is in comparison with the difference between the factually produced in days from the months and averagely for the month in comparison with the average for the month. The differences are from +187 % to -90 % for the month with intensive production and from +277% to -92 % for the month with minimum production. The average daily production is accepted as a foundation in comparison to which the fluctuation of the electricity production is defined. This means that every day for the prognosis for the expected electricity production it is not enough to use the average daily production and the fluctuation in comparison to it is extreme in values in every direction.



Фиг.7. Distribution of the pauses of the wind generator for the month with intensive electricity production

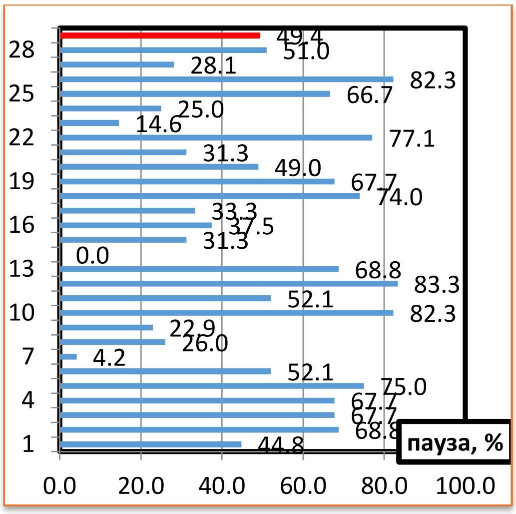


Fig.8. Distribution of the pauses of the wind generator for the month with minimum electricity production

The pauses and the working hours of the studied wind generator for the month with intensive electricity production in (table 1, quantity 4, quantity 5) and for the month with minimum electricity production (table 1, quantity 9, quantity 10) have been studied. The total number of the pauses during the first month is 141,25 h, their average length is 5,04 h, their change range is between 0,25 h and 15,25 h, or 61points. The total number of working hours during the first month is 530,75 h, their length is 18,9 h, their change range is between 8,75 h and 23,75 h, or 2,71 points. The pause distribution of the wind generator for the month with intensive electricity production in % is illustrated in fig. 7.

The total number of pauses during the second month (with minimum production) is 344,15 h, average length is 11,9 h , the range of change is between 1 h and 19,75 h, or 19,75 points. The total number of working hours during the second month (with minimum production) is 339,75 h, average length is 12,1h , the range of change is between 4 h and 18,5 h, or 4,625 points. The pause distribution of the wind generator for the month with minimum electricity production in % is illustrated in fig. 8.

After the comparison between the hours in pauses and work between the two months – the first of intensive and the second with minimum electricity production, it follows that they are in the following ratios: 2,43 times more are the pauses during the second month; 1,56 times more are the working hours during the first month.

The so called triangle for daily electricity production by hours of the day has been introduced for visualization of the character of the daily electricity production. Two schedules (fig. 9 and fig. 10) have been introduced. The comparison base is the schedule Pn. This is the electricity production in case the wind generator would work at a nominal power during the whole day, in which case it would produce 12000 kWh electricity. The first is for the month with intensive electricity production (fig. 9).

Graphic #1 is the day with the highest reached production of the month – 7595 kWh, while the next graphic # 2, the produced quantity is much less and it is 514 kWh, with long pauses. Analogically, the electricity production for the month with minimum electricity production (fig. 10) has been introduced through the triangle. Graphic #1 represents the highest production – 3018 kWh, awhile graphic #4 - the day with lowest production - 5,5 kWh and long pauses.

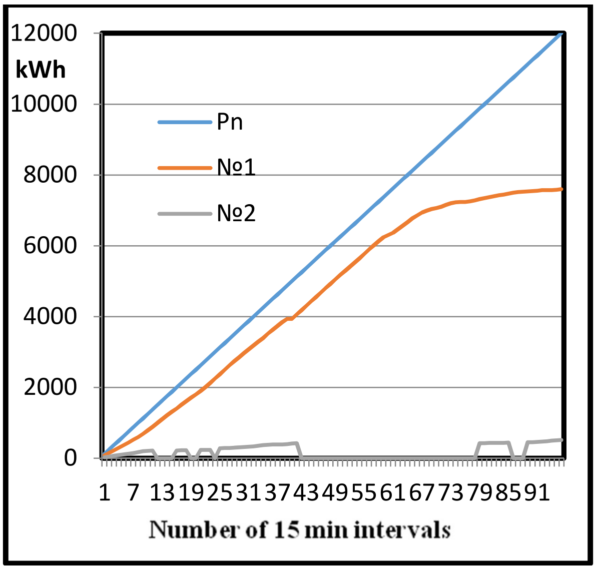


Fig.9. Triangle of daily electricity production for the month with intensive electricity production

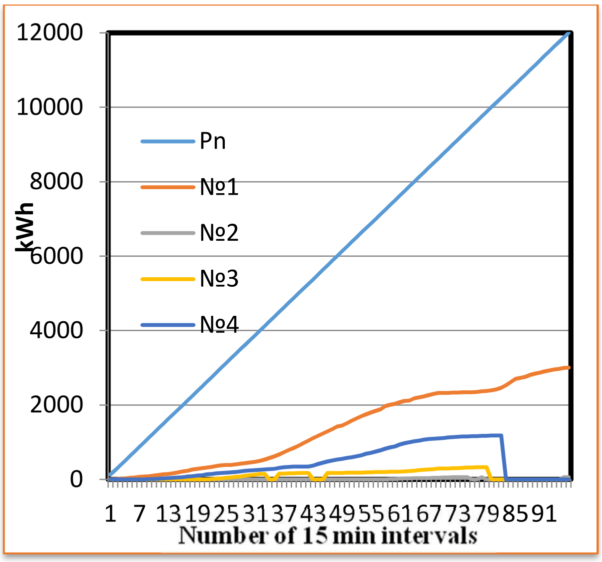


Fig.10. Triangle of daily electricity production for the month with minimum electricity production

CONCLUSION

1. The load schedule indicators of the studied wind generator, irrespective that it has been working in the Kaliakra zone, are utterly unsatisfactory: at nominal power of 500 kW, during the winter month the average power is 113 kW (22,6 % use coefficient of power), through 34kW (6,8 % use coefficient of power). These results show that the wind generation centrals put into operation in Bulgaria, including in the Kaliakra region, do not work at energy efficient regimes.

2. The electricity production by months is uneven. During the summer month the lower production is 3,44 times less the electricity in comparison with the winter month's highest production. The daily electricity production is uneven also – the differences for the winter month are up to 28 points, for the summer – up to 42,5 points.

3. There is a big duration of pauses – for the winter month it is up to 21 %, for the summer – up to 49,4 %. The average duration of the working hours during the winter month is 18,9 h, and during the summer month it is 12,1 h.

4. The proposed triangle for comparison of the daily electricity production of the wind generators show the big differences in the daily electricity production and uneven distribution of the produced electricity during the day.

5. The calculated results from the analysis of the electricity production of the active wind generator in the Kaliakra region show that in front of the electricity system in the country, as well as in front of the very owners if wind generation parks, there is a complicated task of effectively using of these powers.

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COGENERATION AS AN ALTERNATIVE TO THERMAL POWER PLANTS

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Resume: The heat systems charged by TPP in the country are depreciated, the production and thermal power transfer losses are great. The generation blocks are working on inefficient regimes. It is obvious that the thermal companies using such energy technology and equipment have no future. The solution is the change of existing TPPS with cogeneration blocks. This report present an analysis and a solution to using cogeneration power and decommissioning of the active TPPs.

Key words: Combined production of energy, Thermal power plant, cogeneration.

INTRODUCTION

The active companies, which supply thermal energy in the country, produce electricity, water steam and hot water. The companies, which are registered and licensed by CEWR, are 39 [12]. The most prominent ones are: TPP Sofia – it supplies the heating of approx. 1.5 mln citizens in the capital by providing to 430 000 household and business subscribers [6]; TPP Plovdiv is a thermal power plant with combined production of heat and electricity for the needs of the industry and household sector. TPP Plovdiv North’s main fuel is natural gas. In TPP Plovdiv North there is a newly installed cogeneration with total power of 115 MW [7]. TPP Varna annually consumes 17 373 000 m^3 natural gas, it produces 116 993 MWh heat and 32737 electricity MWh [8]. TPP Burgas has nominal heating power of 391 MW [9]. TPP Ruse AD is intended for the production of heat and electricity. The power of the thermos power blocks is 180 MW [10]. TPP Pleven EAD has a total installed heat power of 474 MW [11].

The constructed heat systems in the industrial thermal power plants (TPP), in the context of the deindustrialization of the country, provide mainly the heating of living neighborhoods and household hot water supply (HHWS). The heat load in those regimes is insufficient, especially during the summer, the TPPs work in an ineffective mode, the losses in the thermal power grid are high [2,3]. In case there are no future opportunities for the construction of industrial parks around the TPP, the funds for reconstruction and modernization of the TPPs themselves is not justified. In the same time there are respective substations and grids to them for heating and HHWS of the living buildings in the neighborhoods [1,5]. The 20 kV grids, which power the neighborhood power substation, are built. The TPPs and the thermal power grid are property of one party, the electricity supply – of another, the substations are common [4]. In those circumstances it is necessary to develop energy economical models, on which solutions for the expedience of the construction of local cogeneration power plants (CPP) are based for the provision with electricity and heat energy of the city neighborhoods.

SUMMARY

Base structure of the current modular energy provisional system (MEPS)

In the context of the previous social and political system, MEPS were build in the district and industrial centers with a principle structure, presented in fig. 1, which compounds are:

- Core of the system/ the relevant thermal power plant (TPP);
- Industrial region;
- Thermo powered regions (i.e. North and South region).

Thermal power plant

- The principle scheme of the systems for combined energy supply of the city neighborhoods and villages, as based on the TPP, is given in fig. 1. In the given example, the

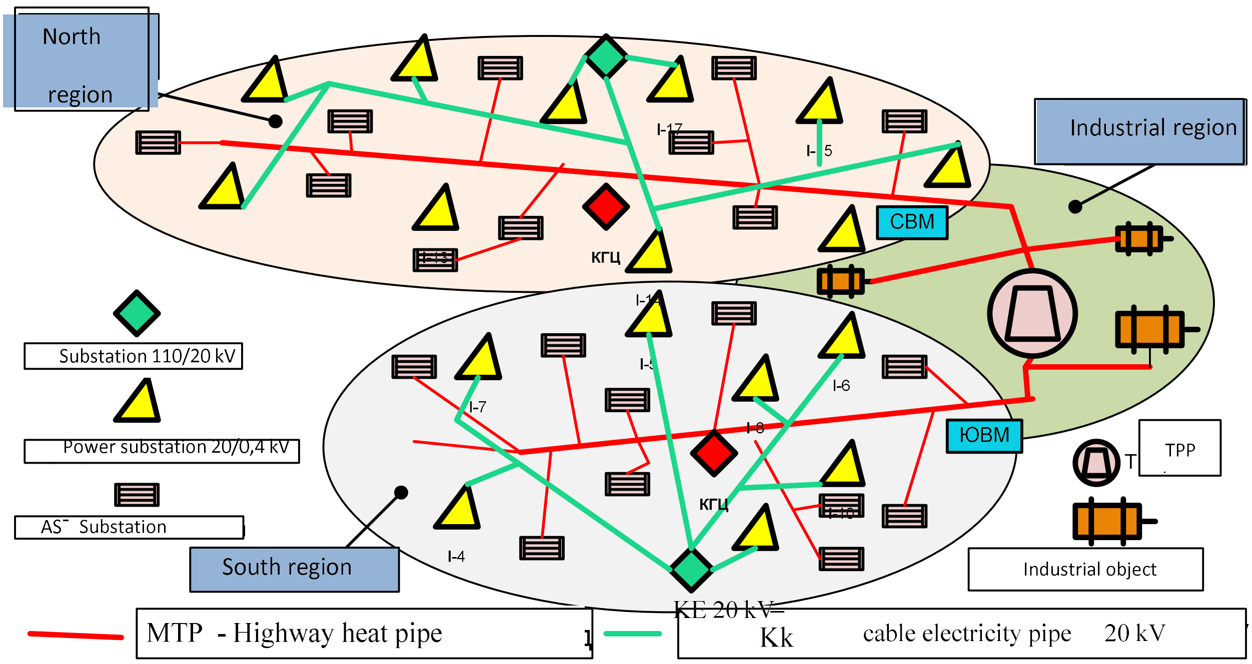

Fig.1. Structural scheme and base contour of the system for combined energy supply of living neighborhoods, regions, villages

TPP is provided with:

- 5 boilers with 220 t/h steam production and 10 MPa/ 540 ºC parameters;
- 4 turbo generators – two with 60 MW and two with 30 MW electricity power with steam lead turbines, each with two regulated steam leads – for industrial steam and heating purposes;
- 2 energy blocks each with 110 MW electricity power with condense turbines and boilers for 365 t/h of steam with 14 MPa/ 540 ºC parameters (fig. 2).

In reality, the industrial steam is not consumed because of the lack of industry production. The usability of the facilities in the TPP is between 10 and 32 % during the winter.

The thermally portable grid for household hot water has the following characteristics:

- Group substations – 11 units;
- Individual substation – 486 units;
- Household subscribers – 16739 families.
- Thermally provided business subscribers – 169 units;
- Water regime of the thermally provided grid – 17163 м^3;
- Total length of the thermally portable grid – 72035 м.
- NWH supplying – 701 м^3/h; returning – 667 м^3/h;
- SWH supplying – 287 м^3/ч; returning – 300 м^3/ч;
- Thermal power grid and the substations towards her.

Usually the grid is powered by several highways. Conditionally, they can be described as south water highway (SWH) and North water highway (NWH).

Group substations: the principle scheme of the group substations is given in fig. 3. The power comes from the TPP. The temperature of the incoming water stream is around 70 ^{0}C, and of the reverse on – around 50 ^{0}C. Two thermally exchanging devices are powered: for household water supply with a contour with a temperature around 55 ^{0}C at the entrance and around 45 ^{0}C at the exit. Every one of the contours is provided with the respective circulation pumps.

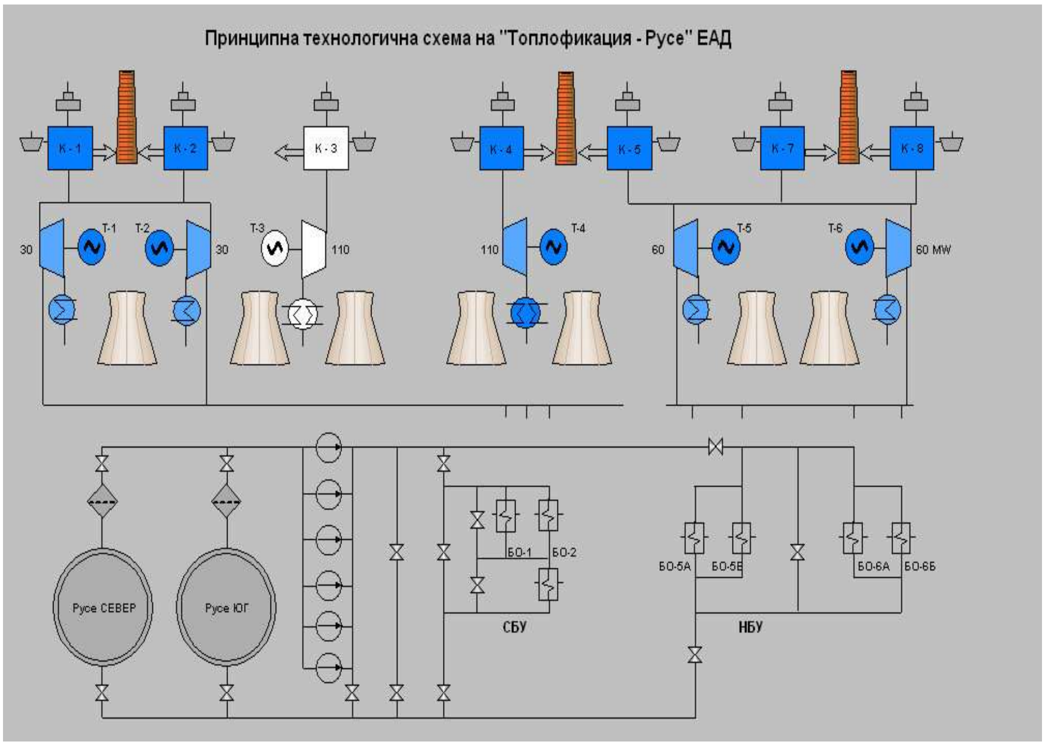

Fig.2. Principal technological scheme of a powering TPP

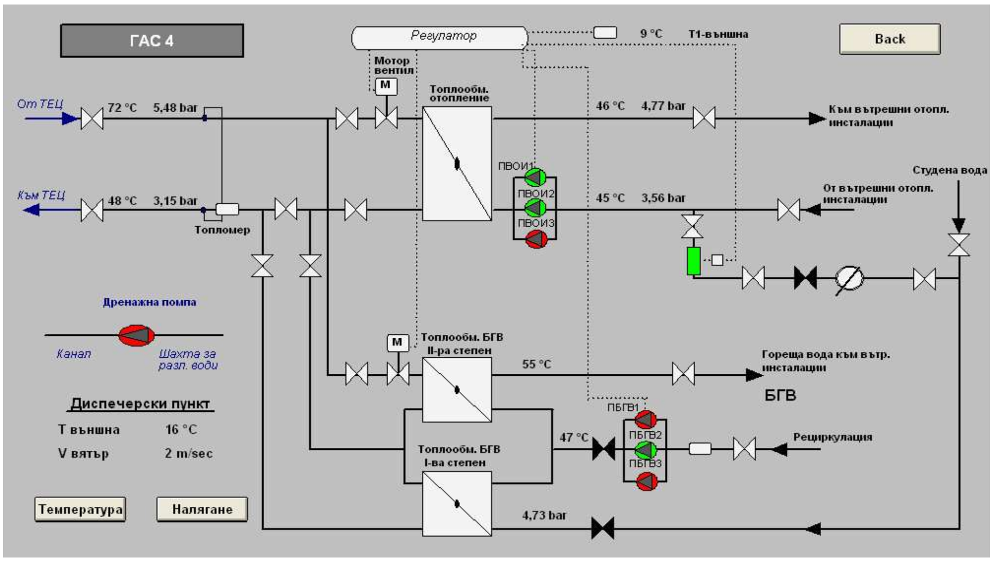

Fig.3. Scheme of a substation

The thermally portable grid with steam thermal carrier towards industrial consumer:

- North steam highway – it powers the consumers in the East industrial region. Parameters: L=3328 м., T_{work}=300 ºC, P_{work}=1,6 MPa ;
- South steam highway – it powers the company Iris. Parameters: L=2962 м., T_{work}=300 ºC, $P_{wor.}$=1,6 MPa ;
- Sugar-Bio steam highway. Parameters: L=3002 м., $T_{work.}$=300 ºC, P_{work}=1,6 MPa.

Electrical system

The electricity supply towards the consumers is conducted by the relevant substations 110/20/10 kV. In the present case they are three:

- Substation 110/20/10 kV with 2 transformers 2X25000 kVA;
- Substation 110/20/10 kV with 1 transformer 25000 kVA -110/10 kV and 1 transformer 25000 kVA -110/10 kV;
- Substation 110/20/100 with 2 transformers 2x40000 kVA.

Summarily, the full crossing electricity power of the substations is 180 000 kVA. The number of power substations in the area are 220. The distribution of the power substations is according to the neighborhoods, living buildings and production objects.

CONCLUSION

The heat supplying companies in the countries have depreciated systems (steam boilers, turbines, generators, heat exchangers and substations) which the companies cannot renovate. Irrespective of that, instead of seeking opportunities for the implementation of a more effective energy production based on cogeneration, the companies continue to collapse through continuous increase of the prices of the service.

The industrial zones are unfulfilling which leads to loss of thermal loads, the production of steam is not used, the TPP cannot be provided with thermal loads and it works in energy inefficient regimes. This artificially leads to the increase of the service prices.

The established practice of electricity supply in reality does not provide for the purchasing of the produced electricity in a combined way and leads again to the increase of the service prices.

All parameters of the thermal power grid are resized – the debits, the pipe sections, the pump aggregates power, the length of the pipelines. The personal needs are much higher than the normal for a TPP, as well as the cost of the produced energy – thermal and electrical. In those circumstances, there is an unconditional necessity to implement qualitatively new energy technique and technology of the cogeneration type.

The construction of structurally new systems for combined energy supply with the usage of the combined energy production based on the existing TPP infrastructure for electrical and thermal supply of the city regions requires the development and adoption of new legislative packages. Those packages would unite the interests of the electricity and thermal companies, the municipalities, the energy market players and the energy subjects. In this way, a permanent and efficient solution for the energy supply of the population in the cities and villages in the country will be provided.

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TESTING NO_X EMISSIONS REDUCTION USING STAGGERED COMBUSTION TECHNOLOGY FOR PULVERIZED COAL OF OLTENIA REGION

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ABSTRACT

The paper presents the research results of burning in the 2 MW pilot boiler furnace of lignite from the Oltenia region in order to determine the NO_x emissions limits. A functional model burner was used that has slots and that develops staggered combustion technology which is to be industrially implemented in the Işalniţa Power Plant. The similarity criteria were observed between the thermodynamic combustion parameters and between the experimental simulation and the real industrial boiler installation.

1. RESEARCH OBJECTIVES

The overall objective is to determine through experimental testing the NOx emission limits when burning lignite from Oltenia region while using a functional model burner with slots that develops staggered combustion technology.

The analysis of the coal used in the final experiments is given below:

Table 1: Energy characteristics of the lignite

Nr.crt.	Parameter	Unit	Value	Work method
1	Total moisture content, W_t	%	21,06	SR 5264:95
2	Ash, initially A^i	%	18,91	ISO 1171:2010
3	Ash content, anhydrous A^{anh}	%	23,95	ISO 1171:2010
4	Higher Heat Value (HHV), initially	Kcal/kg	3640	ISO 1928:2009
5	Lower Heat Value (LHV), initially, *	Kcal/kg	3359	ISO 1928:2009
6	Carbon content, C^i	%	38,28	ASTM D 5373-02
7	Hydrogen content, H^i	%	3,37	ASTM D 5373-02
8	Nitrogen content, N^i	%	0,87	ASTM D 5373-02
9	Sulphur content, initially	%	1,45	SR ISO 334:1994
10	Oxygen content, in difference, initially	%	16,07	PO-SME-16

*) In SI units, LHV is Q^i_i = 14 000 kJ/kg

This coal is the Oltenia region lignite under the influence of drying in the summer time. In an initial phase of these tests it was tested also the coal having a maximum humidity and a lower heat value of 7900 kJ / kg.

Both sections of experiments have met the criteria of the thermal-gas-dynamics similarity between the 2 MW pilot furnace from the Politehnica University of Bucharest and the industrial 510 t / h furnace from IE Işalniţa.

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The monitored similarity criteria were:
- fineness of the grinding of lignite;
- temperature at the end of the furnace;
- thermal volumetric load of the furnace.

In the study of emissions the following values have been monitored:
- the NO_x emission as the main element of research;
- the CO emission as an element for general characterizing the combustion process efficiency and the flame stability;
- the SO_2 emission for the general characterization of the use of this high Sulphur content fuel .

2. THE PILOT INSTALLATION OPERATION REGIME

The mass flow rate of coal for both experimental categories included three values:

$B_1 = 0,1$ t/h; $B_2 = 0,11$ t/h; $B_3 = 0,14$ t/h

The gas flow rate in the first stage of experimentation was $B_g = 36$ m^3_N/h. Moving to a better quality of coal in the second phase of experimentation allowed its decrease to the value of $B_g = 28$ m^3_N/h.

The initial dosage of the air in burner channels, for both of the experimental stages was: primary air, 25%; secondary air 50%; tertiary air 25%.

The tertiary air reduction was made in the range between 10% to 25%. For the zero dosage, the classical burning is obtained, without its admission control in steps.

3. RESULTS OF THE EXPERIMENTAL TESTS

For grinding the 0.2 t/h mill fan was used. The mill fan is equipped with a pre-drying tower and an inertial separator.

Figure 1 shows the size distribution of coal dust for an appropriate set of sites (90, 140 250 315, 400 μm). In the table attached to the figure the numerical values are shown for the debris remains on each respective site.

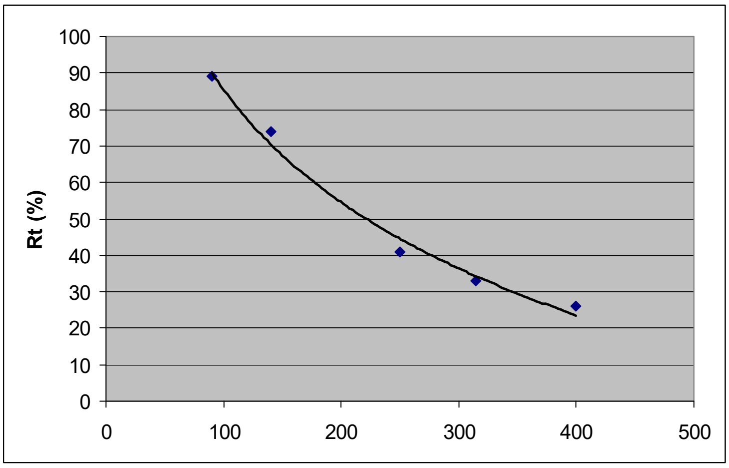

Figure 1. The particle size distribution of the coal dust

This milling finesse is, however, within the technical limitations of such a coal.

The coal dust moisture was 16.5%, corresponding to the values for the industrial use of lignite. The presented values are for a mill flow rate of 0.14 t/h.

Coal quality influence on the volume thermal load for the furnace pilot boiler of UPB is shown in Figure 2. In Figure 3 the recommended values are presented for the volume thermal load of the furnaces in the industrial boilers burning pulverized coal.

For the adopted operation mode, a volume thermal load resulted within the limits between 70-83 kW / m^3.

The proportion of gaseous fuel to sustain a flame coal decreased significantly, the values being presented in Figure 4.

For the stage combustion technology, the emission of NO_x was between 180 mg/m^3 and 230 mg/m^3, with a minimum value of 136 mg/m^3, for the volume thermal load of the furnace of 70 kW / m^3 -75 kW / m^3 - figure 5.

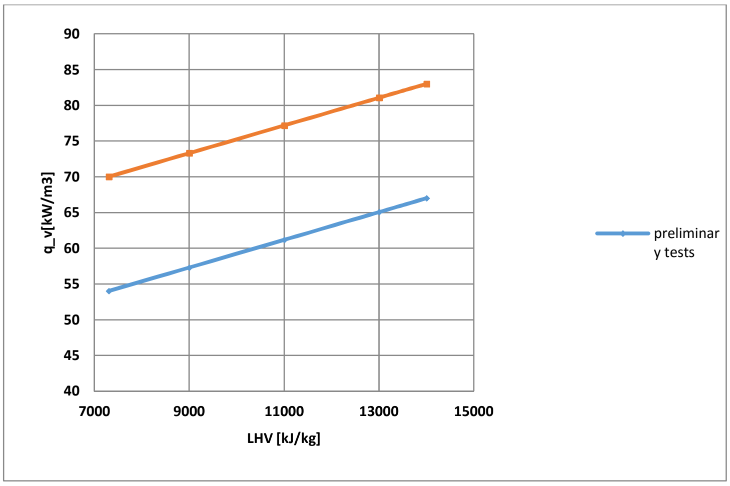

Figure. 2. The influence of lignite quality from the experiments on the volume thermal load of the pilot boiler furnace of UPB

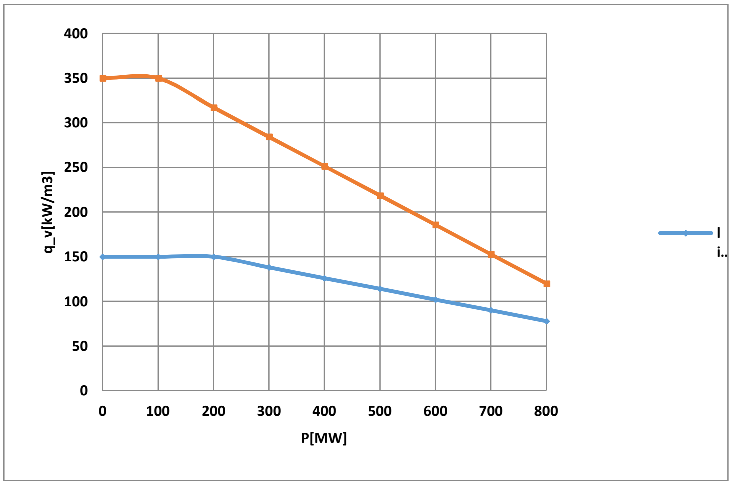

Figure.3. The recommended values for volume thermal load for the furnaces operation with pulverized coal

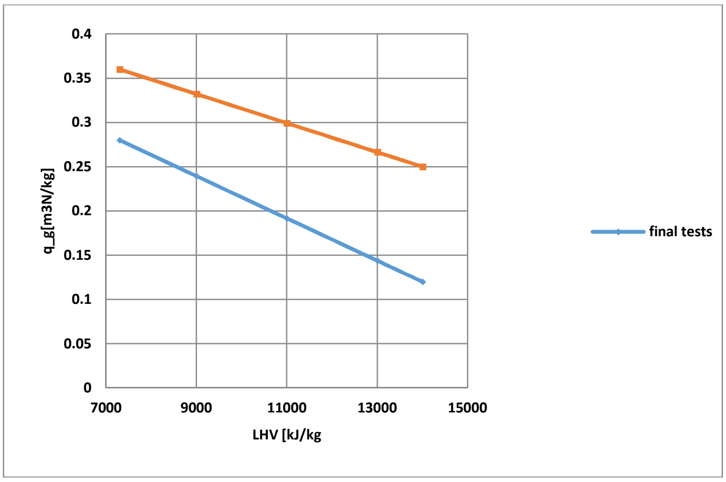

Figure 4: The thermal support variation as a function of the lignite quality

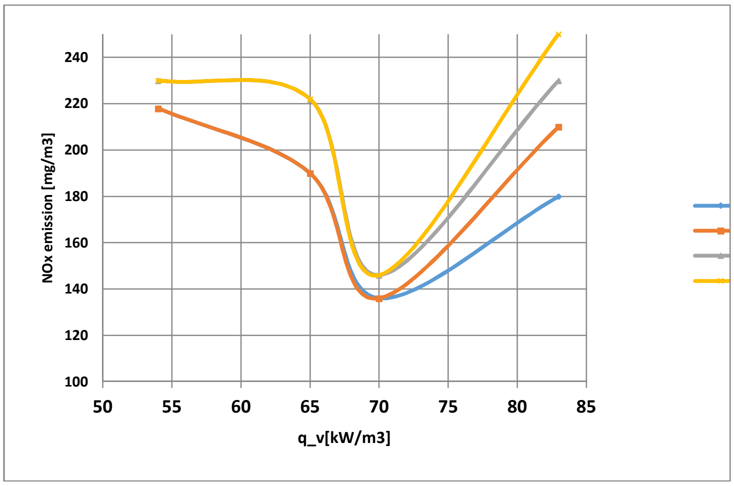

Figure 5: NO_x emission variation during tests :
a- staggered combustion b – without staggered combustion

4. CONCLUSIONS

It has been found that with use of the staggered combustion in the slotted burners for dust coal, the emission of NO_x was lower than 200 mg/m^3, for an operation regime which led to a normal value for the volume thermal load of the furnace.

The decrease in NO_x emission with the introduction of the staggered combustion, speed was 15-30%, depending on the ratio tertiary air / secondary air and the furnace thermal-gas dynamic regime.

Due to the observation of the similarity between the thermodynamic combustion parameters and between the experimental simulation and the real industrial boiler installation, the generalization of the obtained data is admitted. As a result, IE Işalniţa through the obtained data, can estimate future operation of the boiler with respect to the NO_x emission, after the implementation of the combustion technology to the pulverized Oltenia region lignite.

5. ACKNOWLEDGMENT

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CYCLE VARIABILITY STUDY AT A DIESEL ENGINE FUELED WITH LPG

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ABSTRACT

Liquid Petroleum Gas (LPG) fuel can be a viable fuel due to its ability of diesel emissions and fuel consumption reduction. Its special physic-chemical properties lead to specific aspects of the in-cylinder combustion and engine mechanical running for diesel engines. The main aspects of LPG combustion variability in the diesel engine are analysed from the point of view of maximum pressure, maximum pressure timing and indicated mean effective pressure, following the criteria of reduction of combustion variability in terms of indicated main effective pressure and maximum pressure. The cycle variability is influenced in a direct way by the increase of LPG cycle dose which will lead to the increasing of the cycle variability coefficients values, maximum pressure and maximum pressure rise rate. The COV calculated values are bigger comparative to the normal values of diesel engines, but don't exceed the maximum admitted values that provide engine reliability. The COV values analysis establishes the maximum admitted values of LPG cycle.

1. INTRODUCTION

Nowadays, in the global content regarding the impact on the environmental of the gases emissions resulted from the fossil fuels combustion, an interest aspect discussed also on the 21st Session of the Conference of the Parties (COP21) from the 2015 Paris Climate Conference in November 2015, and the gradual diminution of the worldwide oil reserves contribute to the necessity of searching of alternative energy from durable and renewable resources. The replacement of the classic fuels of oil origin by alternative fuels was initiated many decades ago and represents one of the most actual preoccupations linked by the possibility of pollutant emissions decrease and efficiency increase of the diesel engine and necessity of fossil fuel saving [1]. These issues impulse the research's for developing and using new fuel sources which will allow the substitution, even a partial one, of the classic fuels. Liquid Petroleum Gas (LPG) is a worldwide alternative fuel used on a large scale for internal combustion engines [2]. The mixture forming, the heat release, the energetically and pollution performance of the engine are influenced by different vaporization and burning properties of the LPG comparative to diesel fuel. Higher combustion rate of air-LPG mixtures leads to the increase of maximum pressure and maximum pressure rate, with consequences on cycle variability [3], [4], [5]. Thus, the maximum LPG cycle dose admitted in-cylinder can be limited for in-cylinder maximum pressure limitation, efficiency, mechanical reliability, noise, smooth running reasons [1], [2], [6]. The higher autoignition temperature of the LPG, in the field of 481...544 ºC versus 225 ºC for diesel fuel, can allow the use of excessive values for the compression ratio and may required the use of additives for CN improvement or of the diesel pilot injection for air-LPG mixture ignition [1], [2], [12]. The use of LPG at diesel engine, operating on diesel cycle, will required the use of diesel pilot for LPG ignition. LPG raised vapour pressure assure forming of air-LPG mixtures of higher homogeneity. Higher

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octane number (ON propane = 111, ON n-butane = 102 and ON i-butane = 94), a burning laminar velocity comparable with the one of gasoline (0.46 m/s) [1], [2], [12] makes the LPG a suitable fuel for SI engines. Starting the combustion into a relative lean high homogeneity air-LPG mixture influences the combustion process and cycle variability. Also, wide inflamabillity limits of the liquid petroleum gas 2,1…10,4 % versus 0,6 … 5,5 % for diesel fuel will influence the combustion cycle variability and may lead to an improvement of the combustion process and of the pollutant emissions, [1], [2], [3], [5], [6], [7], [9], [10], [11], [12]. The cycle variability for air-LPG mixtures is analyzed comparative to diesel fuelling for a 1,5 litre direct injection supercharged engine, type K9K from Dacia Logan. The engine is fuelled with diesel fuel and liquid petroleum gas by diesel gas method. The LPG cycle dose is injected inside the inlet manifold and electronic controlled by a secondary ECU connected back to back with the main engine ECU (Engine Control Unit).

2. METHODOLOGY

The cycle variability can be characterized by coefficients of in-cylinder pressure variation (COV). The intensity of the cycle variety phenomena is defined by the coefficient of cycle variability, as relation (1) shows. The coefficient of cycle variability is defined as a relative average deviation of maximum pressure values [5], [6], [8]. For *n* consecutive cycles, if is considered a normal distribution of the deviation probabilities, the squared average deviation can be calculated and the cycle variability coefficient is defined as:

$$(COV)a_i = \frac{\sqrt{\dfrac{\sum_{i=1}^{n}\left(a_i - \dfrac{\sum_{i=1}^{n} a_i}{n}\right)^2}{n-1}}}{\dfrac{\sum_{i=1}^{n} a_i}{n}} \cdot 100\% \tag{1}$$

where *n* is the number of cycles, *a* is the parameter of which variability is study and is defined by indicated mean effective pressure IMEP, maximum pressure p_{max}, maximum pressure rise rate $(dp/d\alpha)_{max}$ and the angle where maximum pressure occurs, α_{pmax} in the cycle number "*i*".

Generally, the way of cycle variability evaluation for regimes with spark timing closer to the value of spark timing for MBT (Maximum Brake Torque) the COV of maximum pressure is suitable. The COV of maximum pressure angle, when the maximum pressure occurs, is used for characterization of the combustion cycle variability during the initial phase of combustion. The variation of the IMEP, appreciated by $(COV)_{IMEP}$, is the most suitable instrument to define the engine respond to the combustion process variability [3], [10]. From this point of view the limit value of $(COV)_{IMEP}$ define practically the limit of mixture leaning. This cycle coefficient can also indicate the variability of flame development during the initial phase of combustion.

The physical-chemical properties of LPG show the great perspectives for SI engine use (a high octane number, a laminar flame velocity closer to gasoline, wide inflamability limits) and difficulties for CI engine use (a lower cetane number, high autoignition temperature) that implies special solutions for mixture forming and combustion control [1], [2], [3], [6], [12]. The laminar flame velocity of air-LPG mixtures is comparable with the laminar flame velocity of air-gasoline mixtures. The air-LPG mixture in a higher state of homogeneity, due to propane higher vapour pressure will lead to a high velocity combustion process, after the flame nucleus is forming inside the cylinder next to the diesel fuel jet boundary, [1], [2], [3],

[6]. The initial very lean mixtures of air-LPG achieved inside the cylinder before combustion starts will influence the combustion cycle variability and engine mechanical running. The quantity of LPG injected into the inlet manifold is established by an energetic substitute ratio x_c which take into consideration the lower heating values of both fuels:

$$x_c = \frac{Ch_{LPG} \cdot Hi_{LPG}}{Ch_{DF} \cdot Hi_{DF} + Ch_{LPG} \cdot Hi_{LPG}} \cdot 100 \qquad (2)$$

where: Ch_{DF}, Ch_{LPG} diesel fuel and LPG fuel consumptions, Hi_{DF}, Hi_{LPG} lower heating values of diesel fuel and LPG.

At the regime of 2000 rev/min and 85% load, 150 consecutive pressure diagrams were measured by AVL Indimodul 621 data acquisition system and forward analyzed in terms of maximum pressure, maximum pressure angle and indicated mean effective pressure for different substitute ratios.

Following the aspects that lead to the establishing of a maximum substitution ratio, can be also taken into consideration the values of cycle variability coefficients for in-cylinder maximum pressure and IMEP, $(COV)_{pmax}$ and $(COV)_{IMEP}$, respectively. The cycle variability can be very well appreciated by the values of these two coefficients, and they are related with the engine adaptability for traction. The normal automotive manoeuvrability is assured if $(COV)_{pmax}$, respectively $(COV)_{IMEP}$, don't exceeded 10 %. [3], [8].

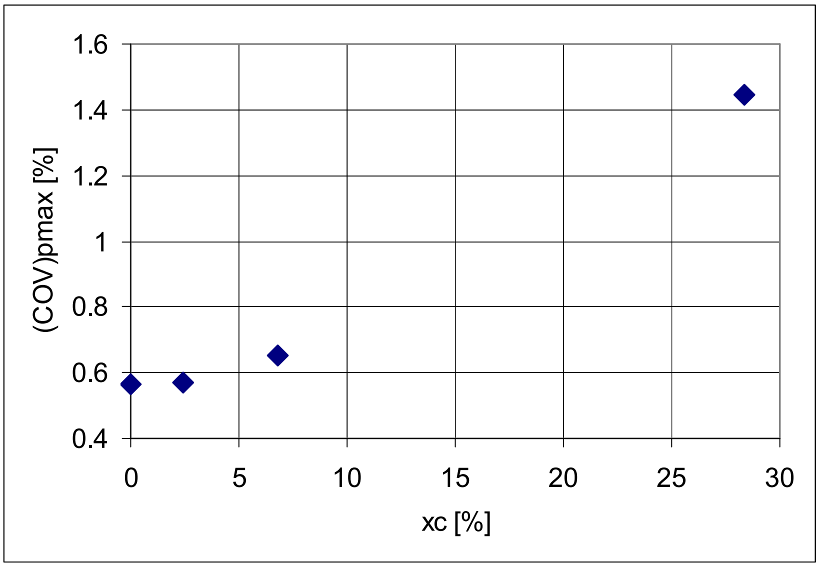

Figure 1: Coefficient $(COV)_{pmax}$ versus x_c at 2000 rev/min speed and 85% load

The coefficient $(COV)_{pmax}$ don't exceed values of 1.6 % at 2000 rev/min speed and 85 % partial load, figure 1, being registered a slightly increase of the coefficient value with the LPG dose. At 2000 rev/min speed regime, the higher dose of LPG leads to a much significant continuously increase of $(COV)_{pmax}$, especially in the range of x_c=6.7…28.4 %. The value registered for x_c=28.4% is 2.5 times bigger comparative to the value of standard engine. Even the maximum value doesn't exceed 1.6%, with no reason for x_c limitation, the further increase tendency of $(COV)_{pmax}$ with x_c, especially for x_c>6,7%, can be take into consideration, figure 1. The limitation of $(COV)_{IMEP}$ maximum value leads to the reduction of the variability of flame development during the initial phase of combustion. For this speed regime, IMEP cycle variability $(COV)_{IMEP}$ is 1.2 times higher for maximum LPG cycle dose comparative to diesel fuelling, figure 3, the cycle variability of the flame developing during the premixed phase of combustion not being significantly affected by the increase of the substitute ratio.

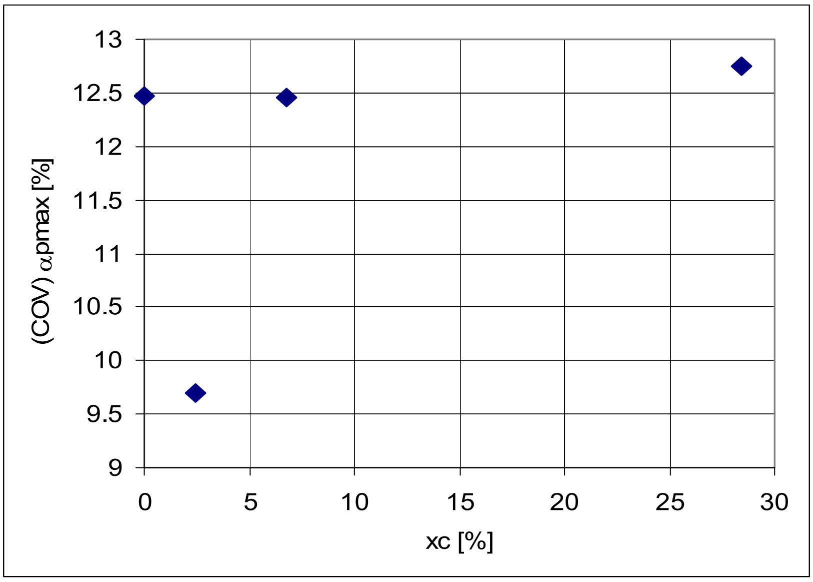

Figure 2: Coefficient $(COV)\alpha_{pmax}$ versus x_c at 2000 rev/min speed and 85% load

For 85% load and 2000 rev/min regime, the increase of LPG cycle dose leads to the increase of cycle maximum pressure and maximum pressure cycle dispersion, thus the dispersion of successive running cycles increase, explained by their coefficients, figure 1 and 2. Also, the angle value for maximum pressure, α_{pmax}, is registered closer to the TDC, with is generally related to a rapid, brutal combustion. The variability of maximum pressure angle slightly, figure 2, increases comparative to reference regime for the maximum substitute ratio, but for averaged substitute ratios 6.7% the values of are similar to diesel running. For x_c=2.5% the $(COV)\alpha_{pmax}$ is improved comparative to diesel fuelling. The general constant value of this coefficient for x_c up till 28.4% can show the maintaining of the cycle variability intensity during the initial combustion phase.

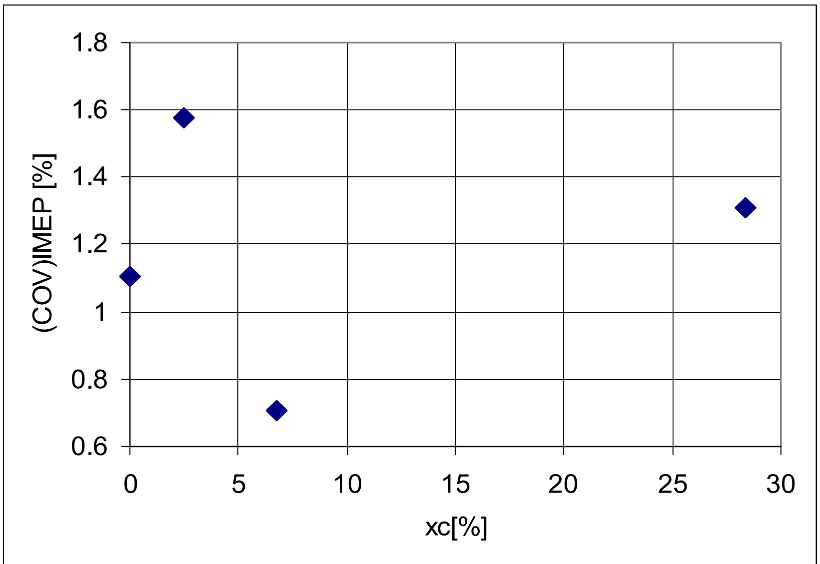

Figure 3: Coefficient $(COV)_{IMEP}$ versus x_c at 2000 rev/min speed and 85% load

The increasing tendency of $(COV)\alpha_{pmax}$ for values higher than x_c= 28.4% can be related with the increased cycle variability during the initial phase of combustion process.

For x_c=2,5 % the value of coefficient $(COV)_{IMEP}$ is 1,4 times bigger comparative to reference value and with 1,2 bigger for x_c=28,5 %, figure 3. The limitation of the LPG dose at x_c=28 % in order to maintain the normal engine running for dual fuelling can become necessary. If the admitted limit is $[(COV)_{IMEP}]_{max}$ = 10%, then appears no limitation issue at this regime for x_c at 28.4%. If the substitute ratio is limited to x_c=28.4% the maximum pressure and maximum pressure rise rate are limited at p_{max} = 138 bar and $(dp/d\alpha)_{max}$ = 6.68 bar/CAD, respectively, values measured in different individual cycles. This phenomenon is related with a combustion process closer to TDC (Top Dead Centre) and leads to the increasing of the maximum pressure rate during the combustion process.

3. CONCLUSIONS

The experimental study shows the main characteristics of the engine running for diesel and diesel-LPG fuelling. The main conclusions can be formulated:

1. The diesel and LPG engine fuelling leads, comparative to classic diesel fuelling, to the increase of in-cylinder maximum pressure and of its cycle variability coefficient $(COV)_{pmax}$ increasing.
2. The increased values of maximum pressure cycle variability coefficient registered at the rise of LPG dose over x_c=28.4% are related with the variation tendency of $(COV)\alpha_{pmax}$ that show the increase of the cycle dispersion between the values of angles were maximum pressure occurs. This aspect may reflect the increase of the combustion cycle variability during the initial phase of combustion at the increase of x_c over 28.4 %.
3. The diesel and LPG engine fuelling leads, comparative to classic diesel fuelling, to an increase tendency for maximum pressure rate $(dp/d\alpha)_{max}$ and cycle variability $(COV)_{IMEP}$ increasing.
4. The diesel fuel substitute ratio by LPG, x_c, is limited by the maximum values or by the maximum variation interval of same running characteristic parameters of the engine, as is follows: if the maximum admissible level of the cycle variability is $(COV)_{IMEP}$ = 1.6 %, for IMEP, then the substitute ratio will be limited to x_c = 28.4 %; if the maximum pressure rise rate is limited to the value $(dp/d\alpha)_{max}$ = 6.68 bar/CAD, then the LPG substitute ratio will be limited to x_c = 28.4 %, value that will lead to a maximum acceptable in-cylinder pressure level of 138 bar.

Aknowledgements
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OPTIMAL TILT ANGLES OF A SOLAR COLLECTOR

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ABSTRACT

The solar collectors must be tilted at an optimum angle to maximize system performance. In this paper, monthly solar radiation intensity is used as an indicator to find the optimum tilt angles for a solar collector installed in the south-east of Romania.

1. INTRODUCTION

Solar energy is considered clean, inexhaustible and cheap and could be a suitable substitute for traditional energy systems.

The performance of a solar collector is highly influenced by its orientation and its tilt angle with the horizontal. The orientation and tilt angle influence the amount of solar radiation reaching the surface of the collector and therefore in the design and operation of solar collectors, it is essential to know the optimum tilt angle. In order to collect as much radiation as possible, a surface must be tilted towards the sun. How much a surface should be tilted is dependent on the latitude and at what time of year most solar collection is required.

Knowledge of the local solar radiation is essential for engineers to make a proper design, optimize and asses the output energy of solar energy systems.

The best information source regarding the solar radiation are the long-term measured data but due to limited coverage of radiation measuring networks it is necessary to develop solar radiation models. The solar radiation model provides data on the amount of solar energy available in the location and how it may vary from month to month in a year.

Because data of solar radiation on inclined surfaces generally are not available it is necessary that solar radiation incident on a tilted surface be determined by converting solar radiation intensities measured on a horizontal surface to that incident on the tilted surface.

The following section describes a method to calculate the irradiation falling on a tilted surface that faces towards the equator for each hour throughout the day.

2. ESTIMATION OF HOURLY SOLAR RADIATION ON TILTED SURFACES

The total hourly solar radiation falling on a horizontal surface, I_{th}, could be estimated from the daily global radiation as follows:

$$I_h = \frac{\pi \cdot H}{3.6 \cdot 24} \cdot \left(a + b\cos(h)\right) \cdot \frac{\cos(\omega) - \cos(\omega_s)}{\sin(\omega_s) - \frac{\pi}{180}\omega_s \cos(\omega_s)} \quad (1)$$

Parameters a and b are defined as:

$$a = 0.409 + 0.5016\sin(\omega_s - 60)$$
$$b = 0.6609 + 0.4767\sin(\omega_s - 60) \quad (2)$$

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- ω is the hour angle of the sun given by:

$$\omega = 15(t - 12) \tag{3}$$

- t is the time of the day in hours and ω_s is the sunset hour angle given by:

$$\omega_s = \cos^{-1}\left(-\tan(\varphi)\tan(\delta)\right) \tag{4}$$

- φ is the location latitude angle and δ is the declination angle of the sun given by:

$$\delta = 23.45\sin\left(360\frac{280+n}{365.15}\right) \tag{5}$$

- n is the day of the year (1 to 365).

The daily extraterrestrial radiation on the surface is:

$$I_o = \frac{24\cdot 3600\cdot I_{sc}}{\pi}\left(1+0.033\cos\left(\frac{360\cdot n}{365}\right)\right)\left(\cos(\varphi)\cos(\delta)\sin(\omega_s)+\frac{\pi\omega_s}{180}\sin(\varphi)\sin(\delta)\right)$$

- I_{sc} is the solar constant = 1367 W/m^2.

The total radiation received by an inclined surface consists of beam, diffuse, and reflected radiation.

The total hourly solar radiation energy incident on an inclined surface is given by:

$$I_i = I_b R_b + I_d + I_h \rho_r \frac{1-\cos(\beta)}{2} \tag{6}$$

- ρ_r is the angle the surface makes with the horizontal β is the surrounding diffuse reflectance and R_b is the hourly geometric factor given by:

$$R_b = \frac{\cos(\theta)}{\cos(\theta_z)} \tag{7}$$

- θ is the incidence angle, the angle between the beam radiation on a surface and the normal to that surface and it is given by:

$$\begin{aligned}\cos(\theta) = {} & \sin(\delta)\sin(\varphi)\cos(\beta) - \sin(\delta)\cos(\varphi)\sin(\beta)\cos(\gamma) + \\ & + \sin(\delta)\cos(\varphi)\cos(\beta)\cos(\omega) + \\ & + \cos(\delta)\sin(\varphi)\sin(\beta)\cos(\gamma)\cos(\omega) + \\ & + \cos(\delta)\sin(\beta)\sin(\gamma)\sin(\omega)\end{aligned} \tag{8}$$

Where θ_z is the solar zenith angle calculated as:

$$\cos(\theta_z) = \cos(\varphi)\cos(\delta)\cos(h) + \sin(\varphi)\sin(\delta) \tag{9}$$

3. RESULTS

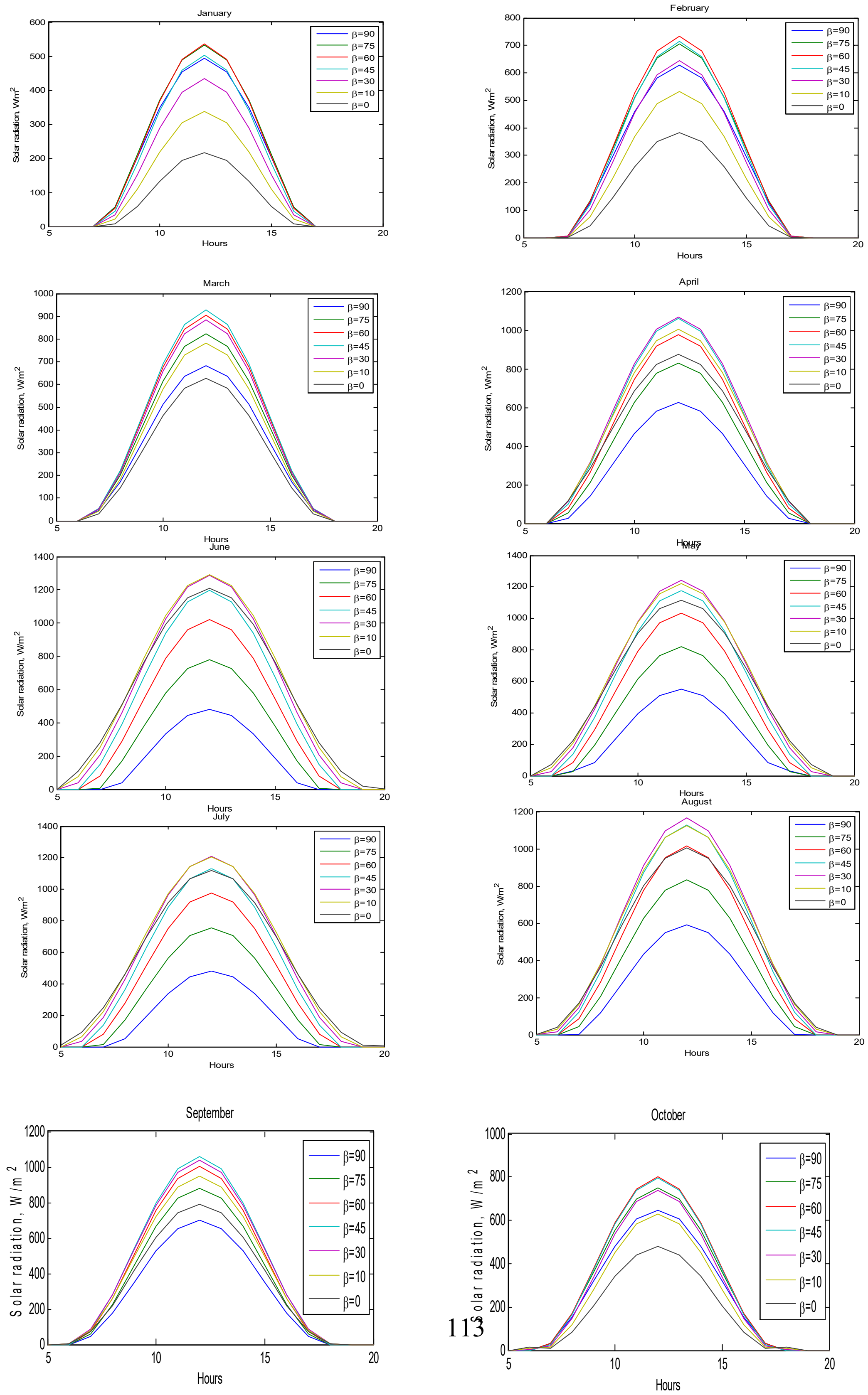
A computer program in Matlab has been developed to calculate the hourly solar radiation on a tilted surface towards equator as the tilt angle is changed from 0 to 90° in steps of 15°.

Figure 1 shows the hourly solar radiation on a tilted surface at Galati, Romania.

These graphs shows that are an optimum tilt angle for each month of the year for which the solar radiation has a peak.

The optimum tilt angle of a flat-plate collector increases during the winter months and reaches a maximum of 75° in December and the hourly solar radiation falling on the collector surface at this tilt is 518 W/m2. The optimum tilt angle in summer goes to a minimum of 15° in June and the maximum hourly solar radiation at this angle is 1292 W/m2.

The solar radiation increases from December to June by 60%.



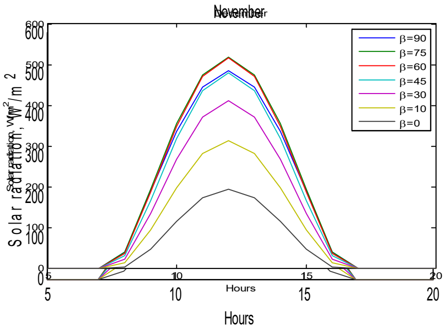


Figure 1. Hourly solar radiation in Galati area for surface with different tilt angles

3. CONCLUSIONS

The results showed that the optimum tilt angles of a flat plate collector for maximum collection of solar radiation ranges between 23° and 68° in June and December, respectively.

The seasonal average of tilt angle was determined by calculating the maximum monthly average of hourly radiation for each season and as a result we need to change the collector tilt three times a year. In spring and autumn the tilt should be 47°, in summer in order to maximize solar collection the surface should be tilted at 23° degree and in winter the surface should be tilted more to the vertical at 68°.

When using a fixed slope all year round the optimum tilt angle was found to be 40 degrees. For the solar collectors tilted towards the south, in the period between October to March, the effect of tilt angle on the received solar radiation is relatively small but in the period April to September the tilt angle has more significant effect.

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UNIFICATION BETWEEN THERMODYNAMICS WITH FINITE SPEED AND THERMODYNAMICS IN FINITE TIME AND ITS CONSEQUENCES ON THE DEVELOPMENT OF TFS

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ABSTRACT

The first attempt to unify *Thermodynamics with Finite Speed (TFS) and Thermodynamics with Finite Time (TFT)* has been achieved by Petrescu, Harman and Bejan in 1992. Since then, several papers that have been published played an essential role in the whole development of TFS, finally leading to the *Validation of the Direct Method and TFS* for 12 Stirling engines.

The present paper presents the results of *the second unification between TFS and TFT* by taking into account in addition to the Finite Speed, two other causes of internal irreversibility in thermal machines, namely Friction and Throttling. In this way we achieved quantitatively what was very clearly explained by Thomson Kelvin only qualitatively, namely that "the main causes of irreversibility are: the finite speed, friction and throttling".

1. INTRODUCTION

The official historical beginning of *Thermodynamics with Finite Speed* (*TFS*) is the year 1964, with the seminal paper [1] of Stoicescu and Petrescu, "*The First Law of Thermodynamics for Processes with Finite Speed, in Closed Systems*", which conducted to Petrescu's PhD thesis [2] and to other papers [3-6] considered essential for the basis of TFS.

The beginning of *Thermodynamics in Finite Time* (*TFT*) can be considered the works of Chambadal [7] and Novikov [8], followed years after by the famous paper of Curzon and Ahlborn [9], where they introduced the well-known nice *radical*. Hundreds of papers followed this research trend, mainly because of its capability to emphasize optimal operation conditions for thermal machines.

The *First Unification between TFS and TFT* has been achieved by Petrescu, Harman and Bejan [10], followed by other two works [11, 12] that played an essential role in the whole development of TFS after 1992, conducting finally to the *Validation of the Direct Method and TFS* for 12 Stirling Engines [13]. After this achievement of TFS, more and more researchers [14-17] all over the world became interested in this direction.

The present paper presents the results of the *Second Unification between TFS and TFT* by taking into account in addition to the Finite Speed, two other causes of internal irreversibility: *Friction and Throttling*. Based on the First Unification achievement [10], new expressions are derived for the power output and efficiency of the direct Carnot cycle with finite speed processes. The results emphasize optimum speed values generating maximum power output, as well as the effect of irreversibilities on the optimum cycle high temperature.

The impact of the Carnot cycle with external and internal irreversibilities analysis on the development of Thermodynamics with Finite Speed and the Direct Method, and tendency of unification between TFT and TFS are discussed.

2. CARNOT CYCLE WITH EXTERNAL AND INTERNAL IRREVERSIBILITIES ANALYZED IN THERMODYNAMICS WITH FINITE SPEED WITH THE DIRECT METHOD

a. Analysis of a Carnot engine with internal and external irreversibilities

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A closed cycle Carnot engine is modeled analytically and is shown *T-S* coordinates in Figure 1.

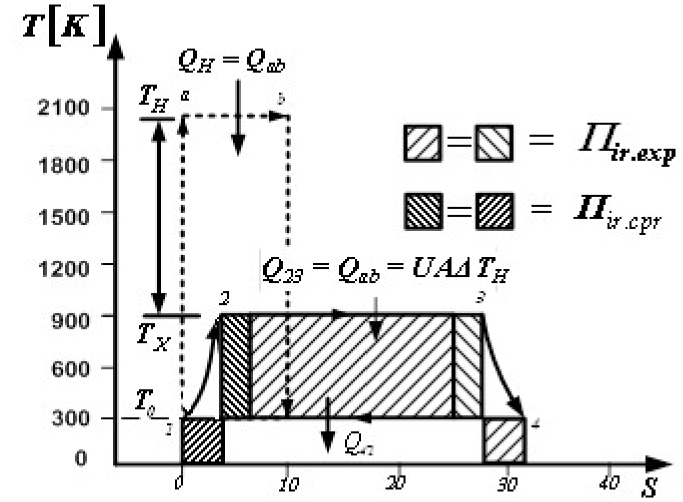

Figure 1: Carnot cycle with internal irreversibilities [18]

The engine has external irreversibility due to the heat transfer from the source of fixed temperature, T_H, to the cycle high temperature, T_X, during the isothermal heat process 2-3. It has internal irreversibilities due to finite piston speed during only the adiabatic compression and expansion processes. The sink temperature and the cycle low temperature are the same. This temperature, T_0, is fixed but the cycle high temperature T_X, is variable.

b. **The First Law of Thermodynamics for Processes with Finite Speed that takes into account friction and throttling**

By cumulating the effects of various internal irreversibility causes for a compression or an expansion process with finite speed, among which we mention: (1) the finite speed of the piston, (2) the throttling of the gas and (3) the friction between piston and cylinder, the general equation of the First Law of Thermodynamics for Processes with Finite Speed for closed complex systems was obtained [11, 13, 19, 20]:

$$dU = \delta Q - P_{m,i}\left(1 \pm \frac{aw}{c} \pm \frac{b\Delta P_{thr}}{2P_{m,i}} \pm \frac{f\Delta P_f}{P_{m,i}}\right)dV \tag{1}$$

where: $\frac{aw}{c}$ – the *finite speed's* contribution ($a = \sqrt{3k}$; $c = \sqrt{3RT}$); w – the piston average speed; $P_{m,i}$ – the *instantaneous average pressure;* b – the coefficient related to the gas throttling, $0 < b < 2$; ΔP_{thr} – the pressure losses caused by throttling; f – the fraction of the heat generated by friction between the machine moving parts that remains in the system ($0 < f < 1$); ΔP_f – pressure losses due to friction between the moving parts of the machine.

Note that eq. (1) is the essence of Thermodynamics with Finite Speed, by combining the First Law with the Second Law for irreversible processes generated by finite speed.

Irreversible mechanical work for processes with finite speed for closed complex systems is given by [11, 13, 19, 20]:

$$\delta L_{irr} = P_{m,i}\left(1 \pm \frac{aw}{c} \pm \frac{b\Delta P_{thr}}{2P_{m,i}} \pm \frac{\Delta P_f}{P_{m,i}}\right)dV = P_p dV \tag{2}$$

where: P_p – pressure on the piston.

In both equations, the (+) and (–) signs inside the parenthesis correspond to compression and expansion process respectively.

The mechanical friction and throttling losses are expressed in a similar manner to the case of internal combustion engines from Heywood [21] that was adapted [11-13] in an appropriate way to be included in the expression of the *First Law of Thermodynamics with Finite Speed* applied to any piston-cylinder machine. The expressions of these losses are:

$$\Delta P_f = A + Bw; \quad \Delta P_{thr} = C_{irr} w^2 \tag{3) – (4}$$

where: *A=0.97 ; B=0.045 and* C_{thr}*=0.005* [11].

By integrating the mathematical expression of the First Law of Thermodynamics for Processes with Finite Speed that takes into account the piston speed, friction and throttling on the adiabatic expansion, the actual thermal efficiency of the irreversible Carnot cycle results as:

$$\eta_{act}^{irr} = 1 - \frac{T_0}{T_X}\left\{1 + 4\left[\frac{aw}{c_1} + \frac{\Delta P_f}{P_{m34}} + \frac{\Delta P_{thr}}{P_{m34}}\right]\frac{\left(1-\sqrt{\frac{T_0}{T_X}}\right)}{(\gamma-1)\ln\frac{p_2}{p_3}}\right\} \tag{5}$$

To better emphasise the irreversibility effect on the cycle efficiency, eq. (4) can be also expressed as:

$$\eta_{act}^{irr} = \eta_{CC}\eta_{IIad.irr}^{w,thr,f} \tag{6}$$

where the reversible Carnot cycle efficiency and the Second Law Efficiency are, respectively:

$$\eta_{CC} = \left(1 - \frac{T_0}{T_X}\right), \quad \eta_{IIad.irr}^{w,thr,f} = 1 - \frac{C_{irr}\frac{T_0}{T_X}}{\left(1+\sqrt{\frac{T_0}{T_X}}\right)} \tag{7) – (8}$$

Internal irreversibilities generated by the finite speed, friction and throttling in the internal being considered by the irreversibility coefficient C_{irr}.

$$C_{irr} = 4\left(\frac{aw}{c_1} + \frac{\Delta P_f}{P_{m34}} + \frac{\Delta P_{thr}}{P_{m34}}\right)\frac{1}{(\gamma-1)\ln\frac{p_2}{p_3}} \tag{9}$$

The actual power output of the cycle, assuming that heat transfer is generated by a finite temperature gap, $\Delta T = T_H - T_X$, results:

$$\dot{W}_{act} = \dot{Q}_H \eta_{act}^{irr} = UA(T_H - T_X)\eta_{act}^{irr} \tag{10}$$

where: U is the overall heat transfer coefficient and A is the heat transfer area at the hot-end.

In order to get a general model of the Carnot cycle with internal and external irreversibilities, the non – dimensional power is used:

$$P_{ND} = \frac{\dot{W}_{act}}{U\,AT_H} \tag{11}$$

Equation (10) may also be written: $$P_{ND} = \left(1 - \frac{T_X}{T_H}\right)\left(1 - \frac{T_0}{T_X\Phi}\right) \tag{12}$$

with: $$\Phi = \frac{1}{1 + C_{irr}\left(1 - \sqrt{\frac{T_0}{T_X}}\right)} \tag{13}$$

where Φ is the *external and internal irreversibility coefficient*.

The optimal temperature corresponding to the maximum of the *non-dimensional power* and taking into account the internal irreversibility was derived as:

$$T_{opt}^{(w\neq 0)} = \sqrt{T_H T_0\left[1 + C_{irr}\left(1 - \sqrt[4]{\frac{T_0}{T_H}}\right)\right]} \tag{14}$$

Values of $T_{X,opt}$ were graphically obtained as illustrated in Figure 4.

3. OPTIMIZATION RESULTS OF AN IRREVERSIBLE CARNOT CYCLE ENGINE

The analytical results of the model are illustrated for air as working fluid and the following input data: $T_H = 2000K$; $T_0 = 300K$; $\gamma = 1.4$; $p_2 = 3bar$; $p_3 = 1bar$.

Figure 2 shows that the *actual thermal efficiency* of the cycle decreases more rapidly with piston speed and it is reduced by each internal irreversibility cause, mainly by throttling.

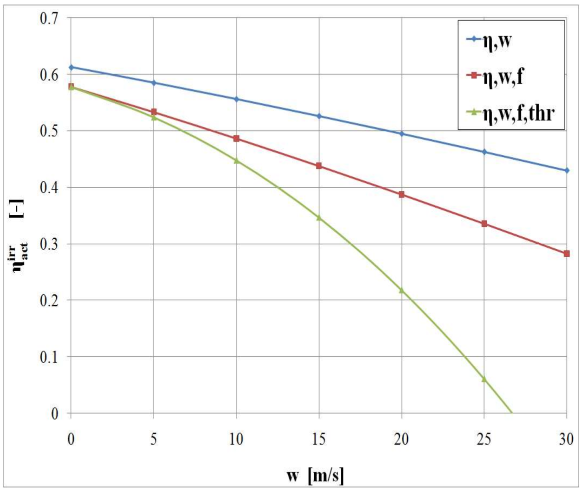

Figure 2: The effect of irreversibility causes on the actual cycle efficiency

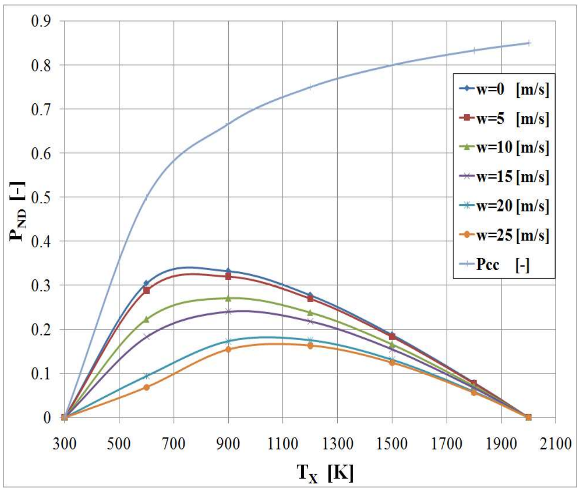

Figure 3: The non-dimensional power as a function of the cycle high temperature and piston speed *w*

The *non-dimensional power* variation as a function of the cycle high temperature and *piston speed* is shown in Figure 3. The reversible Carnot power, P_{CC}, was added for comparison. The *non-dimensional power* is seen to have a maximum value for any *fixed piston speed* or internal irreversibility and this maximum occurs at increasingly the cycle higher temperature T_X as the *piston speed* or *internal irreversibility* increases. Also, these maximum values decrease with increased *piston speed*. Figure 4 shows the *optimum temperature* variation with the *piston speed*, which proves a strong influence of internal irreversibilities, i.e. for $T_{X,opt} = 1000K$ $(w = 15\,m/s)$ compared to 780 K $(w = 0\,m/s)$.

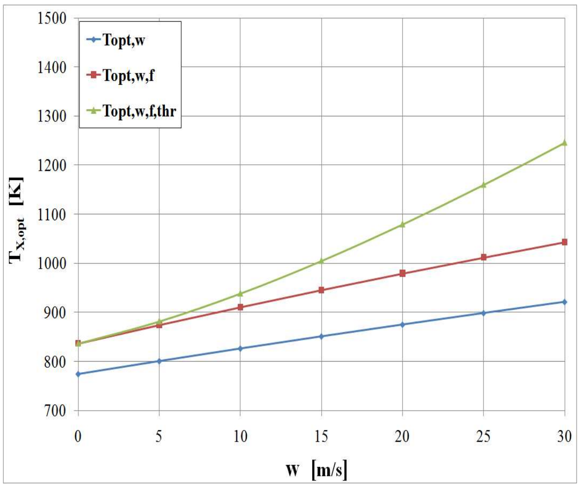

Figure 4: The effect of piston speed and irreversibilities on optimum high temperature

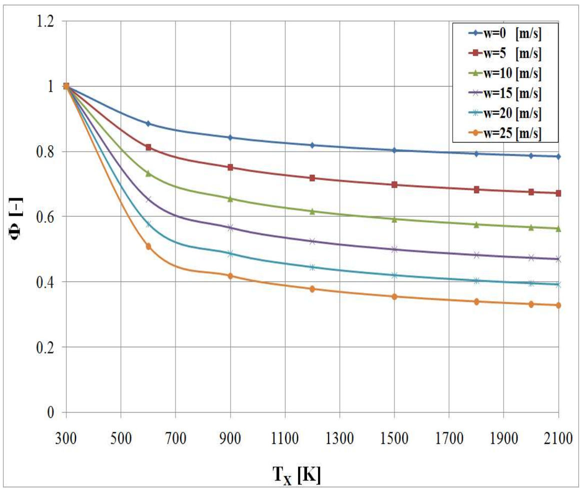

Figure 5: The irreversibility coefficient Φ versus the optimum high temperature

Figure 5 shows that the *internal and external irreversibility coefficient* decreases with increased piston speed, as expected, and it decreases more rapidly with piston speed at lower cycle high temperatures.

4. THE IMPACT OF THE CARNOT CYCLE WITH EXTERNAL AND INTERNAL IRREVERSIBILITIES ANALYSIS ON THE DEVELOPMENT OF THERMODYNAMICS WITH FINITE SPEED AND THE DIRECT METHOD, AND THE UNIFICATION TENDENCY BETWEEN TFT AND TFS

A recent work [20] explains the origins of paper [10] and its impact on the *Development of Thermodynamics with Finite Speed* and the present tendency of unification between Thermodynamics with Finite Time and Thermodynamics with Finite Speed.

Actually, the year 2011 marked 50 years from the beginning of *Thermodynamics with Finite Speed* (TFS), in which the *Direct Method* was *invented* [12, 19] and then *validated* [13, 20]. The Direct Method provides *analytical expressions for Efficiency and Power (as function of speed), which are very useful for Optimization and better Design of Thermal Machines.*

As the present analysis has shown, the unification of TFT and TFS introduced a *correction of the famous formula* of Curzon-Ahlborn, where the "nice radical" appears in the *Carnot Cycle Efficiency* (eq. (5)). As it is well known, the TFT approach takes into account only *external irreversibilities*. Based on the Fundamental Equation of TFS, namely First Law for Processes with Finite Speed, analytical corrections were made here by taking into account internal irreversibilities generated by the Finite Speed of the piston, *w*, in addition to the external ones.

5. CONCLUSIONS

The analysis and optimization of an irreversible Carnot engine operating was presented. Equations were developed for the *internally* and *externally irreversible* Carnot cycle. The *internal irreversibility* has been related to the *finite piston speed* by taking into account in addition to the Finite Speed, two other causes of internal irreversibility in thermal machines, namely *Friction* and *Throttling*. The Curzon-Ahlborn expression for the efficiency of the *externally irreversible* Carnot cycle was modified by an *internal* and *external irreversibility coefficient* that was shown to increase with increased *piston speed* and to be significant at high but attainable piston speeds. Actually, this *coefficient* Φ may be regarded as an important *achievement towards the unification* between TFS and TFT. The variation with the piston speed of the *optimum cycle high temperature*, *maximum power*, and *efficiency* for the *internally* and *externally irreversible Carnot cycle* were presented. The *optimum temperature* corresponding to *maximum power* is shown to increase with increased *piston speed*. The impact of these achievements on the *Development of TFS* and on the present tendency of unification between TFT and TFS was discussed.

We hope that this work marks an important step toward the development of a more powerful Engineering Irreversible Thermodynamics, which could be a synthesis or unification between Thermodynamics with Finite Speed and Thermodynamics in Finite Time.

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COMBINED OPTIMIZED HEATING METHOD FOR AN ISOLATED BUILDING

USING A MOTOR-GENERATOR AND A GEOTHERMAL SOURCE

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ABSTRACT

Following the most actual methods referring to co-generating and tripled-generating processes, the above mentioned theme proposed a multipurpose schematic in which an isolated location could be supplied with electricity, providing meanwhile central heating and warmed household water. The installation is based on the use of a Diesel natural gas engine operating an electric generator and a deep-water pump to deliver the geothermal agent as the main heating source. The engine operation is optimized to furnish a maximal power of 20 kW (at 1500 rpm constant speed) to the generator and to ensure 2 kW heating power from the exhaust gases to the main water endusing boiler for household consumption. The electric pump allows the thermal agent flowing (with 60ºC at the entrance) for a necessary residence heating capacity of 28 kW. The global efficiency of the installation is maximized at around 75% corresponding to a 31% brake thermal efficiency (BTE) of the engine.

Key words: co-generation, Diesel natural gas engine, geothermal energy, high efficiency

3. INTRODUCTION

Co-generation processes are moreover used in order to ensure high efficiency of classic installations to produce meanwhile thermal and electric energy for industrial and residential purposes. The produced mechanical energy and the waste heat recovery (WHR) of the internal combustion engines have been used as parts of combined energetic circuits in many applications by now [1]. Rankine Cycles (RC) or Organic Rankine Cycles (ORC) are frequently used with the contribution of the thermal engines as heating and overheating cycles sources [2] [3]. The result is the usage of combined circuits, one concerning the air-fuel mixture and the exhaust gases and the other one referring to the liquid and steam phases of the main thermal agent, for which the goal is to maximize the global efficiency of the entire system. Therefore, the use of the stationary internal combustion engines is significantly improved in terms of efficiency and emissions levels beyond their basic appliance of motion energy furnishing to the electric generator.

Characterizing the normal facility in producing electric power, Diesel engines are often installed in isolated residential and industrial locations deserving autonomous applications [4][5]. This always represents a solution to be taken into consideration separately or together with the other particular energy means, such as the wind turbines, the solar panels, the hydro-turbines, the fuel cells and nevertheless the geothermal resources.

This work theoretically analyzes the importance of the combined used of diesel engine thermal and mechanical capacities together with the geothermal factor in providing heating energy, electricity and hot water preparation for a household necessities, under high combined efficiency.

4. DESCRIPTION OF THE FACILITIES

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The 20 kW electric power necessary for the exemplified household is given by the motor-generator assembly, which represents the core of the global installation. The generator function is operated by a turbocharged Diesel gas engine, with a brake power of 20 kW, at nominal speed of 1500 rpm. The features of the group are listed in Table 1 [6].

Table 1: The features of the motor-generator group

Electrical output, P_{el} [kVA]	20
Nominal revolution speed, n [rpm]	1500
Brake Thermal Power, P_e [kW]	20
Power factor, cos ϕ [-]	1
Monophasic voltage, U [V]	240
Frequency, f [Hz]	60
Number of cylinder, i [-]	2
Total swept volume, V_t [cm^3]	997
Compression ratio, ε [-]	9.5:1
Maximum Gas consumption at full load , C_h [m^3_N/h]	7.96
Length [mm] x Wide [mm] x Height [mm]	1218 x 638 x 732
Weight, m_{gen} [kg]	238

The geothermal agent, with the inlet temperature of 60ºC and the outlet temperature of 45ºC is circulated through the heating system which requests an installed capacity of 28 kW. The circulation of the hot water, from the bottom of the well (10 m), at 1.3 m/s speed and under 2 bar constant pressure is ruled by the electric pump (P), with a maximum power of 2 kW. The schematic is completed by the presence of the filter (F) and of the degasser (DG), due to the water compounds to form undesirable internal deposits (see Fig.1).

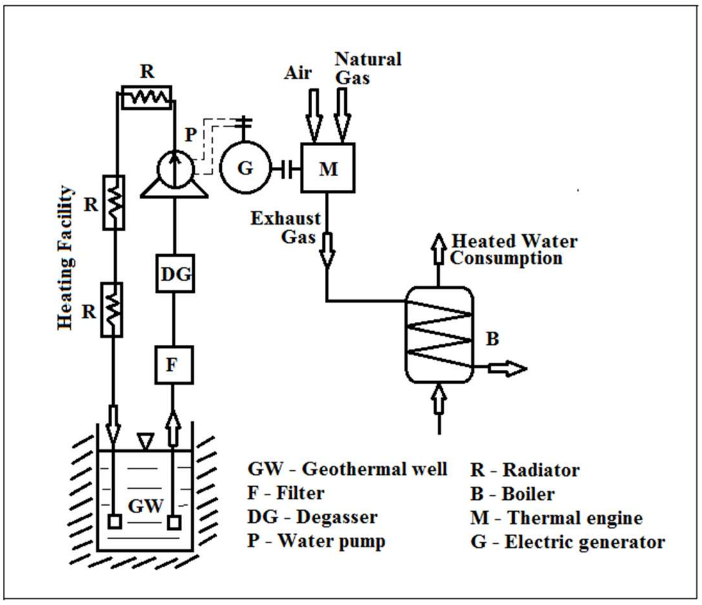

Figure 1: The schematic of the household facilities

The warm water is prepared using a 50 l capacity boiler, heated with the waste heat of the engine exhaust gas. The necessary heating power is around 2 kW, enough to prepare 45 kg of consumable hot water during 1h time period, from 20ºC up to 60ºC. The boiler is able to keep at constant level the water temperature even with an extra electric consumption. In terms of water zero consumption with no significant heat losses, exhaust gases are purged directly outside through a special designed valve automatically controlled as a function of water temperature.

2. SYSTEM EFFICIENCY

This chapter is supposed to answer to the questions regarding the installation compounds efficiency and the entire system efficiency. Starting with the calculation of the thermal agent flow rate m_{ag} from the heating power P_h, established at 28 kW, it can be written:

$$\dot{m}_{ag} = \frac{P_h}{c_w \cdot \Delta T_w} = 0.444\, kg/s \qquad (1)$$

where c_w is the water specific heat, and the heating degree ΔT_w is 15ºC. With the chosen pipes diameter of 25.4 mm the agent circulation speed can also be calculated:

$$w = \frac{4 \cdot \dot{m}_{ag}}{\mu \cdot \pi \cdot d_i^2 \cdot \rho_w} = 1.258 m/s \qquad (2)$$

where μ is the pipe flow rate coefficient and ρ_w is the agent density.

For the natural gas Diesel engine, the fuel consumption C_h at full load and 1500 rpm is 7.96 $m^3{}_N$/h, or 5.97 kg/h. The engine power resulting from the combustion process is:

$$P_{comb} = \frac{C_h \cdot Q_i}{3600} = 63 kW \qquad (3)$$

where Q_i is the natural gas low heating value (LHV). The engine brake thermal efficiency η_e and the brake specific fuel combustion c_e result as following, knowing its brake thermal power P_e is 20 kW.

$$\eta_e = \frac{P_e}{P_{comb}} = 0.317 \qquad (4)$$

$$c_e = \frac{C_h}{P_e} \cdot 10^3 = 298.5 g/kWh \qquad (5)$$

The minimum motion power for the circulation pump has to be calculated as a sum between the several types of pressure effects, dynamic, potential and stationary and the result is covered by the chosen value of 2 kW, deduced from the installed electric power and which takes into account the total pressure losses from the agent flowing circuit.

$$P_p = \dot{m}_{ag} \cdot \left(\frac{p}{\rho_w} + \frac{w^2}{2} + g \cdot \Delta h \right) = 133 W \qquad (6)$$

where p is the stationary agent pressure of 2 bar, w is its flowing speed of 1.3 m/s, ρ_w is the agent density and Δh is the 10 m depth of the geothermal well.

The global efficiency of the system can be deduced according to the following expression:

$$\eta_{inst} = \frac{P_e + P_{exh} + P_h - \Delta P}{P_{comb}} = 0.746 \quad (7)$$

in which P_e is the engine brake thermal power, equal to the electric produced power (20 kW), P_{exh} is the boiler heating power from the exhaust gas thermal energy (2kW), P_h is the central heating power (28 kW), ΔP is the sum of the electric and mechanical power losses, (3 kW) including the electric power requested by the agent circulation pump and P_{comb} is the engine combustion power (63 kW).

3. CONCLUSIONS

The above presented case study has been referring to the possibility to instal a hybrid type of heating system, as a combination between the use of the geothermal energy for the central heating and the use of the waste heat of the motor-generator exhaust gas, which also furnishes the global necessities of electric energy.

The combined system is improving the efficiency which otherwise should remain at one certain level characterizing the turbocharged gas Diesel engine, motioning the electric generator.

The described analysis could be easily extended in case of further theoretical research with the presumed optimization of the system elements interoperability, starting from the given boundary data and looking forward to increase the global efficiency.

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ENERGY EFFICIENCY AUDIT OF A COMPANY PRODUCING FAIENCE AND FLOOR TILES AND SANITARY PRODUCTS

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ABSTRACT

An energy audit of a company producing faience and floor tiles and sanitary products has been done. The following 2 energy saving measures (ESMs) have been proposed as a result of the energy audit: 1.Replacing the old Carfer type kiln with one single-layer roller kiln; 2.Replacing an old electric driven compressor with one screw compressor with variable speed drive. Implementation of the new equipment reduces energy consumption by 45%. The natural gas consumption will be reduced by 734.5 kNm^3, the electricity consumption - by 371 MWh and the CO_2 emissions will be reduced by 1596 tons per year. The annual O&M costs will be reduced by EUR 767. The total annual cash savings is EUR 295,314.

1. INTRODUCTION

Climate change and security of energy supply are two major challenges needing urgent action. They have common causes and common solutions. Except of that the future seems marked by permanently rising prices of energy, which we use in all areas of our own life.

Analyses based on Euro stat data show retardation of Bulgaria in basic energy-economical indicators for sustainable development. Except of that Bulgaria is one of the most dependent countries with regard to import of energy resources in Europe – 71, 6%.

The proposed energy efficiency project aims to reduce the energy consumption of industrial processes of a company producing faience and floor tiles and sanitary products ("Khan Asparuh Jsc") by replacing some of the outdated technological equipment. The new equipment will allow the company to continue producing all of their current products but at lower energy costs.

2. PROJECT BASELINE AND PROBLEM IDENTIFICATION

An energy audit of the Khan Omurtag Jsc factory was done. The factory is a part of KAI Group and is located near Shumen town about 100 km west of the Black Sea. KAI Group is the largest Bulgarian manufacturer of ceramic tiles and the only manufacturer of glazed and unglazed porcelain tiles on the Balkan Peninsula. Their product range includes wall and floor ceramic tiles, porcelain tiles and decorative elements for indoor and outdoor decoration. The annual production capacity of the Group' factories exceed 17 million sq. m. of floor and wall ceramic tiles and porcelain tiles. A detailed analysis of the working regimes of the existing equipment, including the analysis of natural gas and electricity consumption and O&M costs, were performed. Khan Omurtag Jsc uses both electricity and natural gas in the process of the ceramic tile production. Electricity is used for running the electric motors of the machines in the production line and a compressor. Natural gas is used during the drying and firing/kilning of the production. Their annual energy use for the kiln and compressor, which have to be replaced, is:

- Natural gas consumed by the old kiln: 1,582 kNm^3
- Electricity consumed by the old kiln's electric motors and the old compressor: 1,274 MWh

The total annual O&M costs for the old kiln and compressor is EUR 6,136. The balance of energy consumption of 2 equipments which have to be replaced is shown in Figure 1.

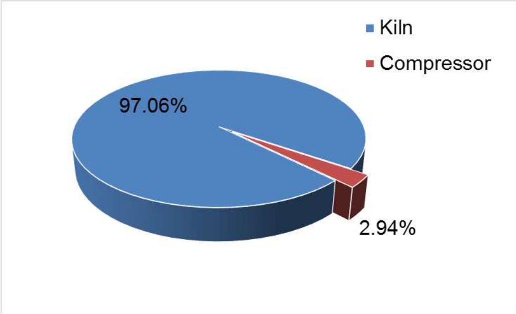

Figure 1: Energy Consumed by the Equipment that is to be replaced

Existing condition of Khan Omurtag Jsc kiln used for production of ceramic tiles. Khan Omurtag Jsc uses many types of dryers and kilns for production of ceramic tiles. The company owns 4 kilns (Sacmi 2070/50.4; Carfer; Sacmi FMS 250/100.8; Sacmi FMS 285/100.8 MSX). The Carfer kiln's condition is poor. It is morally and physically outdated and is proposed for the replacement. The kiln is used for firing the ceramic tiles and is located in one of the company's production buildings. Railroad cars filled with tiles are transported to the entrance of the kiln, where they are unloaded and fed into the kiln. Kiln temperatures are strictly controlled at each point of the kilning process, depending on the type of the tile and the raw materials used. The firing process takes 30 to 75 minutes at temperatures above 1,100ºC. The kiln's operational area has several modules: initial module, heating zone module, heating and firing module zone, fast cooling module, slow cooling module and final cooling module. The transportation of the ceramic tiles through the kiln operational area uses rollers. Total installed capacity of the engines running the kiln is 130 kW. The production line's estimated operational hours are 7,680 hours, resulting in electricity use of 798,720 kWh per year. The tile firing uses natural gas burners. The total consumption of the natural gas by the old kiln's burners is 205 Nm^3 per hour. Additional natural gas, 8,090 Nm^3/year, is used for covering the heat losses through the kiln's envelope. Hence the old Carfer kiln's total annual natural gas consumption is 1,582 kNm^3 per year. Average natural gas consumption for kilning of 1 kg of production is 2930 kJ/kg. Productivity of the kiln - 2.5 t/h and maximum productivity is 70 t/24 hours (2.916 t/h). The kiln's O&M cost is EUR 5,113 per year. Figure 2 illustrates the kiln's current condition.


Figure 2: Photographs of the Carfer Kiln, which has to be replaced

Existing condition of Khan Omurtag's compressor. Khan Omurtag Jsc owns one compressor, Hafi, type V4-055-L08S, for the production of compressed air. The compressed air runs the pumps transporting the slurry and glaze as well as for sorting of the production. The installed capacity of the compressor is 55 kW. The productivity of the compressor is 9.1 m^3 per min at 8 bar pressure. The compressor's estimated annual hours of operation are 8,160 hours. The annual electricity consumption of the compressor is 474,862 kWh per year. The existing compressor is old and inefficient. Its O&M cost is EUR 1,023 per year.

3. DESCRIPTION OF RECOMMENDED ENERGY SAVING MEASURES

The main objective of this Khan Omurtag Jsc project is to reduce energy consumption and O&M expenses. This is achieved through the implementation of the following energy energy saving measures (ESMs):

- ECO 1: Replacing one Carfer-type old kiln with a single-layer roller kiln
- ECO 2: Replacing an old electric driven compressor with a screw compressor with a variable speed drive

Replacement of one old kiln with another single-layer roller kiln. This energy efficiency project plans to install one single-layer roller kiln, type FMS 285/111.3 (Figure 3), at a price of EUR 1,072,500. Technical data for new kiln are presented in Table 1.

Figure 3: Photo of a Single-Layer Roller Kiln, Type FMS 285 (Source: internet)

Table 1: Main Characteristics of the Single-Layer Roller Kiln, Type FMS 285

Model	Max. chanel width	Optimum load width	Indicative length	Indicative firing cycles	Max. working temperature	Fuel consumption	Minimum size that can be produced	Atmosphere
130	1300	1060	29-50	30-120	1160-1250	Gaseous	75x75	Oxidizing
165	1650	1410	50-70	30-120	1160-1250		100x100 (95x95)	
191	1910	1670	50-105	30-120	1160-1250		100x100	
207	2070	1830	50-130	30-120	1160-1250		150x150	
223	2230	1990	50-150	30-120	1160-1250		150x150	
250	2500	2260	65-150	30-120	1160-1250		150x150	
260	2600	2360	65-180	30-120	1160-1250		150x150	
285	2850	2600	75-200	30-120	1160-1250		200x200	
305	3050	2800	75-200	30-120	1160-1250		200x200	

The new kiln is of the fixed air/modulated gas type. It provides outstanding pressure stability inside the kiln. The number and characteristics of the burners make the system both clean and flexible. Installation of a high number of burners, from pre-firing onwards, guarantees progressive, uniform heating and prevents the creation of hot spots and/or "shadow" areas inside the kiln. Each burner can be adjusted independently and allows for the accurate control of the firing curve. Moreover, Sacmi uses patented RAY-type burner units that compensate for the lower temperatures that can occur up against the walls of the firing channel. This improves the way in which the heat is distributed over externally located pieces and so eliminates one of the most common tile defects (trapezoidal warping). Sacmi made scientific research regarding the flame of RAY-type burners. A CFD (Computational Fluid Dynamics) study shows that temperature field in the kiln is very stable and well distributed. The even layer temperature can be achieved with lower consumption of natural gas.

The new kiln has 53 modules distributed in 7 zones: inlet zone, heating zone, initial heating zone, firing zone, fast cooling zone, slow cooling zone, and final cooling. The modules have thermal insulation applied on walls and roof, rollers for transporting the tiles in the accordance with the zones' specifics, rollers drives, fans, natural gas burners with flame control, control panel, chimneys, and an electricity generator for drainage of the kiln in case of the interruption of the main power supply. The kiln is equipped with latest systems for natural gas savings – system SPR. The SPR system is specially designed for this type of kiln. The system allows separation of final cooling of the kiln as using the hot air from the kiln for supplying of the burners. The fans operating in high temperatures accomplish this separation. This system reduces the consumption of natural gas by 15% by providing hot air to the burners at a temperature of 230ºC. The productivity of a new kiln is 6 tons of tiles per hour. The new kiln's operational hours are 3,200 hours per year (the same as the old kiln). Total installed capacity of the electric motors serving the kiln line is 235 kW. Their electricity consumption is 601,600 kWh per year. The average natural gas consumption of the burners is 265 Nm^3/hour. The total annual natural gas consumption is 848,000 Nm^3/yr. The new kiln's annual O&M cost is EUR 4,090. The expected annual cash savings from replacing the old kiln is EUR 285,702.

Replacement of an old electric compressor. This ESM envisages delivery and installation of one electric screw compressor with variable speed drive, type Gardner Denver VS 75, price EUR 27,500. The new compressor is an efficient and versatile solution even for the most demanding industrial applications. The variable speed drive/motor/compressor combination is designed to meet the varying demands of industrial systems at the lowest possible specific power. Inverter is integrated in the electric cabinet and protected from dust by replaceable inlet filters. The maximum operational pressure of the compressor is 13 bars and the minimal - 5.00 bars. The flow rate at nominal pressure and maximum revolutions is 13.64 m^3 per min. The flow rate at nominal pressure and minimal revolutions is 2.26 m^3/min. Integrated microprocessor is used for managing, monitoring, control and service. An Air Smart system automatically controls the compressor through change of revolution of the engine with frequency converter. The optimal operational temperature of the environment is between 1 and +45ºC. Increased temperature of the compressed air at the outlet of the system with +8ºC is expected. Needed flow rate of the cooling air is164 m^3/min. Relation between the flow rate of the compressed air and installed power is shown in Figure 5.

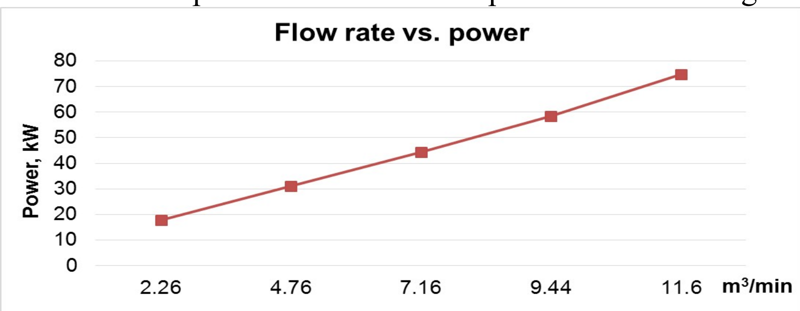

Figure 5: Flow Rate of the Compressed Air Delivered by the Compressor vs. Power

The new compressor is equipped with a variable speed convertor allowing the adjustment of the compressor's output to the needs of the system. It is established that average consumption of compressed air is 9.1 m^3/min. This amount of flow has to be delivered to the system by the compressor approximately 80% of the time. The power needed for delivering such amount of flow at the requested pressure, according Fig. 5, is 58.5 kW. For 15% of the time the compressor will deliver an average flow rate of 4.72 m^3/min. Only 5% of the time compressor will operate at its maximum flow rate and pressure. This will significantly reduce the electricity consumption required for compressed air at the plant. This ESM's implementation will result in reduced electricity consumption of 174.3 MWh per year. The annual O&M cost will increase by EUR 256. The total expected annual cash savings from ECO 2 is EUR 9,613.

4. RESULTS FROM PROPOSED ESMS.

The project cost includes the costs for design, equipment delivery and installation. The impact of the ESMs implementation is presented in Table 2.

Table 2: ESM Fuel Consumption, Expenses and Savings

	Electricity		Natural gas			Energy total	O&M	Total	ESM cost	Simple payback period
	MWh/yr	EUR	1000 Nm³	MWh/yr	EUR	MWh/yr	EUR	EUR	EUR	Years
ESM 1: Replacement of old kiln with single-layer roller kiln										
Baseline	798.7	45216	1582	14860	589310	15658.3	5113	639639	1072500	3.75
After	601.6	34057	848	7963	315790	8564.3	4090	353937		
Savings	197.1	11159	734	6897	273520	7094.0	1023	285702		
ESM 2: Replacement of old compressor with new one										
Baseline	474.9	26882				474.9	1023	27905	27500	3.72
After	300.5	17014				300.5	1278	18292		
Savings	174.3	9869				174.3	-256	9613		
Total consumption, expenses and savings for the project										
Baseline	1274	72098	1582	14860	589310	16133	Energy Saving Ratio = 45.05%			
After	902.14	51070	848.0	7963	315790	8865				
Savings	371	21028	734.5	6897	273520	7268				

Table 3 presents the base project cost breakdown without VAT. The project's investment expenditures include costs for delivery of equipment and construction. The total cost for the project's implementation is EUR 1,100,000, of which EUR 1,000,000 will be financed by bank loan and Khan Omurtag Jsc will pay EUR 100,000. Project investment will be made in October 2013 and January 2014. The project's operational costs include all costs related to the operation of old kiln and compressor installed at the Company. The baseline annual O&M costs for the old kiln and compressor are EUR 6,136. The costs include cost for maintenance and repairs, spare parts and lubricating materials. After implementation of the ESMs the O&M costs for each measure are EUR 5,369 and O&M costs savings are EUR 767.

Table 3: Base Project Costs for Each ECO

		Equipment (EUR)	Construction Works (EUR)	Total Project Cost (EUR)
ESM 1	Replacement of old kiln with single-layer roller kiln	897 750	170 750	1 068 500
ESM 2	Replacement of old compressor with new one	27 500	4 000	31 500
Total Cost		925 250	174 750	1 100 000

Activity based schedule (ABS). Table 4 shows the activity-based schedule of the project. The ESMs implementation occurs from October 2013 to January 2014.

Other project benefits: As a result of the ESMs' implementation, in 2014 the CO_2 emissions of Khan Omurtag Jsc will decline by 1,596 tons and for the period 201 to 2015 they will decrease by 3,337 tons. The CO_2 emissions reduction for the period 2014 to 2015 is presented in Table 5.

In 2014, the SO_2 emissions will decrease by 0.84 tons, and for the period 2014 to 2015 the total SO_2 emissions will decline by 1.76 tons (see Table 5).

In 2014 the nitrogen dioxide ($NO_{x)}$) emissions will be reduced by 1.30 tons. The estimated NO_x emissions reduction is 2.72 tons for the period 2014 to 2015.

Table 4: Activity Based Months

		2012			2013	
		X	XI	XII	I	II
ESM 1: Replacement of old kiln with single-layer roller kiln						
	Equipment delivery of single-layer roller kiln	xxxx			xxxx	
	Construction works & Implementation of the system				xxxx	
ESM 2: Replacement of old compressor with new one						
	Equipment delivery of screw VSD compressor	xxxx				
	Construction works & Implementation of the system			xxxx		
Total Project		xxxxxxxxxxxxxxxxxxxxxxxxxx				

Table 5: Carbon Dioxide Emissions Reduction

Emission Characteristics		**2014**	**2015**	**Total**
Elektricity Savings	MWh/yr	340	371	712
Natural Gas Savings	GJ/yr	24829	24829	47588
CO_2 Emission Reduction from Electricity	t CO_2 /yr	326	355	681
CO_2 Emission Reduction from Natural Gas	t CO_2 /yr	1270	1385	2655
CO_2 Emission Reduction Total	**t CO_2 /yr**	**1596**	**1741**	**3337**

In 2013, dust emissions will be reduced by 0.21 tons. The estimated dust emissions reduction is 1.03 tons for the period 2012 to 2015.

Productivity improvement: The implementation of the proposed ESMs will improve the quality of the manufactured products while reducing energy and O&M costs at Khan Omurtag Jsc.

Other benefits: The new energy equipment and facilities installation will improve employee safety at Khan Omurtag Jsc. The equipment is designed and manufactured in accordance with the contemporary European standards for employee safety.

4. CONCLUSIONS

Energy audit of a factory producing faience and floor tiles and sanitary products was done. A detailed analysis of the working regimes of existing equipment, including the analysis of natural gas and electricity consumption and O&M costs, were performed. It is found that some of the equipment was morally and physically outdated. Because of that the following 2 energy saving measures (ESMs) were proposed: 1.Replacing the old Carfer type kiln with one single-layer roller kiln; 2.Replacing an old electric driven compressor with one screw compressor with variable speed drive. Implementation of the new equipment reduces energy consumption by 45%. The natural gas consumption will be reduced by 734.5 kNm^3, the electricity consumption - by 371 MWh and the CO_2 emissions will be reduced by 1596 tons per year. The annual O&M costs will be reduced by EUR 767. The total annual cash savings is EUR 295,314.

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EFFECT OF NATURAL VENTILATION ON GREENHOUSE INTERIOR TEMPERATURE

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ABSTRACT

The paper presents the effect of natural ventilation on the interior air temperature of a vegetable greenhouse located in Muntenia, Romania. Energy balance equation is applied for the greenhouse in order to determine the interior air temperature without adding any exterior heating or cooling load. The solar irradiance received by the greenhouse is estimated based on isotropic sky analysis models in clear sky conditions. Interior air temperature profile is numerically simulated all along a day, in winter and in summer. In order to maintain a constant optimum interior air temperature during vegetation, heating and respectively cooling loads are consumed. In order to diminish the cooling load, natural ventilation is generally applied. Different dimensions of the ventilation window are considered. A daily profile for optimum opening is proposed in order to maintain the interior air temperature as close as possible to the set value and thus to minimize the cooling load.

1. INTRODUCTION

The paper is devoted to the study of natural ventilation of a greenhouse located in Romania, 44.25ºN latitude. The aim is to provide useful information regarding the necessary ventilation in order to maintain an inside temperature around the optimum value for vegetation with minim energy consumption for cooling.

An important number of publications presented studies related to optimum shape of a greenhouse at different latitudes [1][2], optimum orientation [3], materials, thermal models [4]. Sethi [2] concluded that uneven-span shape greenhouses receive maximum solar radiation. Dragicevic [3] stated that an E-W orientation should be preferred at latitudes of 44ºN and 54ºN. Panwar et.al. [5] summarized a review study regarding thermal modelling, shapes and orientations of greenhouses.

In our previous studies related to greenhouses in Romania, we have proved that E-W orientation is also preferred [6] as it involves lower inside air temperatures and solar heat gain in summer and higher ones in winter, in comparison to a N-S orientation. Also, applying energy balance equations to the greenhouse, we have found important inside air temperatures reached in the vegetation period for a non-ventilated greenhouse when compared to a ventilated one [7]. The conclusion is that a daily profile for natural ventilation would be very useful in order to diminish the energy consumption for cooling.

2. THERMAL MODELLING

A standard peak even span type greenhouse is considered in this study, of dimensions 4m wide, 40m long and 2m high, oriented on E-W direction. On the lateral side ten ventilation windows are performed, each of dimensions 2m high and 4m long that could be

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opened independently (see figure 1). The cover is made of polyethylene sheet having a thermal conductivity of 0.3 W/(m·K).

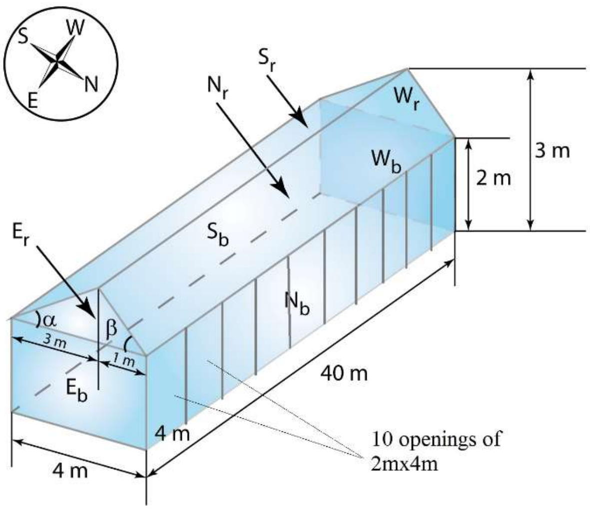

Figure 1: Studied vegetable greenhouse with independent openings for natural ventilation

The numerical simulations will be done in seven cases, ranging from no ventilation window opened (non-ventilated greenhouse) to one full lateral side opened (all ten windows opened). One window opened represents the case of $8m^2$ opening from a lateral surface of $80m^2$, i.e. 10% opening. The other considered cases are: 10% opening, 20% (2 windows), 40% (4 windows), 60% (6 windows) and 80% (8 windows) opening.

Energy balance equation is applied in steady state:

$$\dot{Q}_{Ab} + \dot{Q}_{Crop} + \dot{Q}_V + \dot{Q}_L = 0, \tag{1}$$

where, $\dot{Q}_{Ab}$ is the heat rate absorbed by the greenhouse air, in W, from solar radiation,

$\dot{Q}_{crop}$ is the crop transpiration rate, in W,

$\dot{Q}_V$ is the heat rate associated to natural ventilation, in W,

$\dot{Q}_L$ is the loss heat rate between greenhouse air and environment, in W.

The considered sign convention is that any heat rate entering the system is positive, while any heat rate exiting the system is negative.

The solar radiation density absorbed inside the greenhouse through its cover surface A is computed taking into account the transmittance-absorptance property of the cover material, polyethylene, $\tau\alpha$ =0.5:

$$\dot{Q}_{Ab} = \sum(\tau\alpha) G_T A, \tag{2}$$

G_T represents the solar radiation density, in W/m^2, computed by applying Hottel and Woertz model in clear sky conditions [8]-[10]. If experimental data are available, G_T should be considered on a time basis (daily profile).

The crop transpiration rate is computed according to HORTITRANS model [11]:

$$\dot{Q}_{Crop} = \lambda\left[a(\tau\alpha)G_T/\lambda + h_t(1-\Phi)p_{sat,Ti}/(\lambda\gamma_{psy})\right]A_{soil}, \tag{3}$$

where $a = 0.154LN\left(1+1.1LAI^{1.13}\right)$ and $h_t = 1.65LAI\left[1-0.56\exp\left(-(\tau\alpha)G_T/13\right)\right]$ are computed for a leaf area index LAI= 1 corresponding to young plants. The simulation was done by coupling Matlab [12] to EES (Engineering Equation Solver) [13] environment and thus, the saturation pressure of water vapors $p_{sat,Ti}$ was directly determined at the imposed inside temperature. The relative humidity Φ was chosen 90%. λ is the latent heat of vaporization (2540 kJ/kg) and γ_{psy} =66Pa/K is the psychometric constant.

The heat rate associated to natural ventilation in case when openings are performed is computed as:

$$\dot{Q}_V = \dot{V}_V \rho c_p \left(T_a - T_i\right), \tag{4}$$

where the exchanged air volume flow rate is, according to Roy et.al. [14]:

$$\dot{V}_V = 0.5A_w C_D \left(0.5gH_w \Delta T / T_a\right)^{0.5}, \tag{5}$$

H_w·represents the window height, T_a is the ambient air for which experimental data are considered [15], density ρ and specific heat c_p for air are computed. The discharge coefficient depends on window width W_w and opening angle α_w=90º (the window is full opened) [14]:

$$C_D = \left(1.75 + 0.7\exp\left(-W_w/\left(32\sin\left(\alpha_w\right)\right)\right)\right)^{-0.5} \tag{6}$$

Heat transfer loss between inside air and ambient is considered by wind convection and radiation:

$$\dot{Q}_L = h_{cv}\left(T_a - T_i\right)A + \varepsilon\sigma\left(T_a^4 - T_i^4\right)A, \tag{7}$$

A wind speed w = 0.4 m/s was considered for computing the convection heat transfer coefficient h_{cv}= 0.95+6.776*($w^{0.49}$) [16].

The algorithm applied is the following: for each month of the year the daily variation of solar radiation is computed and daily variation of air temperature is considered from experimental data. A time step of 10 minutes was applied. Heat rates are computed according to equations (2)-(7). When applying eq (1), the inside air temperature is determined. The simulation is done for each of the above mentioned cases (from non-ventilated to one lateral side fully opened).

3. RESULTS AND DISCUSSIONS

Results are presented for the period February – May, as considered the most important for early vegetation. Figures 2 and 3 present the daily variation of inside air temperature for February and April, respectively, for different openings. One may notice that without ventilation and on a fully sunshine day a temperature of 20ºC might be reached in February due to solar radiation. In a previous paper [7] when experimental solar radiation data were applied, and thus cloudy days were considered, the results emphasized an important difference: only 8ºC were reached instead of 20ºC. The present study is strictly discussed for clear sky days. Each opening degree contributes to the reduction of inside air temperature by few degrees. The most significant difference (of about 10ºC) is between non-ventilated and one-opening ventilated greenhouse.

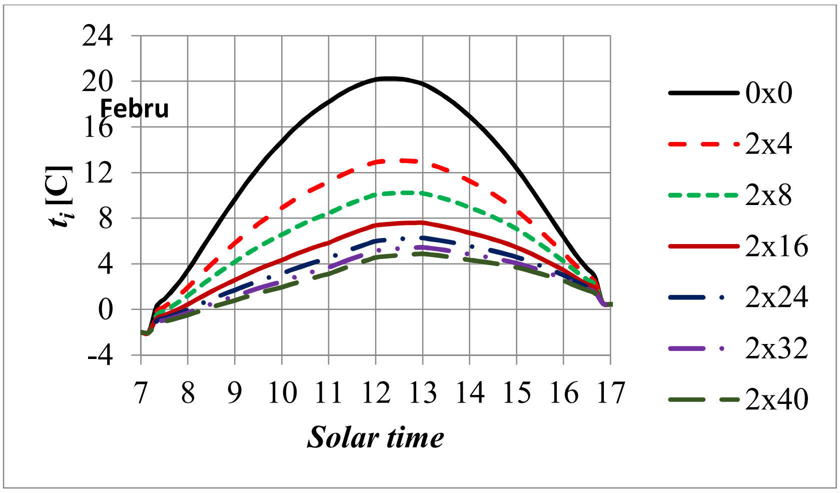

Figure 2: Inside temperature in February for different openings

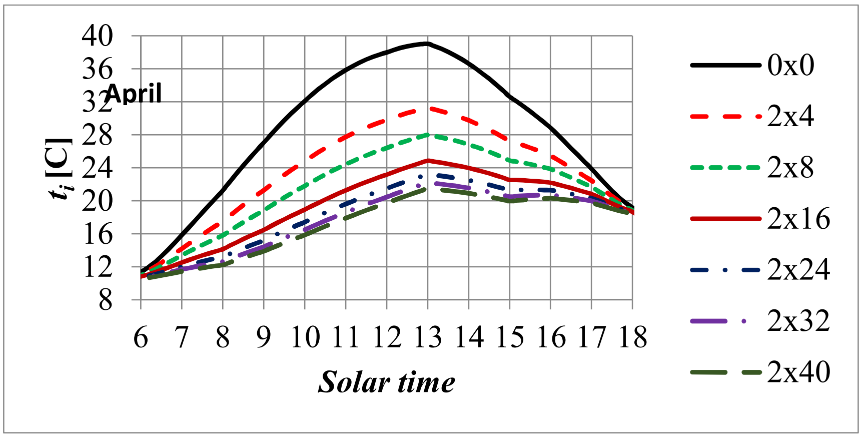

Figure 3: Inside temperature in April for different openings

Analyzing these results, one might think about choosing the right timing for applying gradual opening in order to maintain an inside temperature as close as possible to the optimum value. For an important number of crops, 20ºC is the desired level. Thus, the above obtained results were worked so that a certain opening is performed when the inside air temperature overcomes 20ºC. In Table 1 one may notice the corresponding time interval for each month. In February there is no need for natural ventilation as the temperature does not overcome 20ºC. More than that, heating is required as the inside temperature is far below 20ºC, even below freezing. In March, the inside temperature is above 20ºC between 10AM and 3PM, reaching a maximum of about 30ºC at 1PM. Thus a gradual opening is applied between 10AM and 1PM followed by a gradual closing of the ventilation windows from 1PM to 3PM. This is represented in Figure 4 by the green dotted curve. The corresponding air temperature reached under these circumstances is plotted in Figure 5 by the green dotted line. The result of applying the above procedure is a period of about eight hours of 20ºC inside the greenhouse.

Table 1: Inside temperature above 20ºC in clear sky conditions.

February	-
March	10-15
April	9-17
May	7-21

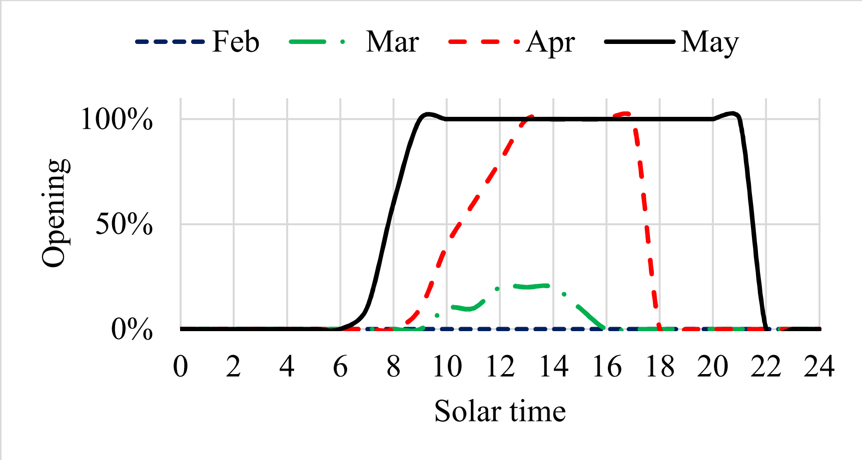

Figure 4: Optimum opening

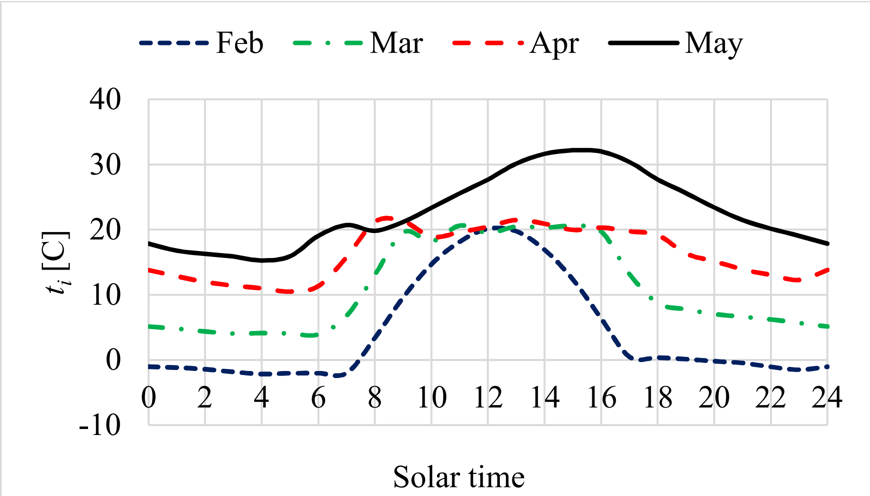

Figure 5: Inside temperature corresponding to optimum opening

In a similar manner, in April, natural ventilation should be performed between 9AM and 5PM. This time, the required opening ranges from 8m^2 to one lateral full side opened for two hours, between 2PM and 4PM, as emphasized by the red line in Figure 4. The corresponding air temperature is maintained at 20ºC from 8AM to 6PM (the red line in Figure5).

In May the inside temperature increases sharply, reaching 48ºC for a non-ventilated greenhouse at 1PM. Openings should be applied from 7AM to 9PM, as presented in Figure 4 by the black continuous line. The temperature is decreased, reaching a maximum of only 32ºC.

4. CONCLUSIONS

The above obtained results are important for sizing energetic systems of greenhouse cooling. Optimum timing for opening or closing natural ventilation windows are presented and accordingly their effect on the inside air temperature. Applying variable natural ventilation along a day, the inside air temperature might be kept around an optimum value for a longer period of time, so that the energy consumption for cooling is reduced.

Acknowledgements

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SPACE ANALYSIS AND ENERGY PERFORMANCE ASSESSMENT USING A BUILDING INFORMATIONAL MODEL

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ABSTRACT

Building Information Models (BIMs) are files containing physical and functional characteristics of the building and linked data, which can be exchanged or networked to support decision-making. BIM represent a current trend that permits exchange of information in digital format between different areas of activity, design, construction, energy assessment and Facility Management. A Building Information Model has been done using a Romanian office building and its digital plans. The goal of this paper is to make a space allocation for the newly created BIM that can offer multiple meanings: organizational structure, functional structure according to European norm EN 15221-6, and a grouping of the spaces to facilitate energy performance assessment of the building. For this purpose ARCHIBUS, a Facility Management software, was used. It is for the first time when, in ARHIBUS, such a multiple interdisciplinary space classification is done.

1. INTRODUCTION

BIM is a worldwide trend at the moment and it is beginning to change the way buildings look, the way they function, and the ways in which they are designed and built.
From the worldwide preoccupation related to BIM we can mention, BuildingSMART alliance [1], a council of the National Institute of Building Science. It is a North American organization that coordinates the creation of tools and standards that allow projects to be built electronically before they are built physically using Building Information Modeling. The organization develops standards as United States National CAD Standard [2] and United States National BIM Standard [3], comprehensive norms related to building informational models development.
From the definition given by International Facility Management Association (IFMA), Facility Management (FM) is a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology [4]. According to EN 15221-1 [5] definition FM represents "integration of processes within an organization to maintain and develop the agreed services which support and improve the effectiveness of its primary activities." A good presentation of FM and its history can be found on European Facility Management Network (EuroFM) [6]. An important promoter of Facility Management in our country is Romanian Facility Management Association (ROFMA) [7].
In order to help facility managers to conduct their activity a lot of appropriate pieces of software have been developed. According to [8], Buildium is a finest choice of property

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management software, especially for residential properties and associations. Buildium stands out for its clean and easy to navigate interface. Total Management is good commercial property management software. One of the best features is the highly customizable dashboard and it is optimal for multitasking. Another classification of facility management software [9] presents software as DirectLine, a Web-based service that provides solutions management maintenance and inventory cost and has 25 years of successful implementations. CAFM explorer is a software product for organizations looking to better utilize space, improve service levels, and tighten cost control. Here ARCHIBUS, , a global provider of software and services for real estate, facility, and infrastructure management can be found too. From the facility management field presentation done in [10] results that ARCHIBUS is one of the industry's leading software packages that it is compatible with Microsoft Office products and AutoCAD. The author mentions also IBM - Maximo Asset Management, a commercial maintenance management system. According to [11], ARCHIBUS is a brand of internationally renowned property management software. Its condition assessment function predicts and evaluates the future repair and cost efficiency of the maintenance activities. It is also designed to track the execution progress of maintenance activities.
BIM models can be used by some of the facility management software. This kind of software is an IWMS (Integrated Workplace Management System) that gets a single, integrated real estate-focused solution that addresses all operational areas of the five core functional areas: Space Management, Operations and Maintenance, Real Estate Management, Capital Project Management, Sustainability and Energy Management. Space Management module has features that permit CAD/BIM integration.
Before IWMS it was used CAFM system that has less functional area and operates from multiple technology platforms whereas true IWMS solutions are based on a single platform and database repository [12]. A typical CAFM system is defined as a combination of Computer-Aided Design (CAD) and/or relational database software with specific abilities for Facilities Management (FM) [13].
In this paper it is wanted to allow the use of the same building model for more disciplines. That means a time economy and a systematization of the data. At the same time, it is desired that a modification of the building model to generate the modification of the data to be transmitted. For those purposes a BIM model was realized and linked to a FM software.

2. METHOD AND PROCEDURE

2.1 Building description

MultiGalaxy, building rented by OMV Petrom Global Solutions SRL, is a big office building, with ten floors and a gross area over 15.000 sqm, inaugurated in 2008. It is an A class office building, according to BOMA [14] and has a very good add on factor 3.7% (difference between the usable area and the rentable area of an office building expressed as a factor of the rentable area). The building is provided with two generators of 700 kW power and last generation security and protection systems.
The building has curtain walls composed of Schuco structure and glass type Guardian. The HVAC system is realized by a three pipes heating/cooling plant type Sanyo with VRF (Variable Refrigerant Flow) with ecological Freon agent. This kind of system, with three pipes presents the advantage that they can operate simultaneously in heating or cooling regime. A heat recovery system has the ability to simultaneously heat certain zones, while cooling others. The input power of the system is realized by acting the heating pumps compressors using a thermal engine with gas fuel. This kind of system can be used at nominal capacity for outdoor temperatures up to -21 degree.

Figure 1: MultiGalaxy, building rented by OMV Petrom Global Solutions SRL

2.2 Software description

From the FM software presented in the introduction of this paper the best choice for our purpose is ARCHIBUS. It is a Facilities and Real Estate Management software for every industry that offers a variety of platform options to accommodate the organization's needs - from single users within a department, to worldwide access via the Internet. The new Run Anywhere architecture eliminates the need to extract, duplicate, or e-mail data and files [15].
ARCHIBUS software is an IWMS platform that integrated a lot of domains and permits a continuously workspace customization. This software is a complete solution with a lot of real estate capabilities, but in our research Space Planning&Management domain present interest. The building plans can be linked to ARCHIBUS database and thus outline each floor's gross areas, service areas, departmental areas, and other space classifications. Any further modifications of the plans will lead to automate database modification. These kinds of space classification allow an accurate room inventory, employee assignment to organizational space allocation, internally bill departments for their space usage and other benefits.

2.3 Spaces assignments

Although in our days BIM refers mainly to 3D buildings models, in this paper, respecting its basic definition as “a model that contains characteristics of the building and linked data which can be exchanged” our works can be considered to be related to a BIM model.
Using MultiGalaxy building floor plans and ARCHIBUS Smart Client DWG Editor, the rooms surfaces linked to ARCHIBUS database were realized. After that, the surfaces were allocated to different space categories. Usually, as in ARCHIBUS, an organizational company structure is made of: business unit, division, department, office, and sub-office. In figure 1, a department structure of spaces can be seen. In figure 2, functional structure of spaces according to EN 15221-6 was realized. According to this standard the room’s areas are classified in primary area, circulation area, technical area, and amenity area (toilets, showers, changing rooms).
In figure 3 a new space classification according to Romanian norm SR 1907-2 was done. The rooms were classified according to certain specific conventional indoor temperature types.

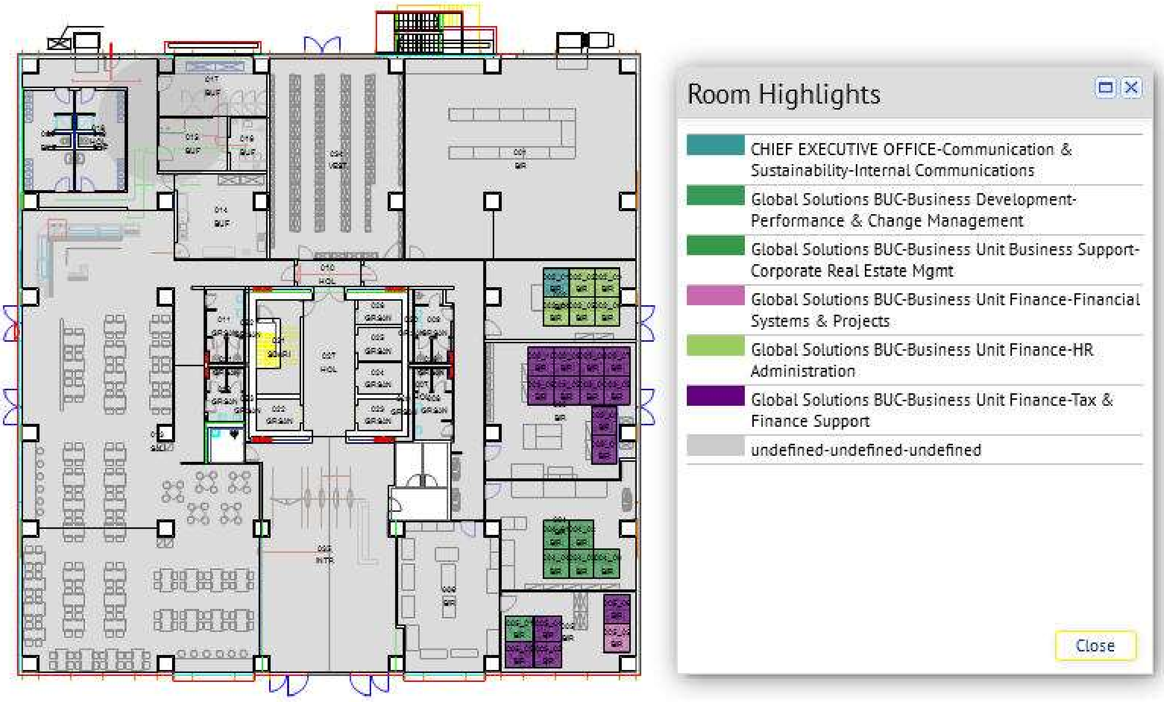

Figure 2: MultiGalaxy, ground floor, the organizational structure of spaces

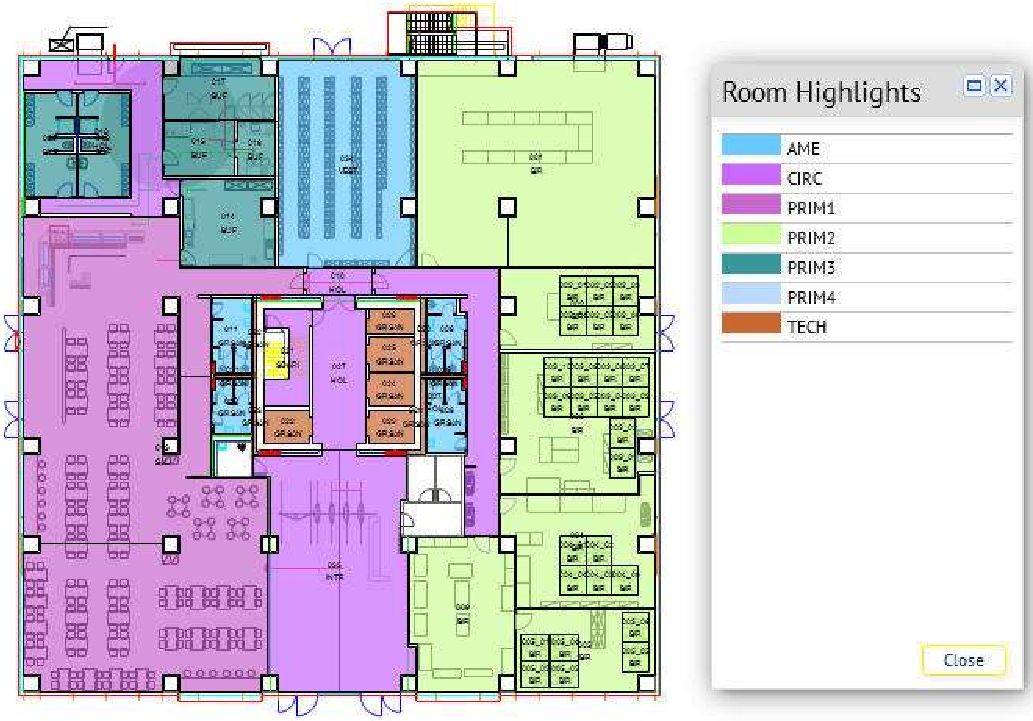

Figure 2: MultiGalaxy, ground floor, the functional structure of spaces according to EN 15221-6

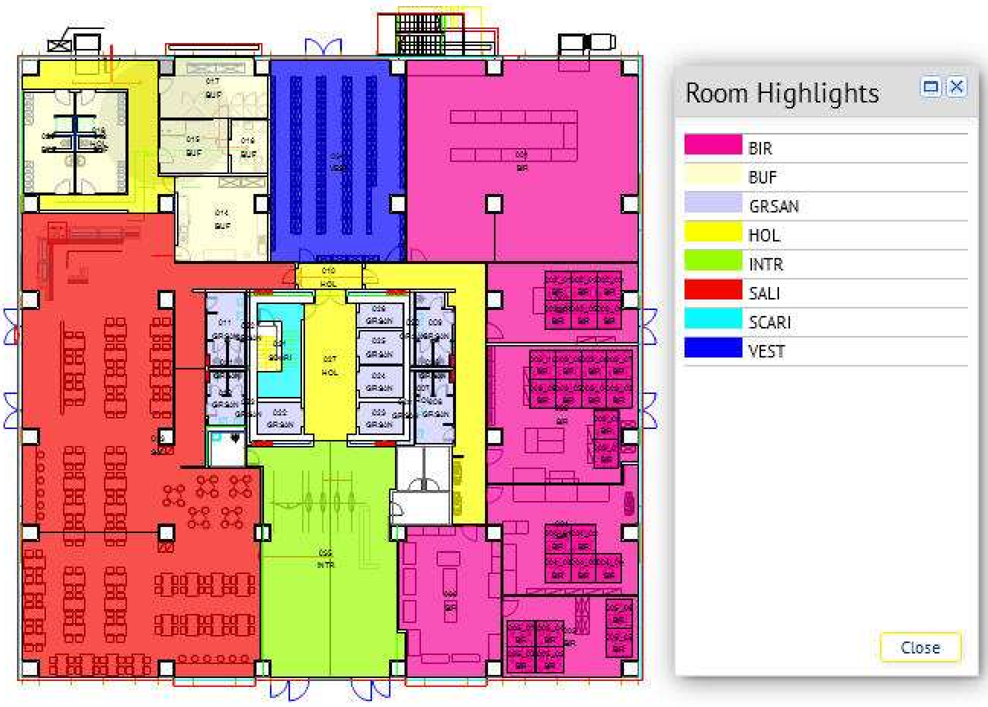

Figure 3: MultiGalaxy, ground floor, the space structure according to SR 1907-2 [16]

3. RESULTS AND DISCUSSIONS

Building energy consumption can be reduced by the modernization solutions of the building and its systems or by a rational use of energy. More than this, optimal space use generates an energy consumption reduction, in the case in which it is reported to employee, not to square meter. Based on industry studies, many organizations, both from public and private sector, found that their office space is underused.

Employee assignment can be done for the organizational structure of the building, fig. 1. Thus, an efficient usage of the spaces is accomplished and energy efficiency, reported to employee instead of sqm, is significantly reduced. For functional classification of the building, fig. 2, the space use is carefully watched and the common area, for example, can be reduced and thus, the energy used, reported to sqm of rented area, can decrease. From space structure classification, according to SR 1907-2, fig. 3, the room areas corresponding to different conventional indoor temperatures were exported from ARCHIBUS to Excel files. The data is systematized in table 1, where the indoor reduced temperature is computed. It is used further in energy evaluation programs, in order to find energy use for the studied building. More than this, indoor space classification, according to the temperatures recommended by the standard can be used in the set point setting for the HVAC system sensors. Thus, energy saving can be done.

Table 1: MultiGalaxy, groound floor, indoor reduced temperature computation

	BIR	HOL	GRSAN	BUF	INTR	SALI	SCARI	VEST		
Supr [m^2]	519.1	54.4	84.3	115.6	123.5	376.0	12.2	105.8	1390.9	TOTAL
T_i [ºC]	20	15	15	20	12	18	15	22	18.4	T_i_red

4. CONCLUSIONS

It is for the first time when, using ARCHIBUS software, such a multiple interdisciplinary space classification is done. Organizational and functional space classifications are specific to this software, but a new space classification according to SR 1907-2, and used in further computations for building energy assessment, was realized. Different methods of energy efficiency approach are discussed. An inadequacy between SR 1907-2 conventional indoor temperatures and real temperature values used in office buildings can be observed. It would be useful to update the Romanian norm to real conditions in the nonresidential buildings.

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COGENERATION SYSTEM FOR HEATING OF GREENHOUSES IN COLD AND ISOLATED ZONES

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ABSTRACT

It is known that in the cold and isolated zones, the heating of communities during the cold season is difficult and costly. Those communities are many times situated in mountainous areas where the cold season is longer and employment opportunities for people are limited. Heating of homes is mostly done with wood, harming the environment through the emissions of carbon monoxide, dioxide and the clearing of forested areas. In some areas an average as high as 4.32±0.99 kg/capita/day was recorded. [1].

The present paper proposes a cheap and simple aeroderivative cogeneration system which can be used by small communities (small villages). The system is composed of a turboshaft/turboprop whose lifespan has come to an end which drives an electric generator. The exhaust gases are evacuated through multiple nozzles along the bottom of an open basin filled with water. In this way the water is intensely heated through direct contact with the hot gases. After heating the water, the exhaust gases are freely evacuated into the atmosphere. The heated water is then pumped to the houses and greenhouses of the community. After heating the houses and greenhouses, the water returns to the basin where it is heated again and the cycle is repeated.

1. INTRODUCTION

In this case we have a heat transfer between the exhausted burnt gases and the water in basin. After expansion in the power turbine, the exhaust gases are injected obliquely in a water pool covered by a floating cover. A 3 D image can be seen in fig.1.

Obviously such cogeneration equipment must have a minimum possible price of manufacturing and low running costs. After the engine has reached its maximum flying hours, the price of turboshaft engines (for example those powering helicopters) drop to a minimum, and the water pool and pumping system can be built with local means and workforce by the communities. Experience shows an aero-turboshaft engine can work thousands of hours after its lifespan has ended, if its rating is reduced to 85-90%.

On the other hand, the aero-turboshafts can be easily converted for bio-fuels because this does not imply the redesigning of the combustors.

The bio-fuel can be easily and locally produced through the collecting of fallen forest leafs or other vegetables/residuals generated by local farms.

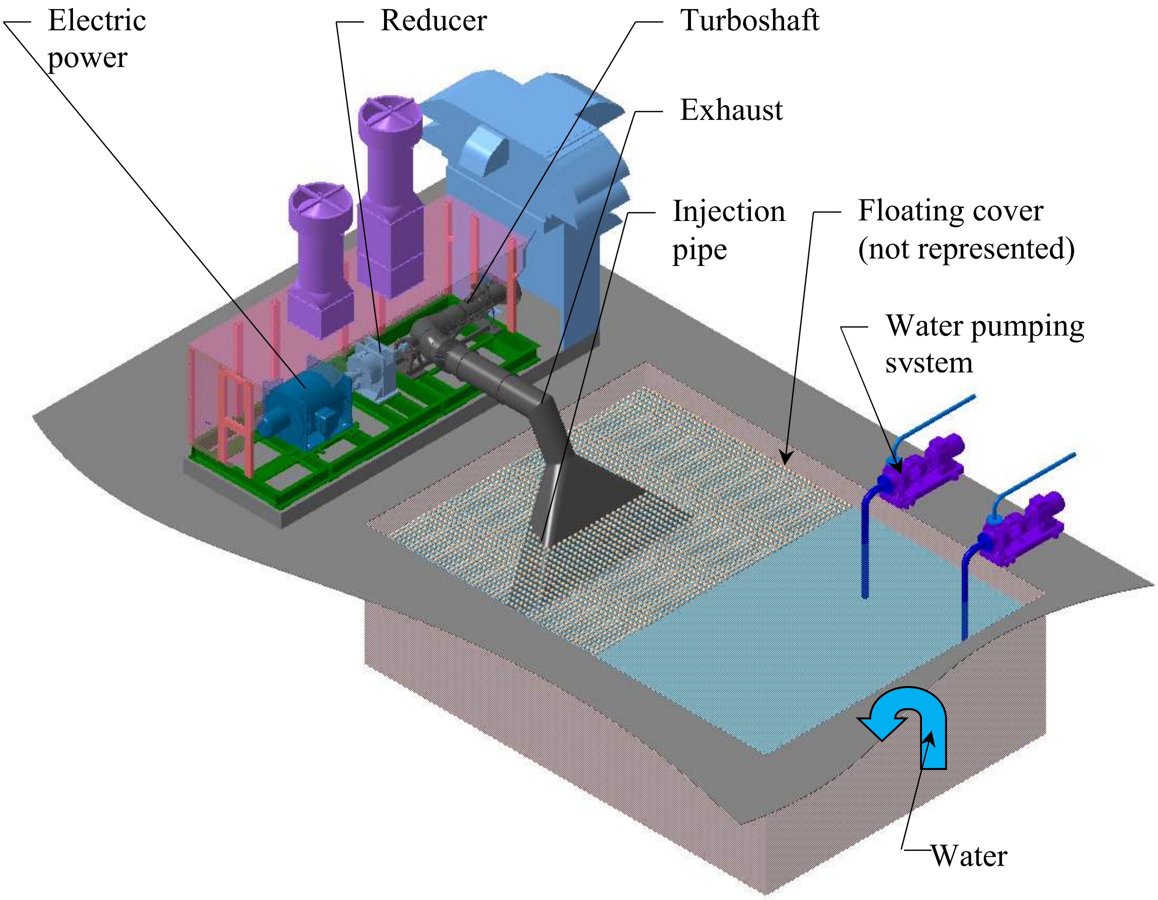

Fig.1 3D View of the station setup

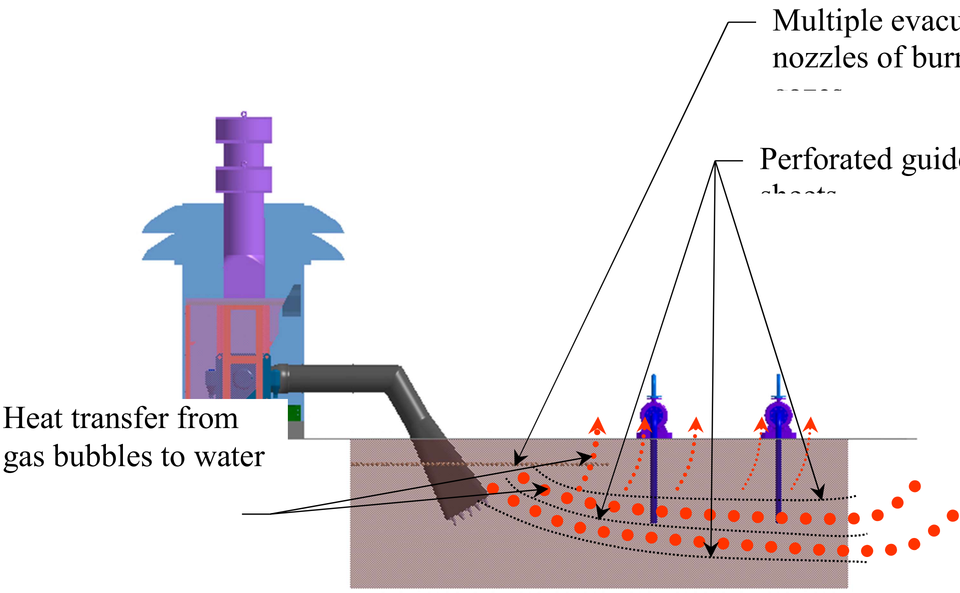

Fig.2 Side view of equipment shown in

2. EXAMPLE OF A TYPE OF AERO-TURBOSHAFT WHICH COULD BE USED

A good example of a turboshaft engine that can be easily used for building such an equipment is the Klimov TV3-117 engine.

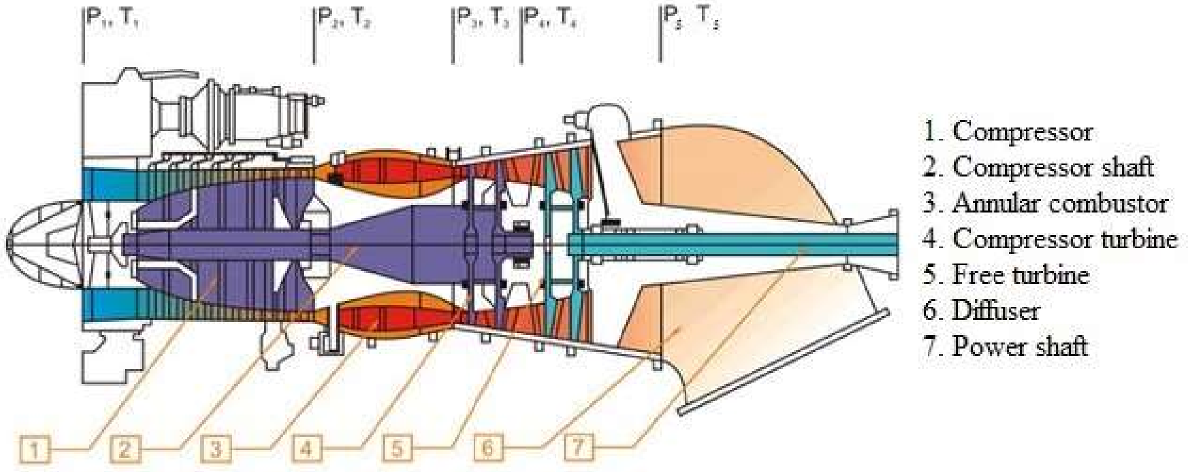

Fig.3-Klimov TV3-117 turboshaft[2]

This is a Russian gas turbine aero engine. It is frequently used in medium lift, utility, and attack helicopters designed by the Mil and Kamov design bureaus. This turboshaft engine was developed in 1974. Back then the Klimov TV3-117 was installed on 95% of all helicopters designed by Mil and Kamov Engineering Centre. Thousands of engines were produced in many variants.

The general characteristics of this engine are [3]:

- Type: Free-turbine turboshaft
- Length: 2,055 mm (80.9 in)
- Diameter: 728 mm (28.7 in) (height)
- Dry weight: 294 kg (648 lb)

Components

- Compressor:

Performance

- Maximum power output of engine: P_e = 1,640 kW (2,200 shp) (take-off)
- Overall pressure ratio: $\pi c = 9.4:1$
- Air mass flow: Ma = 8.7 kg/s (19 lb/s) minimum
- Turbine inlet temperature: t3* = 920-990 ºC (Turbine entry temperature)
- Specific fuel consumption: c_{sp} = 0.308 kg/kW/hr (0.507 lb/shp/hr)

Using such an engine at only 85% of nominal power, taking the efficiency of the reduction gearbox η_r=98.5% and the efficiency of the electric power generator η_{ge}=96%, the electric power generated by the cogeneration station will be:

$$P = 0.85 \cdot P_{TV3} \cdot \eta_r \cdot \eta_{ge} = 0.85 \cdot 1640 \cdot 0.985 \cdot 0.96 = 1318 \text{ kW} \quad (1)$$

Where P is total power and P_{TV3} is the engine power

At an maximum consumption of 10 kW/family, this power is sufficient for a community of about 132 families which can be considered a small to average community.

3. EVALUATION OF TV3-117 PERFORMANCES FOR COGENERATION

Taking into account the TV3-117 turboshaft engine parameters, and considering a compressor and turbine efficiency of $\eta_c = \eta_t = 0.9$, adiabatic coefficient k=1.4 for the whole cycle, specific heat coefficient at constant pressure c_p=1kJ/kg, for the given maximum temperature of cycle T3*=273+920=1193 K, the compressor specific work is:

$$l_c = i_2 - i_1 = i_1 \cdot (1 - \pi_c^{\frac{k-1}{k}}) \cdot \frac{1}{\eta_c} = 287 \ kJ/kg \tag{2}$$

Where π_c is the compression ratio, i_1 and i_2 are air enthalpy at the beginning and end of compression (i_1=288kJ/kg at atmospheric pressure p_1=1 bar and ambient air pressure t_1=15 ºC).

The gas-generator turbine specific work is:

$$l_{gg} = \frac{l_c}{\eta_t} = 319 \ kJ/kg \tag{3}$$

The free turbine specific work is:

$$l_{pt} \approx \frac{P_e}{M_a} \cdot \frac{1}{\eta_t} = 209 \ kJ/kg \tag{4}$$

The total enthalpy before evacuation is:

$$i_{4*} = i_{3*} - l_{gg} - l_{pt} = 665 \ kJ/kg \tag{5}$$

Obviously with the given approximation, T_4=665 K.
The total pressure before evacuation is:

$$p_{4*} = p_{3*} \cdot (\frac{T_{4*}}{T_{3*}})^{\frac{k}{k-1}} = 1.22 \ bar \tag{6}$$

This shows that this engine has good resources for cogeneration in the present application [4].

4. EVALUATION WORKING OF EQUIPMENT AND OF THE RECUPERATED HEAT

Assume that the center of the exhaust pipe is immersed at 1 m. This means that the exhaust gases exert a mechanical work for pushing the water and evacuation. of $i_{4'*}$ given by:

$$T_5 = T_{4*} \cdot \left(\frac{p_5}{p_{4*}}\right)^{\frac{k-1}{k}} = 649\ K \tag{7}$$

where $p_5 = p_{4*} - \Delta p = 1.12$ bar. $\Delta p = 0.1$ bar is the average counter-pressure for 1 m column of water.
Exhaust gas density is:

$$\rho_5 = \frac{p_5}{R \cdot T_5} = 0.53\ kg\ / m^3 \tag{8}$$

The phenomenon of injection of exhaust gases in water is of an extreme complexity and could not be modeled with numerical method at this time. We evaluate that experiments which will take place eventually, in a European Project will be important.
In a first approximation, using formula (9) for various average diameters for gas bubbles, the total heat transfer area A, generated in 1 second is given in the Table 1.

$$A = 4 \cdot \pi \cdot R^2 \cdot \frac{M_a}{\frac{4 \cdot \pi \cdot R^3}{3} \cdot \rho_5} = \frac{3 \cdot M_a}{R \cdot \rho_5}. \tag{9}$$

Table 1-Heat transfer area.

Crt. no	Bubble dia., mm	A, m^2
1	1	49245
2	5	9849
3	10	4924
4	15	3283
5	20	2462
6	25	1969
7	30	1641

Obviously such a transfer area is much larger than conventional heat exchangers with plates, this way permitting a fast transfer of heat from the exhaust gases to the water.
For controlling the bubbles average diameter, perforated plates like in fig. 2 can be used.

Assuming for example that the water is heated to t_w=90 ºC (T_w=363K), if the whole thermal energy of the exhaust gases is recuperated, the thermal power is:

$$P_t = M_a \cdot (T_5 - T_w) = 2488.2 kW \tag{10}$$

This power can obviously heat a water flow of 8 kg/s from 15 ºC to 90 ºC, sufficient for heating an average-scale green house.

5. CONCLUSIONS

This paper shows that in cold and isolated small villages, cheap and simple aeroderivative cogeneration equipment can be built for local electrical power generation, heating of houses or green-houses of the community.

The innovation consists in the injection of exhaust gases coming from a turboshaft directly into a water pool by means of multiple exhaust nozzles. The heated water is then pumped to the greenhouse or to the houses or both for heating.

The process is of a high complexity and it is for this reason very difficult to be modeled for numerical calculations. Simple evaluations show that the area of heat transfer surface between exhaust gas bubbles and water can reach very large values. For this reason the residual thermal energy of the exhaust gas is efficiently recuperated.

Due to the extreme complexity of the mixing and heat transfer process obviously experiments are necessary.

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IMPROVING THE ENERGY EFFICIENCY OF THERMAL POWER STATIONS ON THE EXAMPLE OF CHP-1

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ABSTRACT

CHP-1 is one of the main sources of energy supply in the city of Almaty. The station releases the products for industry and the public in the form of heat for heating and ventilation, water for hot water, vapor pressure 1.2 - 1.5 MPa, electric energy. In 2007, the unit costs of fuel stations increased by 6.5%, for its own needs for heat supply - by 5.9%. Increased costs for own needs are related to difficulties in unloading the frozen fuel hovering coal bunkers, discharge and increased boiler and turbine loads that reduce plant efficiency, increasing power consumption for own needs and excessive fuel consumption.

1. INTRODUCTION

Careful analysis of boiler and turbine equipment has identified a series of questions that allow to doubt the correctness of indication of the complex means of measuring the heat output by accounting downward: verification carried out only secondary device electrical signals, the primary instrument is not calibrated; only checked compliance of individual signals, not the method and accuracy by averaging operations, rounding and addition; medium density does not always correspond to a table for a given temperature; most of the coefficients calculated and displayed for ideal conditions; metering device, wires, sensors are extremely sensitive to external influences.

2. METHODOLOGY

Keywords: CHP-1, deep-heat recovery of exhaust gases, increasing the share of renewable energy, low-temperature tornado technology.

CHP-1 is one of the main sources of energy supply in the city of Almaty. The station releases the products for industry and the public in the form of heat for heating and ventilation, water for hot water, vapor pressure 1.2 - 1.5 MPa, electric energy. In power boilers CHP-1 during the heating season is burned concentrate Karaganda coal, in the summer - the excess natural gas, hot water boilers - gas, fuel oil.

Determined heat loss: a flue gas q_2 = 5.605%, the mechanical incomplete combustion q_4 = 3%, the external cooling q_5 = 1.7%, in the form of sensible heat q_6 slag = 0.66%, boiler efficiency of 88.5%, the coefficient of heat conservation 0,98.

In 2007, the unit costs of fuel stations increased by 6.5%, for its own needs for heat supply - by 5.9%. Increased costs for own needs are related to difficulties in unloading the frozen fuel hovering coal bunkers, discharge and increased boiler and turbine loads that reduce plant efficiency, increasing power consumption for own needs and excessive fuel consumption. The main reason for increase in specific fuel consumption is the poor performance of devices for accounting of delivered heat with hot water, installed in 2001-2002. Careful analysis of boiler and turbine equipment has identified a series of questions that allow to doubt the correctness of indication of the complex means of measuring the heat output by accounting downward: verification carried out only secondary device electrical signals, the primary instrument is not calibrated; only checked compliance of individual signals, not the method and accuracy by averaging operations, rounding and addition; medium density does not always correspond to a table for a given temperature; most of the coefficients calculated and displayed for ideal conditions; metering device, wires, sensors are extremely sensitive to external influences. All the above-mentioned problem with the heat accounting system such that the underestimation of the released heat is 6 to 8%.

Figure 1. AlES CHP-1.

After the energy audit proposed energy-saving measures for the development of AlES CHP-1.

Energy-saving measures for the current period:

1. Method of deep heat recovery from exhaust gases (RES) is applied when using recuperative, mixing, combined devices operating at different methods of use of the heat contained in the flue gas. The result of the event - increase gross efficiency of the boiler by 2-3%, reducing NOx emissions into the atmosphere due to their dissolution in the condensing water vapor.

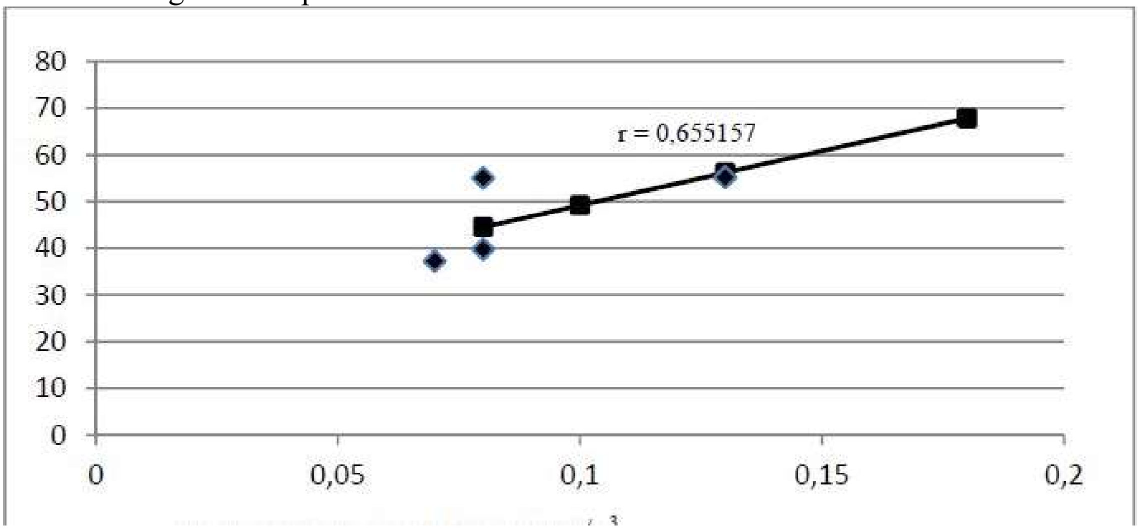

Figure 2. the relationship between the level of pollution by nitrogen dioxide atmosphere and days

2. An effective suppression of nitrogen oxide is significantly affected by feeding them into the flue gas recirculation, which leads to a reduction in the gas temperature in oxygen concentration therein. The consequence is a decrease in fuel nitrogen conversion of nitrogen oxides. In parallel, there is braking process afterburning generated gas components CO and H_2 needed to restore NO_X.

3. Nitrogen oxides suppression mechanism is implemented with a supply of pulverized coal burners of high concentration under vacuum or under pressure in the boilers with an intermediate bunker.

Energy-saving measures for the future:

1. Increasing the share of renewable energy in the total energy of Almaty will reduce GHG emissions from energy by using energy data from 500 thousand tons to 2.5 mln. Tons of CO_2.
2. The increase in forest area as a carbon dioxide sink.
3. Switching from coal and fuel oil to natural gas or biofuels. Switching to biofuel gives almost 100% reductions of GHG emissions.
4. Low-temperature vortex combustion technology reduces the maximum temperature in the furnace at 100-300^0 C and not burn pulverized coal, and roughly pulverized coal.

The medium-term development plan AlES CHP-1 in 2014, aimed at lowering the impact on the environment includes the renovation and construction of the combined system of the ash thermal power station-1, the installation of an emulsifier at the boiler station №8, as well as improving the efficiency of the emulsifier and the second generation of dust-extraction plant. Projected construction of ash disposal area №2 dry storage, with a total area of 14.3 hectares.

As a result, an energy audit was carried out, the calculations of heat loss; energy-saving measures are proposed.

On CHP from 1969 to 1972. installed two turbines with steam extraction for heating water and leave it to industrial customers. Mounted four boiler BKZ-160-100 and two hot water boilers PTVM 100 100 Gcal / hour. In 1976-79gg. put into operation three more hot-water boiler.

Air protection :

It is planned to carry out works for the maintenance of the degree of purification of dust extraction devices boilers stations , repair and replacement of cubes of air preheaters , repair burners boilers , emulsifiers , anti-corrosion work , metal replacement , pipes , worn surfaces , elimination of violations in the technological cycle in the boiler units of CHP - 1 , 2 3 , dedusting the fuel path .

Protection and rational use of water resources:

Repair of zoloprovod, the pump equipment in boiler, turbine, chemical shops, treatment facilities of CHPP-1 is executed, events for reduction of losses of water when transporting the zoloshlakovykh of waste on CHPP-2 and CHPP-3, repair of reverse system of production appointment (bagerny, coolers) on CHPP-2 are held.

Protection of land resources, rational use of a subsoil, florae and faunae:

Works on replacement of worn-out pipelines for prevention of flood the zoloshlakovykh of waste and a pulp, gardening of territories of administrative and territorial units, increase in the areas of green plantings, recultivation of the degraded territories on CHPP-1 and CHPP-3, work on inventory of the antifiltrational screen on CHPP-2 are carried out.

At the end of 2000, out of service and dismantled outdated inefficient equipment. There are three steam turbines - one P-25-90 / 18 and two PT-60-90 / 13 with total capacity of 145 MW, six high-pressure steam boilers BKZ-160-100 and seven boilers PTVM 100 100 Gcal / hour.After the reform of JSC APC HPP-1 started operating on February 15, 2007. as a part of "Almaty Power Stations".

3. CONCLUSIONS

The medium-term development plan AlES CHP-1 in 2014, aimed at lowering the impact on the environment includes the renovation and construction of the combined system of the ash thermal power station-1, the installation of an emulsifier at the boiler station №8, as well as improving the efficiency of the emulsifier and the second generation of dust-extraction plant. Projected construction of ash disposal area №2 dry storage, with a total area of 14.3 hectares.

Joint-stock Company Almaty Power Plants (JSC ALES) – the power making organization which is carrying out activities for production of heat and the electric power in the city of Almaty and Almaty region. JSC ALES provides with the electric power and heat the population, the industrial and agricultural enterprises, is a subject of natural monopoly on production of thermal energy. Now the company is included into JSC Samruk-Energo group of companies. The organizational structure of JSC ALES includes 8 production divisions.

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DEVELOPING A COMBINED SYSTEM FOR MEASUREMENT OF TEMPERATURE, CURRENT, VOLTAGE AND AMBIENT PARAMETERS OF AIR

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ABSTRACT

The complex and multiform nature of thermal processes in heat treatment machines necessitates the experimental approach as a primary method of study. It is especially efficient when applied to discrete physical models of heat treatment machines and special stands allowing a wide range of the experimented factors and precise measurement of the parameters. The experimentally obtained data serve, on the one hand, to discover and analyse some new aspects of the thermal behaviour of machines. On the other hand, these data could be used for application of mathematical models of the behaviour of the constructions by the finite elements method (FEM). In practice, there are none of combined devices for measurement of the parameters during heat treatment of metals.

1. INTRODUCTION

The effective usage of the resources based on the advancement of scientific progress requires a wide introduction of new technologies for heat treatment of metals. This necessitates the development of a combined system for the purposes of their electronification, automation, computerization and so on, for a more precise measurement of the many technological quantities, for a better management of the technological processes, for a better information providing, information archiving and others. This entails higher productivity and quality, better management, documenting, accounting and others. This process is gaining importance in view of the European requirements for a high and sustainable quality, for traceability of production, and lower energy consumption of the technological processes.

2. METHODOLOGY

3.1.Purpose and goal of the development.

The purpose is to create an electronic device for measurement of high values of temperature, current, voltage and parameters of the ambient environment, as well as a software program for processing of the results obtained from the measurement. The results will be used in program applications by MFE to solve non-stationary problems, which will serve as initial and boundary conditions. The solutions of the problems will demonstrate the adequacy of the mathematical models by the values measured in the experiments.

- To achieve this purpose, the following problems are formulated and solved:

5. Designing an electronic system for measurement of temperature, current, voltage and parameters of the ambient environment;
6. Creating a functional model of the electronic system;
7. Synthesizing a principal diagram of the measuring system;
8. Developing an algorithm for operation and relevant software;
9. Analysis of the results for the measurements made after the process of heat treatment in chamber furnaces.

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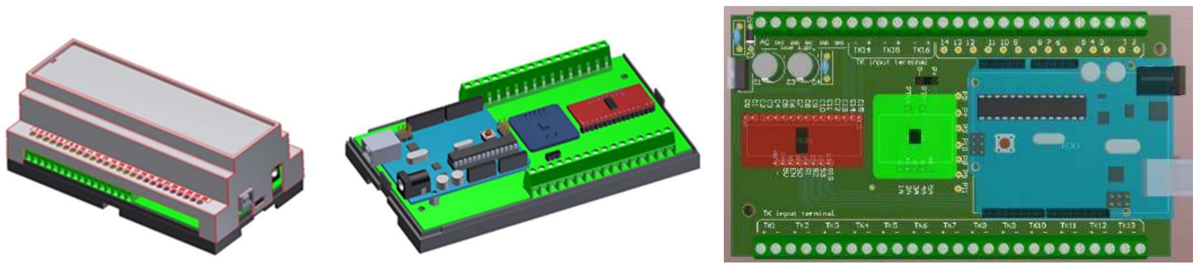
- For a better flexibility and convenience, the following functional options were chosen for the device:
  - Measurement of current, voltage and parameters of the ambient air during the process of heat treatment;
  - Usage of standard, proven in practice elements, sensors, converters, devices, boards, program applications and so on in view of an easier operation in the future system, as well as better reliability, interchangeability, repair fitness and others;
  - Measurement of high values of temperature in chamber furnaces for heat treatment;
  - Testing and corrections of the configured system for measurement of temperature, current, voltage and parameters of the ambient air, registration and archiving of the technological parameters;
  - Opportunity for operation in laboratory and industrial conditions with multiple repetition of the measurement.

3.2.Development of a combined system for measurement of the temperature, current, voltage and parameters of the ambient air.

3.2.1. Designing and making of the device for measurement of the temperature.

Based on knowledge in the field of electronics and the need for designing of a device for measurement of the high temperature, a 3D model of the device was created and computer simulations of the blocks of its main building components. The model of the device was created for a better visualization of the objects in it. Fig.1. a) and b) show the device for measurement of the temperature, designed by a program application Autodesk Inventor Professional, and Fig.1 c) a design of the board developed with Altium Designer.



a) b) c)

Figure 1: Designing of the device for measurement of temperature

By help of literature investigations and the created 3D model of the device for measurement of the temperature, the necessary for the realization and making of the device elements, sensors, converters, devices, program applications and other parts and facilities can be defined or new can be designed and made by the team. The main requirement here will be the usage of standard, proven in practice elements, sensors, converters, devices, program applications, boards and others in view of the functionality of the device.

Fig.2 shows a microprocessor system for 16-channel measurement of temperatures in the interval of 0÷1250°C by thermal couples of K type, consisting of an ATmega328P processor, multiplexor and converter for thermal couples of K type.

a) b)

Figure 2: a) General look of the device for measurement of temperature from the outside with a microprocessor system based on Arduino: 74HC4067 multiplexor and MAX31855 converter b) General look of the device for measurement of temperature in when assembled for a DIN busbar

One of its main elements is ARDUINO UNO. It is an input-output board for developing of free interactive projects. The board allows registration of changes in the environment via sensors as well as reaction to the changes by activating devices and other mechanisms [1]. ARDUINO UNO can be used to create independent interactive elements or to interact with an outside software interface [6].

3.2.2. Measurement of current and voltage.

Digital devices for measurement of current are usually voltmeters based on the method of comparison [5]. When measuring alternating current, the range of ammeters is usually extended through current measuring transformer. The advantage current transformers is the greater safety, which they ensure, because the measuring device and the observer are isolated from the circuit whose current is measured.

a) b) c)

Figure 3: Amp pliers and a device for measurement of current and voltage:
a) Amp pliers model: SCT-013 Series; b) and c) general look of the device for measurement of current and voltage

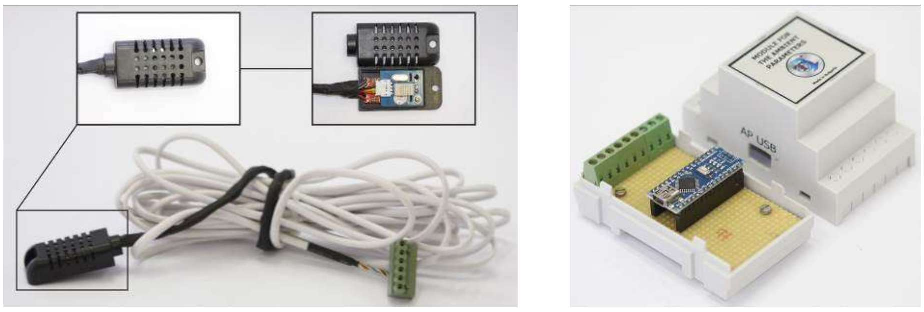
To measure the alternating current of the system, a current transformer is used [3] and amp pliers model: SCT-013 Series. The device is designed for precise measurements of the real value of current for three phases. The scope of measurement of the current is up to 100A and of the voltage up to 250V.

3.2.3. Measurement of the temperature of the ambient air, the relative humidity and the barometric pressure.

For measurement of the ambient parameters of the air outside the furnace, combined sensors AM2301 and BMP085 are designed. The main characteristics of the modules are:

humidity: 0~100 % RH; temperature range: -40~80°C; barometric pressure - 300÷1100hPa - fig.4.

The module for measurement of the temperature, humidity and barometric pressure has a microprocessor board ARDUINO NANO, whereby the connection to it is by coupling.



a) b)

Figure 4: a) Sensor for the ambient temperature, humidity and barometric pressure b) Module for reception of the signal

3.2.4. Making of an aggregate system for reading the parameters of the technological mode.

The reading devices for the parameters of the mode and the environment are placed together in a box with its own electric supply, independent of the electric power grid. During the process of reading, a recording is made; for this purpose, a computer is used and software developed on a specialized application Lab View v2014 [7].

A photo of the aggregate system and its comprising elements and modules is shown in Fig.5.

Figure 5: Aggregate system for reading the parameters of the mode

3.2.5. Developing of software for data collecting and processing from three COM ports.

To create the software, a specialized application Lab View v2014[2] is used, which is a graphic program environment of National Instruments [8].

The programs and subprograms of LabVIEW are called virtual tools. Each of them has two components: a flow chart and a front panel. For a better visualization, Fig.6 shows the front panels of all devices, participating in the system [4]. All modules and tools of the system for measurement of the temperature, current, voltage and ambient parameters of the air transmit their data for processing and recording to a program developed on LabVIEW. The results are recorded on the HDD of the computer.

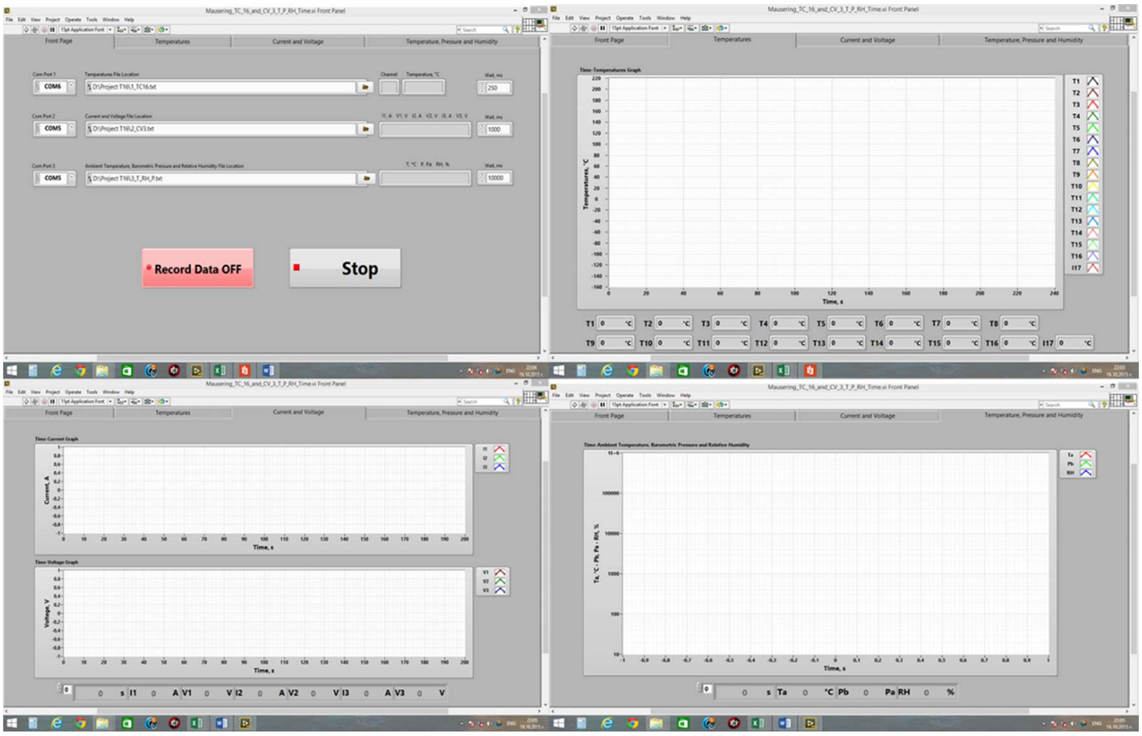
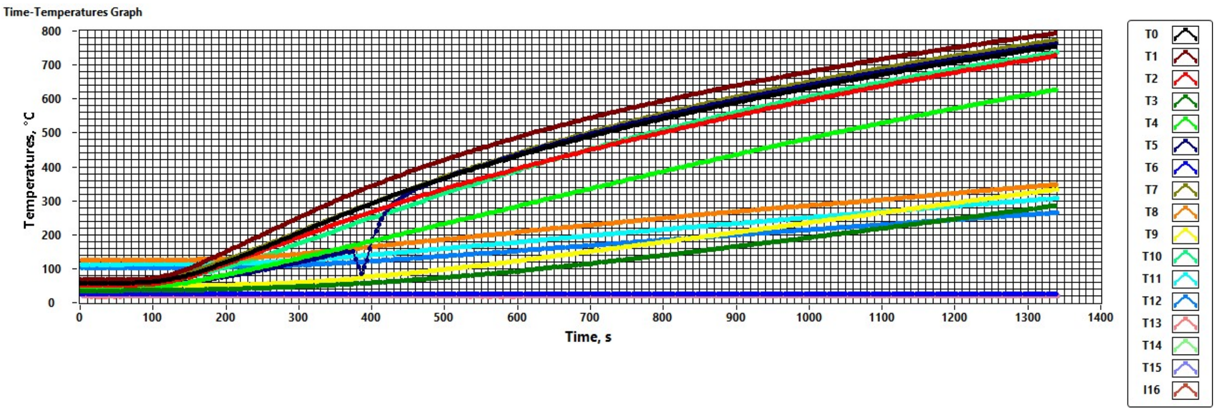


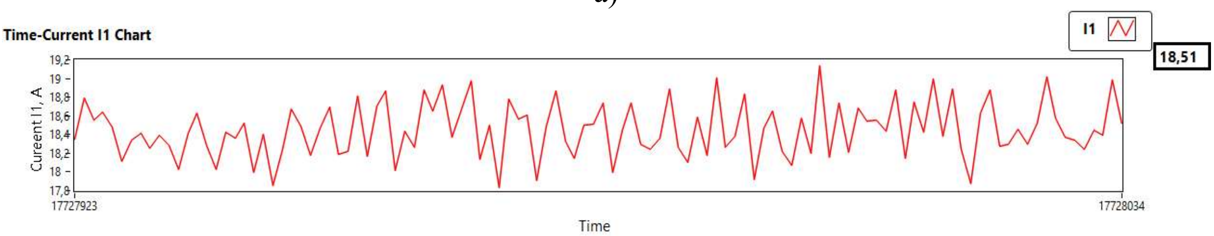
Figure 6: Front panels of all devices participating in the system

3.2.6. Testing of the combined system for measurement of temperature, current, voltage and ambient parameters of air.

The results from the testing of the combined system for measurement of the temperature, current, voltage and ambient parameters of the air in the mode of heat treatment in a chamber furnace are shown in Fig.7.



a)



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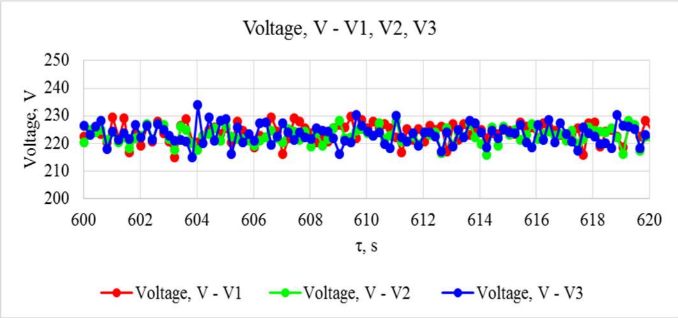
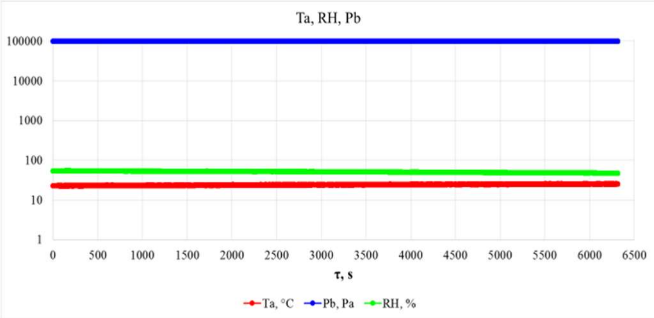


c)



d)

Figure 7: Results from the experiment of measuring: a) temperature; b) current; c) voltage; d) ambient temperature, relative humidity and barometric pressure

3. CONCLUSIONS

On the grounds of the realization of the purpose and goals of this development as well as the obtained results, the following main conclusions can be drawn:

1. A complex electronic system is designed for measurement of high temperatures, current, voltage and ambient parameters of the ambient air, in the mode of heat treatment in a chamber furnace by help of the created functional model of the device for measuring the temperature;
2. A system is realized and tested for calculation of various equations in mathematical physics by commercial licensed software and a microprocessor system for measuring physical quantities, which is directly connected to the computing complex;
3. Algorithm is developed for the operation of the device as well as software for measuring the temperature, current, voltage and parameters of the ambient air in a mode of heat treatment of samples in a chamber furnace.

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REMOVAL OF SOLID PARTICLES IN RECIRCULATING AQUACULTURE SYSTEM USING MECHANICAL FILTERING EQUIPMENT - CURRENT STAGE OF DEVELOPMENT

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ABSTRACT

One of the main challenges of modern aquaculture is to increase the production capacity for fish material simultaneously with reducing the factors that have a negative impact on the environment. For recirculating aquaculture system (RAS) maintaining physico-chemical characteristics of the water at an optimum level for breeding species, is one of the main goals to be achieved in order to talk about what a successful aquaculture means. Studies in the field of recirculating systems underlines the fact that by using high quality food for feeding the fish material, but also by applying a correct management starting with the system design and continuing with its exploitation, a reduction of up to 50% of the quantity of waste evacuated into the environment can be achieved. Technological developments in the field of mechanical filtration in recent decades have contributed in a decisive way in terms of waste water filtration process within a recirculating system, with the aim to improve its quality, but not least significant reduction of waste that are released into the environment. This paper aims to develop a description of the situation that exists at both global and national levels on the range of mechanical water filtration equipment that are used in a RAS.

INTRODUCTION

In order for a recirculating acvacol system to be economic, it must have reliable and efficient technology that is able to maximize the production [21]. The technological installations that are found in a recirculating system must ensure the optimal conditions for the growth and development of species grown, by reconditioning the water which is recycled within the system [23], [7].

One of the main problems of recirculating systems is the problem of removing of solid particles. It was estimated that around 60% of the food introduced into the system remains unconsumed and is transformed in residual solids [14]. According to him (Ariel.E and Jutta.P - 2014), the quantity of waste from a recirculating system is directly proportional to the fish production within the system [2].

Still from the design stage of a recirculating system, focus must fall on controlling and removing the solid particles coming from the unconsummated feed, faecal matter and bacterial biomass Figure 1[24], must be a priority, to prevent in this way the supplementary consumption of oxygen, the uncontrolled increase of the amount of carbon dioxide and of the ammoniacal nitrogen, compounds particularly toxic for fish [12], [13], [20].

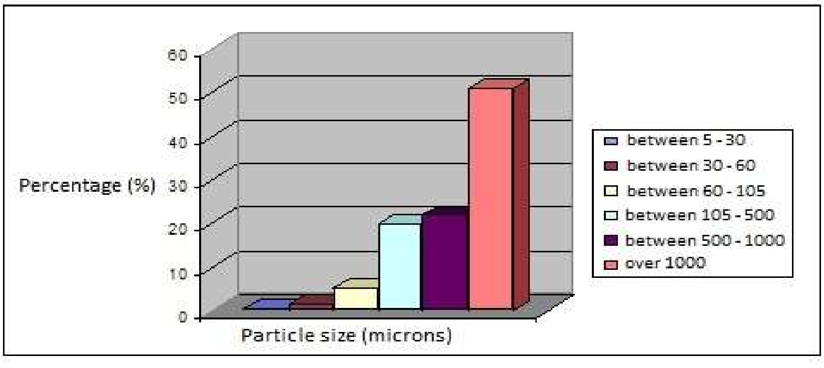

Fig 1. The granulometric composition of the solid particles resulting by dissolving of the granulated feeding stuffs - adaptation (after Timmons and Losordo, 1994) [24]

To reduce the amount of solids in the tanks for growth, solids that can negatively affect the physical and chemical factors of the water, is needed the use of mechanical filtration equipment, dimensioned so as to be capable of removing the organic matter accumulated in the system [23]. Mechanical filtration is one of the major processes of controlling the solid particles from the recirculating system [24]. The role of mechanical filtration as the first water filtration process of RAS is all the more important because of it depend the success of all other stages which will follow in the filtering process [8].

The principle underlying the mechanical filtration refers to the fact that the wastewater coming from the growing tanks passes through a filtering material which is intended to retain the solid particles from water [27]. The filtering material present in filters consists of: sand, gravel or various types of sieves made textile materials or non-corrosive metals [24], [4], [28]

To remove suspended solids in recirculating systems (Losordo et al., 1998) affirm that are specifically used two types of mechanical filters: drum filter and sand filter [7].

In the field of mechanical filtration at present there are a number of devices that can cover a wide range of applications in the acvacol field, the way in which are classified the filtering processes which are used particularly in aquaculture is made according on the nature of the filtering medium: filtration with sieves and filtration with granular agents [24].

As regards the equipments for mechanical filtering with sieves, the largest shares are occupied by the following types of filters: axial filters with rotating sieves, radial filters with rotating sieves and chain filters with sieve. Among the consecrated companies manufacturing mechanical filters for recirculating acvacole systems we mention: Hydrotech - Sweden, FIAP – Germany, Faivre – France, Akva- Denmark.

Nationally one of the companies producing installations designed to the acvacol sector is the company EuroCar - Oradea, and one of the products made by them, which was successfully implemented in several fish farms in Romania is the drum filter.

MATERIAL AND METHOD

Mechanical filtration with sieves is the most common method in the filtering process widely used in commercial Aquaculture and research.

The mode of action of these type of filters is that the water loaded with solid particles passes through a system of sieves, the sieves retaining only the particles of equal size or larger than the sieve meshes [5]. Sieves dimensioning is based on the charging degree of the water with solid particles (TSS) and of the granulometric composition of them [24].

Currently at a worldwide level there are no farms with the recirculation of the water evacuated from the tanks which does not use the filters with microsieves, this and because they occupy a relatively small space, not require the same physical effort as in the case of the sumps when carrying out the maintenance and cleaning works [8].

In the case of filtering with sieves the filtering capacity is given by the mesh size of the sieve ranging between 40 – 100 µm [29], and according to (Stokic-2012) between 60 -200 µm [11].

Cripps and Bergheim, 2000 quoted by (Couturier et al., 2009), concluded that the use of filtration equipment with microsieves with a mesh size less than 60 mm, are not recommended due to the risk of the clogging phenomenon [15].

The filters with rotary sieves, according to (Tchobanoglous and Burton, 1991), represent the most efficient solution to the conventional alternative by sedimentation of solid particles and for this reason these have been successfully implemented on the acvacole farms [19].

The functioning of the filters with rotary sieves, no matter if we speak of the axial or radial ones in both cases these will work only if they are partially immersed in the water to be filtered [7], [2], [16].

RESULTS

To clean strainers, both the radial filters with rotary sieve and the axial filters with rotary sieve are equipped with a system of spraying nozzles disposed above the drum or in the case of axial filter the nozzles are fixed on the downstream side of the sieve, in this way it is done the washing of the retained solid particles [16].

Radial filter with rotating drum. Drum filtering is the predominant technology for the removal of solids with the widest spread worldwide and as the degree of use in recirculating systems [17]. This is due primarily to the filtering capacity that can be adjusted according to the charging with solid suspensions of the recirculating system [31]**.**

Normally, the mechanical filters are able to remove the solid particles larger than 40 - 100 µm [17], whilst (Chenat. Al.1993) states that the mechanical filters are designed to remove only can particles larger than 80 µm [11]. It is specified in the literature (Liberty, 1993 cited Twarowski et al., 1997) that a drum filter can remove about 40% of the total of solids in suspension [12].

In the table below, it can be seen as a percentage of the rate of removal of suspended solids from a SAR, using a drum filter with different types of sieves [6].

Waste	40 µm	60 µm	90 µm
Total phosphorus	65 – 84 %	50 – 80 %	45 – 75 %
Total nitrogen	25 – 32 %	20 – 27 %	15 – 22 %
Solids in suspensions	60 – 91 %	55 – 85 %	50 – 80 %

The working principle of the drum filter is relatively simple; water loaded with solid particles in suspension (TSS) is entering the drum filter in an axial direction and is coming out filtered in a radial direction. During the filtering process as the network mesh of sieve from the drum filter is loaded with solids the water level raises, switching on the spray equipment. Then washed solid material is collected in a trough and discharged outside the system.

Usually, to wash the sieves of a drum filter, is used an amount of 0.2 to 2% of the volume of water through the use of the high-pressure water jet [3]. The main disadvantage of this type of filter is its high maintenance and operation costs [10].

Mechanical filter with discs

The filter with disc is part of the category of rotating filters with sieves due to its setup of the sieves, which is perpendicular to the direction of the water flow [16]. The filter with discs represents a novelty in the field of the filtration with microsieves, because it combines both the performances and the availability of a drum filter.

The main advantage that distinguishes a disc filter from a drum filter is represented by its configuration, so at the same overall dimension, disc filters have a filtration area 2-3 times bigger [35].

The main aspect of a functional nature for both the filter discs and the filter drum is that they become operational only when they are partially immersed in the water flow, in case of the filter disc the level of submergence is approximately 60% [16] [33].

The operating principle is relatively simple water gets inside the drum filter through the gravitational route and wastewater is entering through slots provided on the drum and into the disc system and exits filtered in an axial direction and being sent to the biological filtration unit [33].

Cleaning the discs is obtained by flushing with water in countercurrent by means of a nozzle mounted on a device which performs an oscillatory movement for an efficient cleaning of the sieve [33], in practice it has been found out that by using this type of system with oscillating movements there was a decrease (water consumption) of consumed energy by up to 20-30% [26].

After washing the sieves there is a significant loss of water with values ranging between 0.05 - 3% of the total reported volume of filtered water [33].

Because it is expensive equipment, its use is recommended only in cases that have limited space [1].

Filter with rotary sieve chain-type

From a constructive point of view, this type of filter has the sieve in the form of a funicular strip, made of several articulated panels mounted on a system of drums with horizontal shaft [32]. In the study of (Ebeling et al., 2006) they concluded that filters with chain are the latest technological development to reduce the volume of waste from recirculating aquaculture systems [9].

Filters with chain have proven their effectiveness in cases where the volume of water is reduced and the concentration of solids is high, usually their location is on the exhaust line of water loaded with solids from washing the filters with microsieves [30], [9].

Regarding the cleaning of the sieves, this operation is performed under the action of a continuous water jet. For this reason, the water losses are significant, issue that constitutes in fact one of the main disadvantages of this type of filter.

However in case of the filters with chain there has been developed another method to clean the sieves by using compressed air, which together with a small amount of water has the ability to deploy solid waste from filter sieve [24], [16].

Filtration with grained material

This type of filtering assumes that the wastewater passes through a layer of granular material, which has the function of retaining on its contact surface particles of solids from the water, the most used granular material is the sand, or in certain circumstances the floating balls [10], [24].

According to researches carried out by (Vigneswaran et colab., 1990) it was concluded that the performance of a granular filtering material is largely dependent on the size of particles and pores which are compounding the material of the filter [22].

The mechanical filters with granular medium represent those equipments that can retain a fairly wide range of residual solids smaller than 20 µm. Their use is recommended only for systems with a high degree of water reuse and where it is desired as clean water [8].

The functioning mode of the filters with granular material it is either by gravity or under pressure, and the direction of travel of water through the filter may be ascending or descending [24].

Filters with sand under pressure

Concerning the functioning of the filter with sand under pressure, it is similar to the gravitational filter even if the difference between them is given by the applied additional pressure in the tank to speed up the filtration [24].

The size of the particles forming the filtering medium usually lies between 0.5 and 1 0 mm [30], [36], in addition it also has a layer formed by another granular material usually gravel whose size does not exceed 5 mm [5].

Another parameter that defines the performance of filters with sand under pressure is the height of its layer of the filtering material; literature is recommending a height of 1.2 m [34].

A advantage of using filters with pressurized sand is that they have the ability to remove solid particles smaller than 30µm [5].

Another advantage of the under pressure sand filters is that they have smaller dimensions than the mechanical filters with gravitational drainage, under filtration of wastewater with the same flow [24].

Filters with balls

Filters with balls are considered the oldest equipment concerning waste water treatment process [5].

In their study (Maillard, 1998; Tidwell, 2012) they argued that filters with balls have a greater use than filters with sand under pressure due to low pressure loss and reduced requirements of water for washing [25], [10].

Currently there are several types of filters with balls, but the most spread are filters using plastic balls with a diameter of 3- 5mm [5].

The filtration capacity of filters with balls is up to 50 μm [36], and according to Malone (2013), the ability to filter of filters with balls can reach up to 30 μm [18].

According to Summerfelt (1997), using filters with balls is attracting a number of disadvantages such as the need for presence of moderate pressure inside the filter, complex washing equipment in counter-flow, capital and high maintenance costs and finally the inability to treat large volumes of water [25].

CONCLUSIONS

To have a successful aquaculture, first of all it is important to have high performance, competitive, equipment, to maximize the fish production.

To increase fish production and minimize any loss, we need the water recycled through system to be correctly filtered.

For this reason it is essential to know which are the most efficient equipment for the removal of the solid particles within a recirculating system, and for this we must know what exist today on the market.

One of the most appreciated filtration equipment within a RAS, due to its effectiveness is the drum filter.

ACKNOWLEDGMENT

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QUALITATIVE IMPLICATIONS OF THE WOOD BIOMASS STORING IN BIOMASS CENTRES

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ABSTRACT

Biomass contains large amounts of stored energy, which are commercially used increasingly more. These sources of energy are renewable, easy to store and neutral from the standpoint of the CO_2 releases, which means that they are also environmentally friendly.

The wood meant to heating must have features that meet the requirements of a good combustion, the most important processes in this respect being drying and the correct storing of the wood.

In this paper we set out certain advantages of the utilisation as fuel of the wood biomass derived from wood exploitation. An aspect that ought to be considered in case of using quality biomass is the implementation of a simplified system of quality assurance and quality control (QA/QC), applicable to small businesses with wood biomass.

1. INTRODUCTION

Biomass represents a diversity of vegetal origin elements that surround us, derived from nature or from the human activities, the goal being their best valorisation. Still, the main biomass resource is wood.

The energy associated to forest biomass could be very profitable for the new industries, because all the cellulose matter largely abandoned nowadays (such as branches, the tree bark, trunks, logs) will be turned into energetic products. The utilisation of forest biomass for energetic purposes leads to the production of solid or liquid fuels, which could replace a large amount of the current consumption of oil.

The importance of using wood biomass also results from the fact that it belongs to the category of the renewable resources of energy that it is a combustion source neutral from the standpoint of the CO_2 releases into nature and it can be found in nature in large amounts, in various forms. [5]

2. CONSIDERATION ON WOOD BIOMASS AND QUALITATIVE IMPLICATIONS OF THE WOOD BIOMASS STORING

Wood biomass

The most common utilisation of wood biomass for the production of caloric energy is firewood (round, bark-covered wood). In the past 10 years, the percentage of using wood biomass as briquettes and pellets has increased in Romania, too, mainly because of the environmental protection legislation, which compels the trading companies to valorise the wood waste materials ensued from wood processing. [3]

Area (Regional) storing centres for the wood biomass

The wood biomass is stored in biomass centres, where it is conditioned, sorted out and processed. The area biomass storehouse is organised as an open warehouse of raw materials, where the wood meant to heating is stored in bulk in the open air, canopy-free, before being cut off. The logs cut in 1 m or 33 cm lengths are stored in wood or metal enclosures, which help the wood logs to dry out, subject to where they are placed (for instance, in a sunny area).

In the open warehouses meant to the wood biomass, the wood material is stored and subjected to a process of drying in the open air until humidity reaches 23-35 %.

The wood chips are a product that results from the finishing of the raw materials and which, after being stored around six months (in spring and in summer) in the covered area of the warehouse, is delivered for consumption purposes. [1]

In the biomass centres, the wood products from forestry are stored, conditioned, sorted out and processed. A biomass storage centre is an infrastructure that is fundamental for the production and the professional marketing of wood fuels as such and which makes it possible to make available on the market products that meet technical specifications [3]

Storing and storing logistics in a biomass centre: In order to make available the products (the firewood and the chopped wood) in the adequate quantities, the delivered material has to be stored and dried out. The round wood is brought in right after harvesting and it is stored until it reaches 23-35 % water content, after which it is processed at the chopped wood quality wished for. The chopped tree trunks are stored temporarily, until selling, in large enclosures or in the open air. The chopped wood for small plants (up to 1 MW) is only stored in the chopped material industrial hall, so as to avoid its being subjected to bad weather after processing. [9,10]

Cut wood storing

Before selling, split wood has to be stored in large rooms, in order to be protected from the changing weather. The split dry wood ready to be used is stored in enclosures on the sides of the large rooms. The enclosures contain bulk split wood and the large rooms contain units already packed up for selling, which can be stored in rows – maximum 2 overlapped.

Quality chopped wood storing in the large rooms

Quality chopped wood meant to selling by the small and medium plants has to be stored in sheds or large rooms, in order to guarantee the observance of quality requirements.

The chopped wood from forests or from wasted logs (coniferous and broadleaf trees)

Material from coniferous and broadleaf trees – branches and peaks. The thin gross part of the wood must be chopped out at least 40 %. The mixture between the coniferous tree wood and the broadleaf one may vary, subject to the manufacturing batch.

The purchase chains for solid biofuels: The purchase chains for solid biofuels consist in one or several processes, each of them having got one or several operations (Figure 1).

The operations may be carried out by different companies or within the same company. The purchase chain consists in 3 different processes: the one pertaining to the raw material, the manufacturing process and the distribution one. It is important to understand the relationship among these three stages, because any of them may be involved within the purchase chain, in order to define the indicated quality. [9]

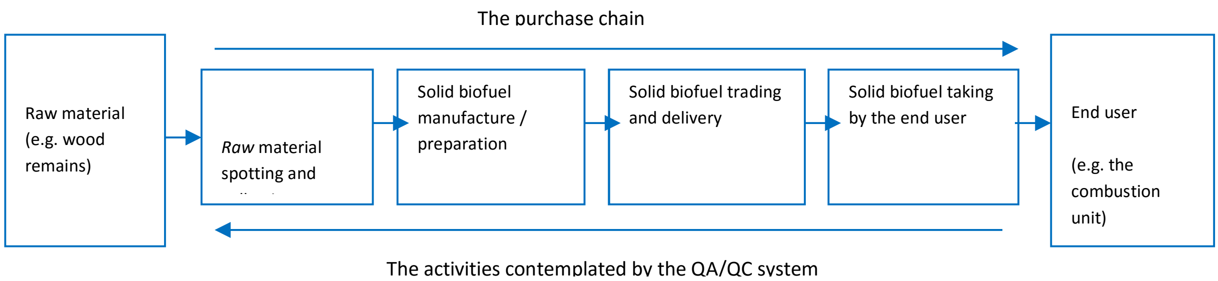

Figure 1. The solid biofuel purchase chain (as modified from EN 15234)

The QA/QC system was designed for the small biomass manufacturers and suppliers, in line with the corresponding CEN (EN) standards and with the technical reports (CEN/TR). The enforcement of the QA/QC system on a large scale cannot be put into practice for the small manufacturers, because of the high costs of the laboratory tests and of the audit costs. This system may be implemented in case of those who produce more than 1000 to/year, where the basic quality parameters can be tested and the goods are tested and declared quality compliant. [9,10]

The provision of the fuel quality during the purchase chain and the check of the solid biofuel quality provide traceability and trust to the customers that all the processes within the purchase chain are under control. The quality assurance system has to be a simple one, meaning to involve minimal additional bureaucracy and to uphold price cuts. [9]

The quality of the wood meant to heating

Firewood quality varies according to the species of trees used for heating, to the conditions in which the trees have grown up, to the particles shape and sizes, to the wood humidity and to the calorific power. [3] (Table 1).

Nevertheless, the most important factor that influences the firewood quality energetically is moisture. The highest efficiency is reached in case of the wood with less than 20 % humidity. The utilisation of wood as dry as possible is vital for the correct functioning of the boilers and ovens, as well as for the assessment of the caloric power of a batch of fuel. [10]

Most boilers that work on firewood are designed to achieve maximum yield on a fuel whose moisture is in a limited range. The utilisation of a fuel outside that range will lead to inefficient functioning and to gas releases. The two quality parameters that influence calorific power, namely moisture content and wood density will be taken into account upon selecting the wood fuel.

The moisture of the freshly cut off wood generally ranges between 45 % and 55 %. After one to two years of storing for drying in the open air, moisture drops to 15-20 % (Figure 2). Ironwood dries out more difficultly than the wood derived from soft wood. The longest drying time is for oak wood. The burning of the freshly cut off wood or of the wet wood gives rise to a small amount of energy and may affect the heat and hot water supply plant. [4].

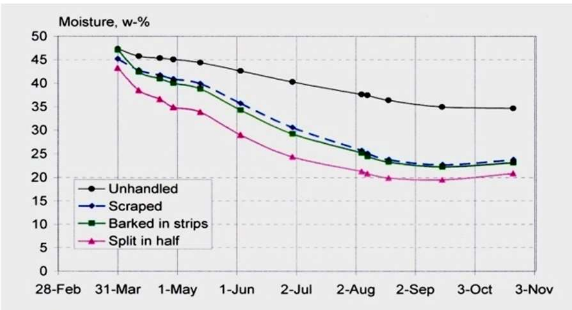

Figure 2. The effect of the bark on drying birch logs in a covered pile [8]

If the freshly harvested wood is left in the open air, its moisture is noticed to diminish gradually: the free water vaporises first, then part of the higroscopicity water, until a balance between the wood moisture and the air humidity is reached, if the temperature and the humidity remain constant. In case of a balance, the tension of the vapours from the wood material is linked to the partial pressure of the vapours in the air. For the climate conditions in Romania, the relative humidity of the wood dried out in the open air varies between 12 % and 15%, which corresponds to the hygroscopic balance for the temperate area. [11]

Table 1

Moisture of the wood compared to the raw wood * and to the dry wood**[11]

Type of wood	U.M.	Absolute humidity **	Relative Humidity*
Pine	%	80-90	44-47
Spruce	%	80-100	44-50
Birch	%	60-80	37-44

The determination of the moisture parameter is needed at the delivery, as the product prices depend thereon. Moisture is determined by the laboratory method or by means of a portable moisture meter. [9]

As regards the caloric value (CV), the differences generated by the wood species are linked to density. The differences generated by the species are little if the moisture is pretty much the same. The calorific power of the various kinds of wood largely depends on their level of moisture (Table 2) [6] and therefore the power of the plants is directly influenced by the type of wood used and by its quality.

Table 2

The caloric value subject to moisture [6]

Condition of wood	Water content (M)	Calorific value (H)
Fresh timber	50-60%	2,0 kWh /kg
Timber stored for a summer	25-35%	3,4 kWh /kg
Timber stored several years	15-25%	4,0 kWh /kg

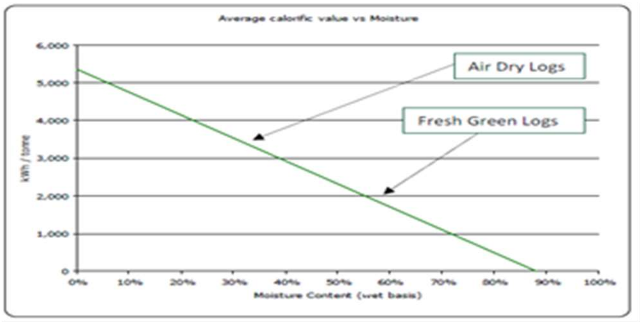

Figure 3. The effect of drying on Calorific Value [12]

The effect of drying on Calorific Value. This graph shows how significant moisture content is in determining the Calorific Value (CV) of wood (Figure 3). A fresh green log of about average moisture content has only around half the energy content of an equivalent, well seasoned log. While the type of tree the log comes from can have some impact on the calorific value, it is usually extremely small.

Wood density. When buying logs, it is common for the seller to let you know whether they are from hardwood or softwood tree species (or mixed). The general difference is that hardwoods (deciduous, broadleaved tree species) tend to be denser than softwoods (evergreen, coniferous species). This means that a tonne of hardwood logs will occupy a smaller space than a tonne of softwood logs. Denser wood tends to burn for a longer period of time meaning fewer 'top ups' are required to keep a log stove burning for a given length of time. If you buy wood by volume you will receive more kilowatt hours (kWh) of heat from a cubic metre (m^3) of hardwood than softwood (at the same moisture content).

Firewood quality in the biomass centres - examples

Wood fuel storing runs three major risks: mould development, weight losses, energetic value losses. An essential element for the quality of biomass storing is represented by the construction and the organisation of the biomass centre, by its size and, last but not least, ventilation – in case of the closed enclosures.

For the production of quality wood fuels (wood chips, log chips), it is important to provide adequate processing and drying operations for the wood used for heating. The drying procedure that leads to a wood biomass adequate to be used for heating purposes is natural drying under the sun and the wind. [7]

The quality of firewood mainly depends on the conditions in which the wood is stored both before and after processing into firewood, chopped wood and wood chips, as well. In order to be used in households, the moisture of firewood has to be 25-30 per cent at the most (Figure 4). By appropriate storing, this can be achieved in less than a year. Furthermore, the weather has got a tremendous influence on the firewood stored in uncovered piles. [6]

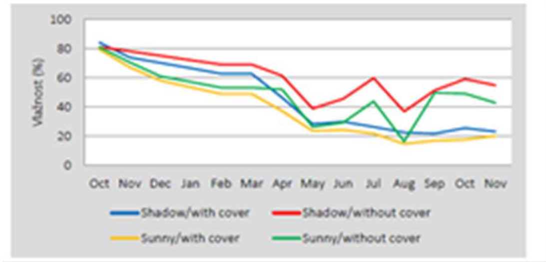

Figure 4. Test of monthly measurements of drying of four different piles of log wood [6]

Logs (firewood) start to lose humidity in winter, however the greatest loss (approx. 10%) takes place in March. During scorching summers (for instance, the summer of 2012) (Figure 5), the wood freshly cut in December and stored under a canopy can reach a 20 % humidity in June, thus becoming suitable for marketing. Nonetheless, in case of the wetter summers (for instance, the summer of 2013) (Figure 5), the differences that can be traced are minimal and the value of 20 % in terms of humidity can be reached indeed, but one month later. Starting from September, the wood regains humidity from the air and the rain. [1] Figure 6 outlines the variations in the moisture of the firewood kept in uncovered sunny enclosures, the tests having been carried out in two small capacity biomass centres, between 2013 and 2014.

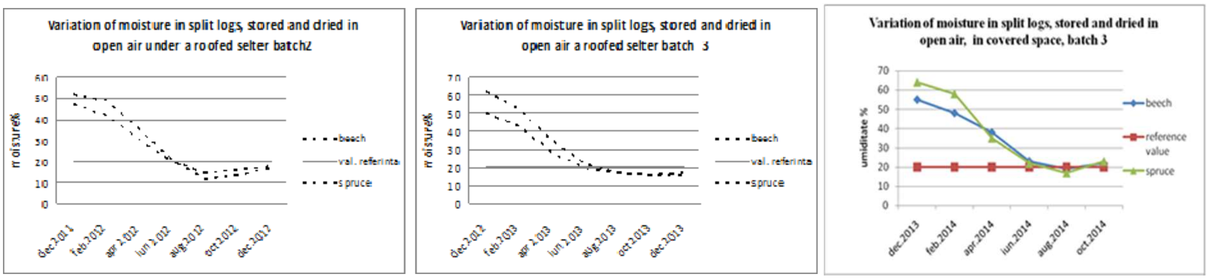

Figure 5.Variation of moisture with split logs and stored in the open air under a roofed shelter between 2011-2012, 2012-2013[1], 2013-2014 [3]

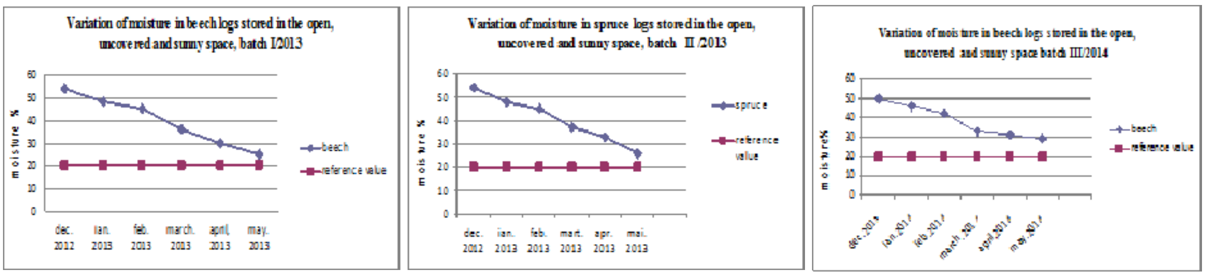

Figure 6.Variation of moisture in dried firewood that was dried and stored in the open uncovered, sunny space 2013 (batch I and II) [1], and 2014 batch III [3]

Quality standards for the wood biomass from the biomass centres

The goal of implementing the quality assurance systems is mainly to provide the possibility of adequately placing solid biofuels on the European market with reasonable prices; in this way, the end user can rely on the quality of the solid biofuels for utilisation purposes and, on the other hand, the manufacturers can improve, check and make their products subject to the market demands.

The standards enforcement and usual utilisation are deemed to be a good measure for shaping a European market more dynamic and longer lasting for the solid biofuels and for bettering the interactions amongst the fuel producers, the suppliers and the end users.

3. CONCLUSIONS

The authors' contribution to this paper is to set out data from the wood biomass literature. The advantages of its utilisation have taken into account quality, in the light of the European standards, some of them being already taken over at the national level.

The main advantages of the wood waste materials/wood biomass are: to valorise the product resulted by its marketing both on the domestic market and in exports, to make a simple alternative for producing heat in households or in manufacturing companies within the small industry, to apply the quality and environment standards existing at the European level
Seeing the importance of such quality parameters as humidity, on which the caloric power depends, the importance for the yield of the heat and hot water supply plants, as well as the particle sizes in the chopped wood and wood chips, it is necessary to implement the quality standards for solid biofuels in the biomass storehouses. The introduction of a quality system is called for in case of the small manufacturers and of the biomass warehouses, in order to guarantee the quality of the products delivered to the customers.

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APPROACHES OF THE CURRENT PARADIGM BIOFUELS VS. FOOD

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ABSTRACT

Biofuels present opportunities as well as risks for food security, as most of the crops used as raw materials in order to produce biofuels are also used as food and feed. This could has direct implications for food security. The critique of biofules and the relationship between fuel and food have to be supported by solid arguments concerning the specific conditions of each particular country or region by taking into consideration the availability, stability, utilization and access to renewable resources. The interest of food industry for biofuels is hence very justified, although with a normal focus on the "food first" issue.

The current opinion worldwide is that the biofuels development should not compromise food security, the core objective from this perspective being to maintain a consistent balance between the right of all people to sufficient, nutritious, affordable food and energy security.

1. INTRODUCTION

Agriculture has always been a source of energy, and energy is a major resource for modern agriculture. The harvest, storage, processing and distribution of food represent a sector involving energy-intensive activities, hence the powerful impact that energy has on agricultural production and food costs. Given that a number of agricultural commodities used as raw material for biofuels, the relationship energy - agricultural products is very actual and acute.

Biofuels present opportunities as well as risks for food security, as most of the crops used as raw materials in order to produce biofuels are also used as food and feed. This could have direct implications for food security [1].

While biofuels have significant agricultural markets, today biofuels produced from agricultural raw materials still represent a relatively small segment of the energy market [2].

Based on the OECD – FAO Agricultural outlook assumptions, the coarse grains and sugarcane still remain the dominant ethanol feedstock, and vegetable oil remains the main feedstock in biodiesel production. Thereby, the biofuel production is expected to need 10.5% of global coarse grains and 13% of global vegetable oil production respectively in 2024. On the other hand 25% of global sugarcane production is used to produce ethanol by 2024, up from 21% in 2014. Regarding the second generation biofuels sector, the ligno-cellulosic biomass based ethanol is forecasted to only about 2% of world ethanol production by 2024 [3].

Biorefining refers to the conversion of biomass (including waste) into chemicals, materials, fuel and energy, with minimum waste and harmful emissions. According to the definition, biorefining is co-producing a variety of bio-products (food, feed, materials, and chemicals) and energy (fuel, heat, electricity) from biomass [4]. Thus, a bio-refinery is an ensemble that integrates biomass conversion processes and equipment to produce fuels, electric power, and chemicals. Biofuels are fuels derived from renewable biomass for use in combustion engines or other forms of power generation, partially or totally replacing fossil fuels.

Renewable Energy Directive 2009/28/EC establishes an overall policy for the production and promotion of energy from renewable sources in the EU, and requires to fulfil at least 20% of its total energy needs with renewables by 2020 to be achieved through the attainment of individual national targets. The directive specifies national renewable energy targets for each EU country, taking into account the specific starting point and the overall potential for renewables. Thereby, these targets range from a low of 10% in Malta to a high of 49% in Sweden. In addition, EU countries must also ensure that at least 10% of their transport fuels come from renewable sources by 2020 [4, 5, 6].

Directive 2009/30/EC was adopted in 2009 as revision of the Fuel Quality Directive 98/70/EC. It amends a number of elements of the petrol and diesel specifications as well as introducing a requirement on fuel suppliers to reduce the greenhouse gas intensity of energy supplied for road transport. The directive establishes also sustainability criteria that must be met by biofuels if they are to count towards the greenhouse gas intensity reduction obligation [3].

2. CHANGES IN EU LEGISLATION WITHIN THE FIELD OF BIOFUELS

On October 2014 the European Council adopted the “2030 climate and energy policy framework”, which does not set a specific sub-target for renewable energy use in transport. To ensure delivery of the overall EU renewable energy target for 2030, on February 2015 the Commission adopted a Communication on the Energy Union.

On September 15 the Directive 2015/1513 was published in the Official Journal and entered into force. It is called the Indirect Land Use Change Directive (ILUC Directive) and amends Fuels Quality Directive and the Renewable Energy Directive. Transposition of the ILUC Directive by the Member States into national legislation has started and it must be completed by September 2017 [7].

The ILUC Directive states also a cap of 7% on the contribution of biofuels produced from food crops, and a greater emphasis on the production of advanced biofuels from waste feedstocks [5].

The interest of food industry for biofuels is hence very justified, although with a normal focus on the “food first” issue. Thereby, FoodDrinkEurope (FDE), the representative body of Europe’s food and drink industry, has been launched the message that the biofuels policy should be designed in order to limit the contribution of food-based biofuels, to enhance advanced biofuels not competing with food and to ensure the sustainability of biofuels [8].

3. EVOLUTION OF THE CONCEPTS ON BIOFUELS RELATED TO FOOD INSECURITY

Based on the last FAO definition, food insecurity is defined as prolonged lack of access to enough food to meet basic needs [9]. FAO considers also that food security involves four relevant dimensions - availability, access, stability and utilization [10].

For more than one decade the general opinion was that biofuels negatively affect food security. This derives from the utilization of food crops as raw materials to produce biofuels (bioethanol and biodiesel).

Based on the OECD – FAO Agricultural outlook assumptions [3], the global ethanol and biodiesel production are expected to expand to reach, respectively, almost 134.5 and 39 billion litres by 2024. Unfortunately, the food-crop based feedstocks are expected to continue to dominate the production of liquid biofuels (bioethanol and biodiesel) over the coming decade. This aspect is mainly due to the next reasons:

- insufficient investment in research and development for advanced biofuels;

- the lack of policies' visibility for operators [3].

The figures for production and consumption of liquid biofuels are forecasted to increase in EU for the next de decade. The bioethanol fuel use is expected to expand by 3.4 billion litres.

Biodiesel use is projected to increase to almost 14.8 billion litres in 2020 when the Renewable Energy Directive target is assumed to be met. Biodiesel use is expected to decrease to 13.4 billion litres in 2024 because of the declining diesel use prospects, increased energy efficiency and the assumed continuation of the double counting rules under Renewable Energy Directive. Bioethanol use is expected to reach an average volume share of 7.8% in petrol types for transport fuels by 2024, and an average share of 6.4% for biodiesel in diesel type fuels [3].

During the 40th Session in 2013, the Committee on World Food Security (CFS) of Food and Agriculture Organisation of the United Nations (FAO) outlined the following aspects on biofuels and food security:

-energy and food security are linked. CFS considers as a challenge the achieving both food security and energy security;

-the biofuel development encompasses both opportunities and risks in economic, social and environmental aspects, depending on specific national and regional context and practices;

-the production and consumption of biofuels influence international agricultural commodity prices;

-the links between biofuels and food security are multiple and complex and can occur in different ways at different geographic levels (local, national, regional, global) and time scales;

-in some cases, current biofuel production creates competition between biofuel crops and food crops;

-it is necessary to ensure that biofuels policies are coherent with food security to minimize the risks and maximize the opportunities of biofuels in relation to food security [10].

CFS encouraged governments to seek coordination of their respective food security and energy security strategies, giving due consideration to the sustainable management of natural resources.

Finally, the CFS main conclusion was that biofuels development should not compromise food security whether the governments will properly coordinate their respective food security and energy security strategies, giving due consideration to the sustainable management of natural resources [10].

FAO General Director José Graziano da Silva declared in an opinion article in 2014 that flexible biofuel policies are necessary for a better food security. José Graziano da Silva considers also that modern biofuels have become a fact of life, but to be truly sustainable, biofuel production must strike a balance between its benefits and its potential hidden costs, between energy security and food security [11].

In a key message of a speech delivered at the Global Forum for Food and Agriculture in Berlin in January 2015, he declared also that the food systems of the future need to be smarter, and more efficient. Moreover, he considers that the competition for resources and energy necessitates a "paradigm shift", and therefore the biofuels should be part of the mix.

Biofuels production and food security need not be mutually exclusive, but the intrinsic link between the two does need to be acknowledged in the policymaking process, in order to maintain a consistent balance between energy security and the right of all people to adequate, nutritious and affordable food [12].

Finally, General Director José Graziano da Silva considers that the biofuel production and food security need not be mutually exclusive and the progressive realization of the right to adequate food for all" should be a priority concern in biofuel development.

4. CONCLUSIONS

The critique of biofuels and the relationship between fuel and food have to be supported by solid arguments concerning the specific conditions of each particular country or region by taking into consideration the availability, stability, utilization and access to renewable resources.

The current opinion worldwide is that the biofuels development should not compromise food security, the core objective from this perspective being to maintain a consistent balance between the right of all people to sufficient, nutritious, affordable food and energy security.

It is obvious that the links between biofuels and food security are multiple and complex and can occur in different ways at different geographic levels (local, national, regional, and global) and time scales.

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STUDY ON THE INFLUENCE OF MECHANICAL VIBRATIONS TO THE ENERGY REQUIRED FOR SOIL TILLAGE

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ABSTRACT

From the various theoretical studies, but also from experimental tests it was found that if the working tool for soil tillage vibrates, conditions are created to ensure a reduction in draft resistance of the working tool through the soil, and, therefore, a reduction in the energy needed to perform soil tillage work. The vibrations of the working tool can be transmitted in longitudinal, transverse direction or in any direction. The same soil can have very different physical and mechanical properties and is impossible to apply classical methods of the mechanics of continuum medium for agricultural soil. Phenomenon related to soil dynamics can be studied by means of some models characterized by a limited number of parameters. In this context, foe modeling it can be used the similarity method or Buckingham's Π theorem in dimensional analysis. The influence of vibrations is equivalent to the action of an additional force applied to the working tool, which influences the traction and friction forces between the working tool and tilled soil. This paper presents the results on the variation of the vibrations intake on reducing the energy consumed to drive the working tool in case of vibration, depending on the orientation angle of the additional force necessary to generate the vibrations to normal in the forward direction for different values of the angle of external friction between the active surface of the working tool and the soil.

Keywords: Vibrating tillage tool, soil tillage, draft resistance, tillage energy

1. INTRODUCTION

From the theoretical studies and experimental tests it has been found that if the working tool for soil tillage vibrates, a reduction in the draft resistance occurs [6]. To explain the effect of reducing the draft resistance in the case of vibrating working tools, were developed a number of assumptions based on analogies and models of different processes, which, until now, have not yet managed to explain all aspects of the results achieved experimentally to the application of vibrations.

The vibrations of the working tool can be transmitted in the longitudinal, transverse direction or in any direction. Some current assumptions allow evaluating, to some extent, the effect of reducing the traction force necessary in case of longitudinal oscillations, but, in case of transverse oscillations, the effect of reducing the traction force is not yet explained.

From the study of the literature, it can be shown that:

- there is a lower limit of forced vibrations amplitude of the working tool below which are not observed changes in the traction force necessary to a vibrated tool compared to a non-vibrating tool [2, 4].
- increasing the vibration frequency leads to the reduction of the necessary traction force, but, at minimum frequency values, is even observed its increase [2].
- changing the forward speed of the machine for a constant frequency of forced vibrations of the active tool leads to the change in soil resistance as follows: at high

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frequencies, increasing the forward speed increases soil resistance, but at low frequencies, the reverse phenomenon occurs [1].
- forced vibrations of the working tool also determine changes in the layer of soil adjacent to the work surface. When applying vibrations that determine inertial forces higher than the cohesive forces between soil particles, it occurs a better crumbling of the soil. Otherwise, only elastic oscillations of the soil occur, or a certain cutting of the soil is produced [5].

Research conducted in this field have pointed out that any process of soil tillage by machines with non-vibrating or vibrating tools involves a number of essential elements, as shown in the following tables.

Table 1: The case of soil tillage with non-vibrating tools

Element	Quantity	Dimension
Engine	Traction force, F_{t0}	$L \cdot M \cdot T^{-2}$, [N]
Working tool	Working width, b	L, [m]
	Travel speed, v_0	$L \cdot T^{-1}$, [m/s]
Tilled material	Specific resistance, σ	$M \cdot L^{-1} \cdot T^{-2}$, [N/m^2]
	Coefficient of external friction, μ	1
	Bulk density, ρ	$M \cdot L^{-3}$, [kg/m^3]

Table 2: The case of soil tillage with vibrating tools

Element	Quantity	Dimension
Engine	Traction force (with vibration), F_υ	$L \cdot M \cdot T^{-2}$, [N]
Vibrator	Frequency, υ	T^{-1}, [Hz]
	Vibrator mass, m_v	M, [kg]
	Eccentricity, e	L, [m]
Working tool	Characteristic lenght, l	L, [m]
	Mass of the working body, m_0	M, [kg]
	Travel speed, v_0	$L \cdot T^{-1}$, [m/s]
	Mean amplitude, A	L, [m]
Tilled material	Specific resistance, σ	$M \cdot L^{-1} \cdot T^{-2}$, [N/m^2]
	Coefficient of external friction, μ	1
	Bulk density, ρ	$M \cdot L^{-3}$, [kg/m^3]
	Coefficient of viscosity, η	$M \cdot L^{-1} \cdot T^{-1}$, [Ns/m^2]
	Elastic constant, k	$M \cdot T^{-2}$, [N/m]

The role of each participat element in the process is as follows:
- Engine – power source;
- Working tool – power reciever;
- Tilled material – power accumulator;
- Vibrator – transformer of the application form of the power.

2. METHODOLOGY

Since the same soil can have very different physical and mechanical properties (depending on its moisture and previous works), some researchers consider that is impossible to apply the usual methods of the mechanics of continuum medium for agricultural soil [3] and that the phenomena related to soil dynamics can be studied using some models characterized by a limited number of parameters. In this context, the similarity method can be used for modeling, for which, as independent variables, are considered:

- traction force in non-vibrating processes, F_{t0}
- travel speed, v_0
- frequency of forced vibrations, υ
- amplitude of vibrations, A.

Using Buckingam's Π theorem in dimensional analysis, it can be written [3]:

$$F_{t0} = \sigma \cdot b^2 \cdot \phi_0(\mu; \frac{\rho \cdot v_0^2}{\sigma}) \tag{1}$$

Variation of the traction force to the movement of the working tool in vibratory regime is the result of overlapping of two processes taking place simultaneously:

- oscillations of the vibrator causes some forced oscillations of the working tool;
- regrouping the forces of interaction between the tool and soil that have the effect of modifying the traction force.

The characteristics of the first process are (according to Table 1):

- for the vibrator: m_v, e, υ
- for the working tool: m_0, A
- for the tilled material: η, k

The most important characteristic of this first process is mean amplitude (A), which can be determined by the equation established based on the Π theorem [3]:

$$\frac{A}{e} = \phi_1(\frac{m_1}{m_0}; \frac{\eta}{m_0 \cdot \upsilon}; \frac{k}{m_0 \cdot \upsilon^2}) \tag{2}$$

The characteristics of the second process are (according to Tables 1 and 2):

- for the working tool: l, v_0, m_0, A, υ
- for the engine: F_{t0}, $\Delta F = F_{t0} - F_v$
- for the tilled material: σ, μ, ρ

The dimensionless characteristic of this process, which represents the relative variation of the traction force, is the ratio expressed by the equation [3]:

$$\delta = \frac{\Delta F}{F_{t0}} = \phi_2(\frac{A \cdot \upsilon}{v_0}; \frac{A}{l}; \frac{\sigma \cdot l^2}{F_{t0}}; \mu; \frac{m_0 \cdot v_0^2}{l \cdot F_{t0}}; \frac{\rho \cdot l^3}{m_0}) \tag{3}$$

From equation (3) it can be observed that the variation of traction force depends on the ratio between vibration and forward speeds, the size of mean amplitude and four dimensionless coefficients that characterize the medium (tilled material).

If in equation (3) is noted:

$$\delta_0 = \frac{A \cdot \upsilon}{v_0} \tag{4}$$

then, from the expressions of terms ϕ_1 and ϕ_2, the parameters A and υ can be eliminated, and equation (3) becomes:

$$\delta = \frac{\Delta F}{F_{t0}} = \phi_3(\delta_0; \mu; \Pi_1; \Pi_2; \Pi_3) \quad (5)$$

The main dimensionless parameter, on which depends the variation of draft resistance, is the speed ratio δ_0:

$$\delta = \phi(\delta_0) < 1 \quad (6)$$

From equation (6) it results that the relative reduction of traction force increases with increasing frequency and amplitude and decreases with increasing forward speed, as the differential:

$$d\delta = \frac{d\phi}{d\delta_0}\left(\frac{A}{v_0}d\upsilon + \frac{\upsilon}{v_0}dA - \frac{A\cdot\upsilon}{v_0^2}dv_0\right) \quad (7)$$

increases with the increase of υ and A for $d\phi/d\delta_0 > 0$, i.e., in the range where ϕ is a monotolically increasing function of δ_0.

The influence of vibrations is equivalent to the action of an additional force *T,* applied to the working tool, which influences the forces of traction and friction between the working tool and tilled soil (Fig. 1) [5]. The reduction of draft resistance (the force required to drive the working tool) can be calculated using the equation:

$$\Delta F = F_{t0} - F_{\upsilon} = \xi \cdot T \quad (8)$$

$$\xi = \frac{\sin(\alpha + \varphi)}{\cos\varphi} \quad (9)$$

where: ξ – is the coefficient of vibrations intake on the reduction of energy onsumed to drive the working tool in case of vibrating. This coefficient must be above unit in order to consider that this intake is obtained.

α – angle of orientation of force *T* to the normal in the forward direction.

φ – angle of external friction between the active surface of the working tool and soil.

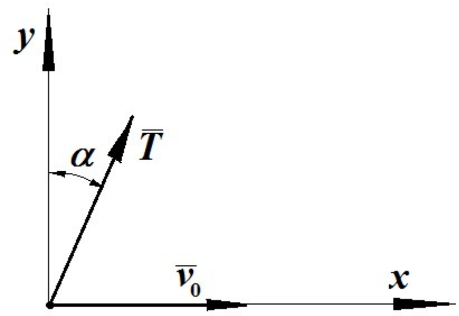

Figure 1: Orientation of additional force towards the forward direction

3. RESULTS

Figures 2 and 3 present the results on the variation of the intake of coefficient of vibrations ξ on the reduction of energy consumed for driving the tillage tool when vibrating, depending on the angle of orientation of the *T* force to the normal in the forward direction (α) for different values of the angle of external friction between the active surface of the working tool and soil (φ).

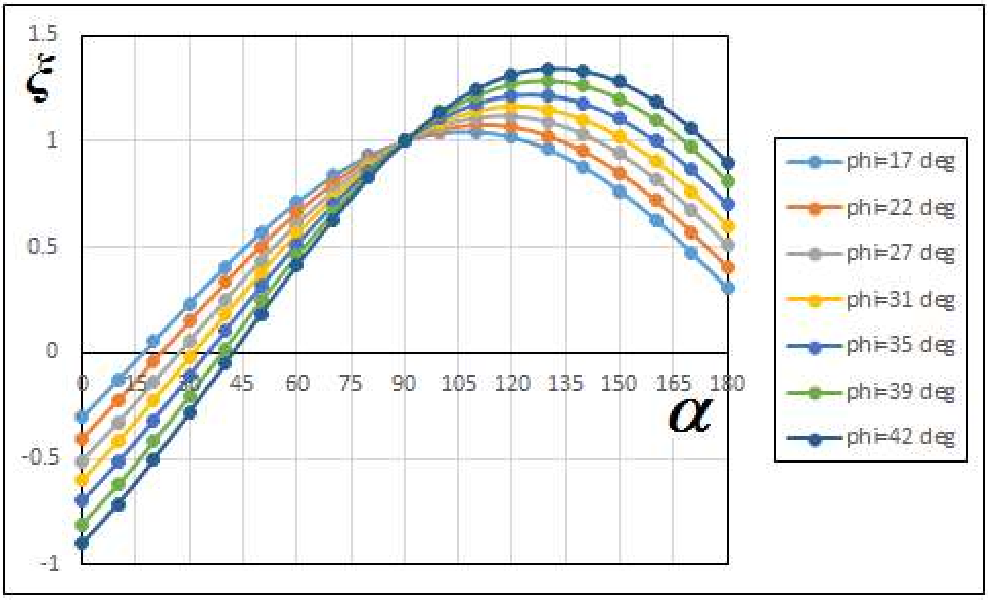

Figure 2: Graphic variation of coefficient ξ dependence of angles α and φ

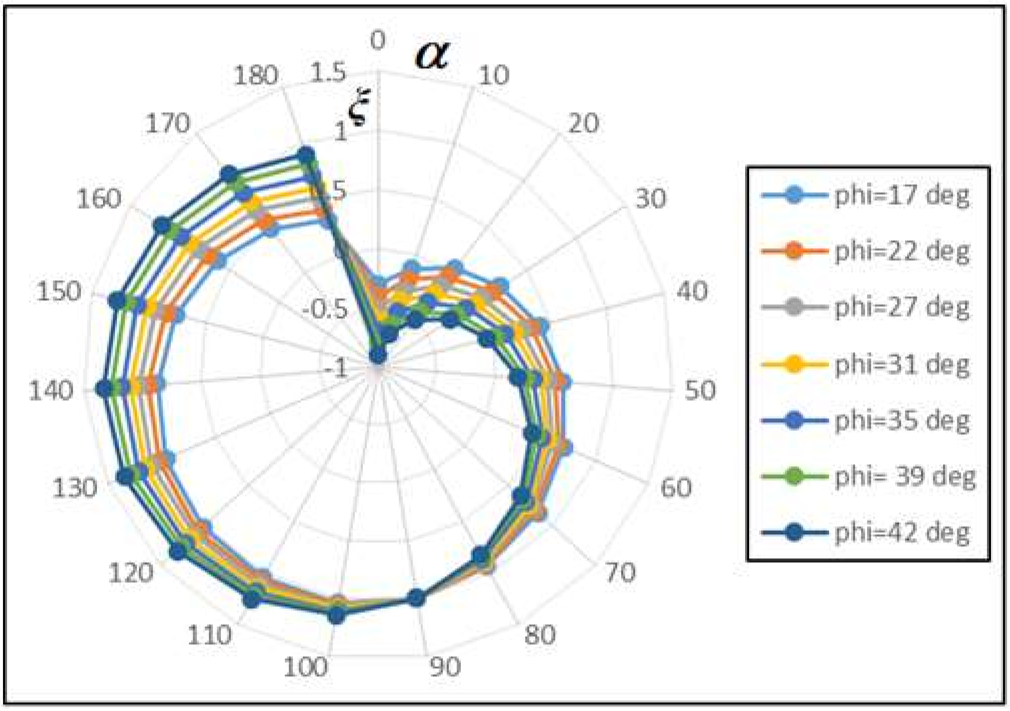

Figure 3: Graphic circular variation of coefficient ξ dependence of angles α and φ

4. CONCLUSIONS

- If the soil tillage tool vibrates, conditions are created to provide a reduction of draft resistance of the working tool through the soil and, therefore, a reduction in the energy required to perform soil tillage works.

- The influence of vibration is equivalent to the action of an additional force applied to the working tool, that influences the traction force and the friction force between the working tool and tilled soil.
- From equation (6) it results that the relative reduction of traction force increases with the increase of frequency and amplitude and decreases with the increase of forward speed.
- Figures 2 and 3 provide valuable informations on geometry configuration of the tool for soil tillage, the direction of orientation of additional force required to generate the vibrations, depending on the physical and mechanical properties of the soil. The value of intake coefficient of vibrations on the reduction of energy consumption for soil tillage must be higher than unit.
- From Figures 2 and 3 it results that, as the angle of external friction between tool and soil is higher, the intake of vibrations in reducing the energy required for tillage is more evident.

5. ACKNOWLEDGEMENTS

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SYNTHETIC PRESENTATION OF A CARBON-BASED PRODUCT FROM BIOMASS

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ABSTRACT

The interest in the effects of biochar application on soils (fertilization/remediation), plant growth, water properties and environmental impact has stimulated a significant quantity of research in recent years. This is mainly due to its properties and the diversity of materials that can be used in their synthesis. The utility of this product for various applications was proved in different fields of activity. The biochar could replace a series of currently used materials obtained from potential dangerous chemical compounds or from high pollutant and energy consumption processes. Consequently, this paper pursues the biochar properties that are relevant to its applicability in a few fields of activity of all known at this time.

1. INTRODUCTION

Once Kyoto Protocol was signed, international efforts were entered in a strong battle on reducing greenhouse gas emissions through the use of alternative energy sources and renewable fuels. Scientists are increasingly advising policymakers that carbon emission reductions of beyond 60% are needed over the next 40-50 years (EREC, 2005). The alternative sources can help to decrease the dependence on fossil fuel reserves and significantly reduce CO2 emissions (J. A. Mathews, 2008; J. Lehmann, 2006a). In the last years more and more voices say that renewable energy represents a key solution to climate change. Also, a renewable product has attracted worldwide interest and it is called one of the key materials for a sustainable future of the planet since it can be applicable in many sectors, ranging from agriculture to medicine and textiles. Biochar is a carbon based product derived from biomass that provide useable energy, can enhance soils and sequester or store carbon (Lehmann et al., 2006b).

Historical use of biochar comes from faraway; it dates back at least 2000 years (O'Neill et al. 2009). Soils from the entire world contain biochar deposited through natural events, such as forest and grassland fires (Krull et al. 2008). There are areas high in naturally occurring biochar, such as the North American Prairie that are some of the most fertile soils in the world. In the Amazon Basin, proof of wide use of biochar can be found in the unusually fertile soils known as Terra Preta and Terra Mulata that were created by ancient, indigenous cultures (O'Neill et al. 2009). Due to the large amounts of biochar integrated into its soils, this region still remains highly fertile in spite of centuries of leaching from heavy tropical rains.

In Asia, especially Japan and Korea, the use of biochar in agriculture also has a long history. In recent times, heightened interest in more sustainable farming systems, such as Korean Natural Farming, has invigorated the use of biochar in Western agriculture. In Japan, biochar has been applied since approximately 1697, where the oldest published mention about the rice

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husk biochar use in soil is made (Ogawa et al., 2010). Since then the biochar has been used in agriculture and horticulture, also for improving the vitality of ancient pine trees near shrines (Ogawa et al., 2010). In the book A Brief Compendium of American Agriculture 1846, R.L. Allen's has included a few remarks about the charcoal use in agriculture, including as a soil amendment and feed additive. In the past, in Spain, the construction of configurations similar to charcoal kilns was used to fertilize soil, this technique still being applied in India and Bhutan (Olarieta et al., 2010).

All of these uses have been practiced in many different pre-industrial cultures. In the modern world, the uses multiply: adsorber in functional clothing, insulation in the building industry, as carbon electrodes in super-capacitors for energy storage, food packaging, waste water treatment, air cleaning, silage agent or feed supplement.

2. MATERIALS AND PROCESS PARAMETERS FOR BIOCHAR PRODUCTION

International Biochar Initiative (IBI) considers that materials used for the production of biochar could be: agricultural and forestry wastes Forest Residue, Bark Wood, Mill Residue, Switch Grass, Corn Stover, Bagasse, Wood chips, as well as Sludge from Wastewater Treatment Plants and Animal manure.

The key chemical and physical properties of biochar are greatly affected by the type of feed stock and the conditions of the conversion process. Pyrolysis processes are performed for waste conversion yielding black biochar and other by-products.

Almost all char production technologies use the thermal processing in inert atmosphere. Pyrolysis represents a very old technology, which is still relevant within energy production and conversion of biomass (Antal and Gronli, 2003; Demirbas et al., 2002). Charcoal has been produced from pyrolysis of biomass for thousands of years, and in recent times this technology has also become attractive for the production of biochar (Laird, et al., 2009). The charcoal solid, termed biochar, if deliberately made for soil application, is generally of high carbon content, up to 50 % of the original plant-carbon. The elevated content of carbon lasting in the biochar is conserved despite the relatively high process temperatures, because oxygen is unavailable for further reaction.

Pyrolysis reactor characteristics, peak process temperature, heating rate, and feedstock quality (e.g. particle size and water content) are the fundamentally parameters that influence the quantity and quality of the pyrolysis products. The consequence of higher pyrolysis temperatures are lower biochar yields (but higher gas yields) with less original structures and chemical components remaining. Biochar characteristics – elemental composition, porosity, particle and pore sizes, and fractions of easily degradable hydrocarbons – are also very much influenced by the above parameters (Antal and Gronli, 2003; Downie, et al., 2009; Gheorghe et al., 2009).

A remarkable characteristic of biochar is its high porosity. The bulk density of biochar generated from plant biomass is inferior to that of the corresponding feedstock and the biochar usually retains the cell wall structure of the biomass (Downie et al., 2009). At a smaller scale, amorphous grapheme sheets are the major part of the biochar content, which give rise to large amounts of reactive surfaces where a wide variety of organic (both polar and non-polar) molecules and inorganic ions can sorbs (Levine, 2009). The effect of different feedstocks and pyrolysis temperature on the development of specific surface area in biochar is shown in Table 1.

Table 1: Effect of pyrolysis temperature and feedstock type on the specific surface of biochar

Feedstock	**Pyrolysis temperature (°C)**	**Specific surface of biochar (m^2g^{-1})**	**Reference**
Oak wood	350	450.00	(Lehmann, 2011)
	600	642.00	
Corn stover	350	293.00	(Lehmann, 2011)
	600	527.00	
Poultry litter	350	47.00	(Mullen et al., 2010)
	600	94.00	
Apple tree branch	400	11.90	(Jindo et al., 2014)
	600	208.69	
Rice husk	400	193.70	(Jindo et al., 2014)
	600	243.00	
Rice straw	400	46.60	(Jindo et al., 2014)
	600	129.00	

3. POTENTIAL APPLICATIONS OF BIOCHAR

According to literature data, the most common use of biochar is its application to increase crop yields and soil fertility, to decrease fertilizer runoff, lime and fertilizer use and to minimize greenhouse gases such as methane and nitrous oxide. Beside these uses, the biochar is recognized as a viable product for removal from soil of various pollutants: heavy metals, polycyclic aromatic hydrocarbons, polychlorinated dibenzo-p-dioxins/dibenzofurans, pesticides etc.

3.1. Soil fertiliser

Fertilization is one of the most important operations in crop production. As a soil amendment, biochar helps to improve the Earth's soil resources by raising the yield and production of the crops, by reducing the soil acidity, and by decreasing the necessity of some chemical and fertilizer inputs. Use of biochar as soil amendment conducts to improving of the water quality because biochar helps retention in soil of nutrients and agrochemicals for plant and crop utilization (Lehmann et al. 2003). This reduces leaching and run-off of soil nutrients to ground and surface waters. It is known that biochar improves the soil texture and ecology, increasing its capacity to retain fertilizers and release them slowly. It naturally contains many of the micronutrients required by plants, such as selenium. It is also secured than other "natural" fertilizers (e.g. manure, sewage) because it has been sterilized at high temperature, and because it releases its nutrients at a slow rate, it greatly reduces the risk of water table contamination.

From the experimental research in the field of biochar use for soils, and for which results have been published, generally, great yield improvements were achieved when biochar was applied on such soils, up to 300% over enough, unamended controls (Blackwell et al., 2009; Lehmann et al., 2006b; Van Zwieten et al., 2010a). Very recent researches focused directly on plant growth responses and agricultural yields when using biochar as a soil amendment, which improvement is the main aim for using biochar in the first place (Field et al., 2013; Lehmann and Joseph, 2012).

3.2. Soil decontamination

Many laboratory studies looking for the potential of various types of carbonaceous sorbents to reduce the bioavailability of PAHs (Brändli et al., 2008; Yang et al., 2009; Beesley et al., 2010; Gomez-Eyles et al., 2011), polychlorinated dibenzo-p-dioxins/dibenzofurans Fagervold et al., 2010), and organic pesticides (Yang et al., 2006; Yu et al., 2006; Wang et al., 2010) in soils have demonstrated a feasible solution.

Other studies have revealed that the integration of biochar in soils can increase the sequestration of organic contaminants. For example, Chen et al. (2011) showed that pine needle biochars produced applying high pyrolysis temperature for six hours, contained increasing concentrations of carbon content and surface area due to destruction of aliphatic alkyl and ester groups. The sorption of naphthalene, nitrobenzene and m-dinitrobenzene rises non-linearly by increasing the temperature of the process used for biochar production. Bornemann et al. (2007) reported augment in the sorption of benzene and toluene onto red gum charcoal produced at higher temperature. More recently, Oleszczuk et al. (2012) reported that addition of either activated charcoal or biochar as an adsorbent can diminish the mass transfer of contaminants from PAH-containing sewage sludge matrix into pore-water.

3.3. Enhancer for revegetation and forest restoration

The majority of biochar materials is characterized by a high pH and can proceed as liming agents, to increase the soil pH. There are cases when organic matter and clay levels in soil are low and soil is coarse textured; in these situation the moisture retention may help the establishment of vegetation and biochar can help with this. Another effect of the biochar application to soil is reduction of the nutrient leaching (International Biochar Initiative).

3.4. Carbon sequestration and greenhouse gas emission perspective

Biochar for carbon sequestration is relatively new research field, emerging with the rising scientific and political awareness of climate change. In the popular media, biochar is recognized as a bit of a miracle cure, see e.g. Al Gore's book 'Our Choice: A Plan to Solve the Climate Crisis' or James Lovelock's article in the Guardian (Lovelock, 2009), or, for quite the opposite view, e.g. "*Biochar for Climate Change Mitigation: Fact or Fiction?*" from the Organisation Biofuel Watch. Turning waste biomass into biochar reduces methane (another potent greenhouse gas) generated by the natural decomposition of the waste. Systems used for biochar production and utilization are different from generally biomass energy systems because the technology is carbon-negative (it removes net carbon dioxide from environment and stores it, as stable soil carbon "sinks") (Lehmann et al. 2006a).

Biochar has proved influence on soil CO_2 and N_2O emissions. Biochar produced by slow pyrolysis of green waste, paper mill waste, and bio solids have proved the reduction of N_2O emissions from an acidic Ferrosol. Similar decreasing was observed for the raw waste feedstock Van Zwieten et al. (2010b).

Biochar represents an efficient instrument for sequestration of carbon in soils. Yoo and Kang (2012) and Kammann et al. (2012) found that biochar produced by pyrolysis at higher temperatures caused a superior reduction in cumulative CO_2 release compared with biochars produced at lower temperatures. Over a 365 day period, Qayyum et al. (2012) measured cumulative CO_2 released from three soils amended with either nothing, wheat straw, hydrochar (200°C), low-temperature biochar (sewage sludge pyrolyzed at 400°C), or charcoal (550°C). Cumulative CO_2 released generally followed the order: wheat straw > hydrochar > low temperature biochar > charcoal = control. The conclusion of the authors was that the biochar utilized for an application should match with the aim of the use, with high-temperature biochars being good for soil carbon sequestration and low-temperature biochars perhaps better for improving soil fertility.

3.5. Industrial application

The contamination of water with synthetic organic compounds (SOCs) such as pesticides, pharmaceuticals and fuel compounds is an upward problem of the world because these chemicals are very dangerous for people, cause cancers and other illnesses. There are often few economically, sustainable and appropriate treatment technologies available for SOC removal in rural areas. Activated carbon (AC) is considered a superlative technology for the removal of SOCs from water in rural areas; however AC manufacturing processes are complicated and usually cannot be replicated in these rural areas without large infrastructure investments. It is known that charcoal can show properties similar to activated carbon.

Studies performed by a research team from University of Florida have demonstrated the effectiveness of biochar for phosphate removal from water (Ying et al., 2011). The study look at the beet tailings, which are culled beets, scraps, and weeds removed from shipments of sugar beets designed for processing to make sugar. In the United States, sugar beets are grown primarily in the Northeast and upper Midwest, but the technology can be adapted to other materials. The biochar was added to a water-and-phosphate solution and mixed for 24 hours. It removed about three-quarters of the phosphate, which was much better than that removed by other compounds, including commercial water-treatment materials.

The capacity of the biochar in removing nitrate has been demonstrated by some research studies (Mizuta et al., 2004). Biochar also has an affinity for organic compounds. This could confound use of the post-treatment biochar product on land; the economic and overall carbon and environmental gain to be achieved from centralized versus diffuse deployment for management of water quality have yet to be assessed. An example for a centralized approach is the present use of activated carbon for the removal of chlorine and organic chemicals (phenols, polychlorinated biphenyls, pesticides, trihalomethanes and halogenated hydrocarbons) and heavy metals (Boateng et al., 2007).

4. CONCLUSIONS

A wide range of organic feedstocks can be used for biochar production under different operational conditions of pyrolysis process. The characteristics of raw material feedstock and pyrolysis parameters induced the physical-chemical properties of the carbon based product, which in turn, determine the suitability for a given application, as well as define its behavior, transport and fate in environment.

The utility of this product for various applications was proved in different fields of activity and in the future it could be used in many more than these. Consequently there is a high market potential for the renewable carbon product synthetic presented in this paper and the world could take advantage from his benefits.

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SUSTAINABLE LIVING IN THE SUBURBAN AREAS

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ABSTRACT

The issues of (sub)urban peripheries development are at the forefront of contemporary urban research. In this respect, one important aspect is how to train young architects to deal with this issues by using innovative and sustainable development concepts and solutions. This paper emphasizes on the conceptual frameworks of the rural development stages in suburban areas, and thus bringing knowledge with regard to the politics of a possible rural development closer to the urban milieu. Furthermore, urban sustainability is thus regarded through imaginative and practical methods for a better future of the peripheral rural areas.

1. INTRODUCTION

Dealing with a continuous increase in the development of urban peripheries, young architects and urban planners need to be able to face new challenges with regard to sustainable development. For this, a couple of studies have been conducted in order to establish which would be the most appropriate approach in dealing with urban peripheries. Those studies have been conducted on several different stages, and students were directly and actively involved in building a solid foundation for a greener future of the cities.

Thus, the students encounter with the issues of peripheries development based on rural politics and principles is the framework for their project development based on three distinct principle blocks: building an ecological settlement, and an global network based on open principles.

2. METHODOLOGY AND DISCUSSIONS

The principles that should lay the base for a competent rural development in the suburban areas can be summarized by the principle blocks written earlier. Those are in fact developing models that will be discussed as follows. The Kronsberg model is a sustainable development project for the city district of Kronsberg, south-east of Hannover, Germany and will be the pedagogical example that we will emphasize on [1]. The Global Villages Network is a community initiative that brings together multidisciplinary specialists that promote the development of liveable habitat [2], and ecological urbanism is a discipline that connects ecology and urbanism in a way that it would matter for the future, as being the binder of the principle blocks discussed earlier [3].

Ecological urbanism gives us some of the most coherent principles for our rural sustainable development. Among those, important for our study would be (1) the relation between comfort and carbon footprint, (2) relation between nature and infrastructures, (3) sustainability, lifestyle and the landscape. Let's start debating on this, before going on with the model of Kronsberg.

First of all, we have to acknowledge that our way of life is influencing the planet's carbon footprint, and thus we are the one that can do something to change that into something better.

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Everything from choosing how much water we use when we shower in the morning to what king of light bulbs we use to light our houses, from using our cars, the public transport or walking down to the office – all this change the carbon footprint of our daily comfort. In the case of suburbs, some of those mentioned before are hard to make (for example walking to the office), but other habits regarding how we use our houses and the surroundings are definitive in determining the daily carbon footprint [4].

Cities have grown at very dramatic rates in past few decades, expanding over the surrounding landscapes, keeping also some attempts to integrate the natural elements where possible. Thus, in the new century's urban condition, the natural elements represent a fundamental dimension of urbanization [5]. The new role that nature has in the cities is dictating the development of infrastructure. This infrastructures are no longer important only for mobility but they are considered "platforms enabling a reconsideration of the role of nature in the city" [6].

With regard to the relation between sustainability and lifestyle, we will make reference to the "Science City" campus of ETH in Zuerich. Their findings determines that "CO^2 production is stratified by social class. Ecological sustainability is not about urbanity, it is about today's global economy and lifestyle" [7]. So, the emphasize is on how we could build more "green" and live by this concept too. Thus, we should "focus on lifestyle, on scale, as well on design and technology" [8].

Other solutions for a more sustainable living in the suburbs are used in order to reduce the carbon footprint, and most of them are implemented in newly developed villages or suburbs (such as urban farming, water and energy conservation etc.), but some solutions might come from reusing the already existing buildings and structure in a way that they reduce their carbon footprint as much as possible. Thus, "it is within our reach to save as much as 40 percent of the energy we currently use – and limit carbon emissions – by effectively retrofitting the entire building stock" [9]. One other solution would be to create some productive urban (or suburban) environments as local farming, markets and community supported agriculture. Those kind of productive urban environments would create some different urban and suburban textures and images, meaning that houses and workplaces will be more integrated into the nature, creating "green environments" powered by sustainable energy. Thus, these solutions would produce a critique of the past urbanism based on density, creating some more open options [10].

All those can also take the shape of other projects, like the GIVE project (Globally Integrated Village Environment) part of the Global Villages community. This kind of community and projects bring together specialists in different fields concerning sustainable development and productive cooperation. As a result, communications and inter-connected work can take the shape of Social Entrepreneur Networks or Open Land Lab and Open Source Ecology, that seeks to create core developer teams and entrepreneurial models based on Open Source Hardware Design. Those would be the foundations for an international emerging real "Global Village Network" platform for setting infrastructure and services to rural and underprivileged areas to be part of a global communication network [11].

KRONSBERG – a pedagogical model

This model is certainly not the only one that covers the important aspects of ecology and development in urban peripheries, but it was considered to be a good pedagogical example, and so it managed to stay in the curricula for several years now.

Teaching through this model enables us to promote several key concepts of sustainable development for a specific suburban area.

First concept (1) is based on open space design, which is generated by front gardens, street lines with trees and neighbourhood parks, and all this with the participation of the future residents. Ecological optimization (2) determined a specific “Kronsberg Standard” from this project and the suburban area was developed using ecological objectives for the Agenda 21 (remember that this project was developed in 2000, near the Expo premises in Hannover). This second concept was divided into several other rather important concepts: energy efficiency optimization, water, waste and soil management and environmental communications [12].

For the first concept, the open space design, we will present some images from the project that will be very conclusive and informative, images that can also be used in showing the other concepts. The second concept is the one that is of more interest for the scope of this paper and also for the young architects and urban planners. First of all, lets keep in mind the scale of the project that covers an area of three kilometres in length, half of kilometre wide and around 140 hectares [13].

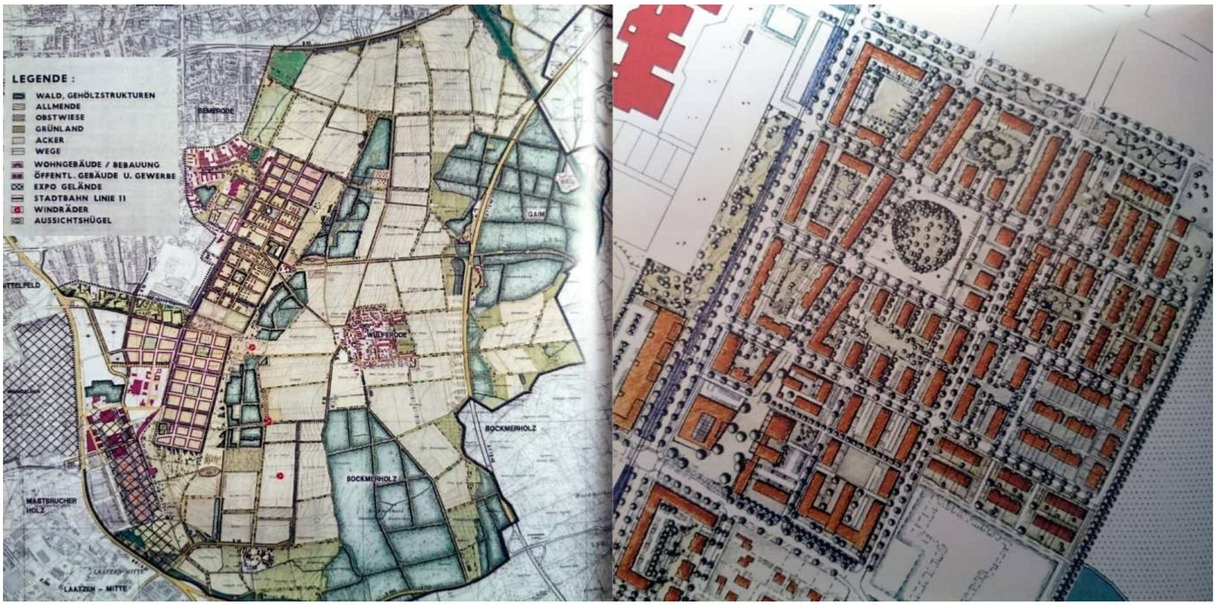

Figure 1: Plan of countryside in Kronsberg, Hannover suburban area (left). Open space plan in the Northern area of Kronsberg (right) [14].

The energy efficiency optimization program was implemented for a better CO^2 emissions reduction and a reduction in energy consumption for residential houses. All these are achieved by low energy house building solutions, integrating wind and solar powered operators and also optimized energy provision [15].

Figure 2: Examples of housing types [16].

The project includes special wooden houses, terraced houses and “agenda 21” houses. All these types have different concepts and building structures, some of them have green roofs and all of them use ecological building materials with low embodied energy, combined in different styles.

Figure 3: “agenda 21” special design houses [17].

For the water, waste and soil management, there have been proposed some innovative solutions in order to achieve the sustainability solution proposed. For example, for the soil management, the innovative solution was to use the soil excavated from the construction site in landscaping projects in the same area. Thus, the soil was used to create new local biotopes [18].

Figure 4: Countryside solutions and soil management [19].

All those sustainable solutions need to be backed up by some innovative ones with regard to the energy saved and the CO^2 emission lower scales. By the time it was implemented, the “Kronsberg Model” was one of the most ambitious in Germany, this is way it became an example for the young students. Therefore, the project came with three main “saving axes” that could lead to the CO^2 reduction and also economic viability: (1) low energy construction principles with quality assurance, (2) district heating provision from decentral combined heat and power stations (CHP) and (3) an electricity saving programme [20].

Now let us have a short discussion on the energy efficiency optimization in the analysed project. This had been obtained by using decentral combined heat and power stations (CHP) using heat exchangers (condensation use) that were extremely efficient converting primary energy to end users. The administration suggested that the efficiency of the CHP was over 94%. The entire Kronsberg suburb has several energy suppliers, each having a certain area that it serves. One CHP plant is used by Stadtwerke Hannover and it serves 2,300 houses, it has 11.7 MW, has two boilers and gas powered generators with a thermal capacity of 1,650 kW and delivering 1,250 kW of electrical energy [21]. Another area is served by Getec, it serves 742 houses and it produces 220 kW total electricity and 3,740 heating energy [22]. After all those implementations in the Kronsberg district, all the houses had been checked to see if they comply with the regulations – the result was surprising as energy savings were up to 2.700.000 kWh p. a., as insulation standards were here than current regulations, thermal bridges were minimized, well constructions were simple and they assured buildings airtightness [23]. Being a special project, the quality assurance is a major aspect in creating a real sustainable settlement.

3. CONCLUSIONS

The reasons we chose the Kronsberg as a pedagogical model is based on its simplicity and complexity at the same time. This project offers clean urban and architectural solutions, thus being an engineering complexity. Being an Central European example, not that far from Romania, is much more closer to being understood by young students, rather than all the North American or Far Eastern solutions. The integration and cultural similarities are important aspects of any architectural and urban planning project, thus the Kronsberg model would be much closer to the cultural footprint of the eastern block.

The engineering details also help young architects determine what solutions to adopt in the developing sustainable settlements, but their main interest is in the architectural solutions this project can provide. All these, together with ecological urbanism principles and solutions can give them a good starting point in creating innovative and sustainable settlements.

Thus, the most important keywords for this kind of project developing would be, in our opinion: anticipate, collaborate, curate, produce, interact, measure, mobilize, adapt, incubate. In this respect, a good professional should anticipate all the possible solutions, measure all the project's needs, mobilize all the active actors and collaborate with them, produce a clean professional solution, adapt it's solutions to possible last minute changes and interact with future inhabitants. All those solutions should be incubated and curated in order to obtain the success of the project, for a viable sustainable urban and rural future.

By dealing with technicalities like those available in the Kronsberg model, students are gradually introduced with the engineering issues of an sustainable development. Thus, knowing the needs for thermal and electrical consumption will determine them to look for the most viable solutions in terms of carbon footprint, resources needed and economical impact on the community.

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EXPERIMENTAL DETERMINATIONS OF THE PHYSICAL PROPERTIES OF ALFALFA AND CUSCUTA SEEDS - SEPARATION METHODS

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ABSTRACT

This paper presents the experimental values for the main physical properties obtained for are two categories of seeds: alfalfa and cuscuta, underlying the separation process and influence their behavior during separation, respectively: mass of 1000 seeds, proper density, surface condition of both seeds categories, shape and geometric dimensions. Also, it shows the constructive types of machines and technical equipment for separating cuscuta seeds from mass of alfalfa seeds whose separation principle is based on differences of physical characteristics determined.

1. INTRODUCTION

The safest way to ensure quantitative and qualitative harvests is to use the superior material quality seeds, with germination power as high as clean, free of any particular weed seeds and parasitic [2, 8, 14].

In the list of risk factors on crops, at both the national and internationally, is one of the most destructive and dangerous weeds quarantine - cuscuta, [13], because the damages on crops are significant, areas of infection ranging from 50 -100 %, [2, 6, 7].

In the normative acts, technical rules and standards in current both at the national, [10, 11, 12], and international, [9], is imposed as the seed material for sowing to be "free" of cuscuta, numeric seed content to be 0, because it was found in 1942 that only one of dodder plant produces 10,000-15,000 seeds, and in 2008 was noted an increase to 100,000 seeds. [13]

So, removing the cuscuta seeds from the mass of seed crop is a work mandatory for all units responsible for providing high productions.

The first condition underlying identify way and the best methods of separating the seed mixture consists in knowing the morphological and biological also in studying the physical and mechanical properties of the two types of seed subject to separation, in this case the alfalfa seeds and seeds of dodder. The following is own determinations on the physical properties of the two types of seeds.

2. METHODOLOGY

To establish the physical properties of alfalfa seeds (Fig.1), Medicago Sativa species form Australian variety, and the dodder seeds (Fig. 2) present in the current seed material.

Due to the very small size of the seeds, to determine the weight of 1000 seeds was used Kern balance that has a precision of 0.01 g and a larger magnifier of 50x, like in Fig. 3.

During this procedure were taken three samples of 1000 alfalfa and cuscuta seeds each.

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Figure 1: Alfaalfa seeds [3]

Figure 2: Dodder seeds [3]

To determine the density of the seeding material was used the pycnometric method. Especial for this kind of seeds was used a pycnometer that has a volume of $V_0=25$ cm^3 and the distilled water.

In the case of alfalfa seeds were used between 330-518 seeds and for cuscuta 317-516 seeds, and this procedure was repeated four times.

In fig. 4, are presented stages from the laboratory activity, especially form determination of seeds density.

Figure 3: Equipments used for laboratory activity [3]

Figure 4: Picture from measurement phase [3]

The mathematical relations used in this activity, [3], are:

Seed density ρ_s**:**

$$\rho_s = \frac{m_s}{V_{sem}} \text{ [g/cm}^3\text{]} \tag{1}$$

Water density ρ_a**:**

$$\rho_a = \frac{m_{pa} - m_p}{V_0} \text{ [g/cm}^3\text{]} \tag{2}$$

Seeds volume V_{sem} **:**

$$V_{sem} = \frac{(m_{pa} + m_s) - m_{pas}}{\rho_a} \text{ [cm}^3\text{]} \tag{3}$$

Seed volume V_p**:**

$$V_p = \frac{V_{sem}}{N_{sem}} \text{ [cm}^3\text{]} \tag{4}$$

Equivalent seeds diameter d_e**:**

$$d_e = 1.24\sqrt[3]{V_p} \text{ [mm]} \tag{5}$$

Where: N_{sem} - the number of the seeds from the sample; m_s - seeds weight (g); m_p - pycnometer weight; m_{pa} - pycnometer weight filled with distilled water (g); m_{pas} - pycnometer weight filled with distilled water and seeds (g); V_0 - pycnometer volume (cm3).

The shape and the dimensions of the seeds, where established using FLUO3 microscope, Fig. 5, equipped with the objectives 10x and 40x, to obtain pictures with good quality (contrast and focus) and Leica S6E Stereomicroscop equipped with 16x, Fig. 6, in order to examine the external surface of those two kind of seeds.

Figure 5: Microscop FLUO3

Figure 6: Stereomicroscop Leica S6E

Below are shown the results obtained from the experimental activity and the physical properties.

3. EXPERIMENTAL RESULTS

The values of the masses of 1000 seeds for the two types of seeds are shown in Table 1, and the values of the densities, volumes and the equivalent diameters of the seeds are presented in Tables 2 and 3. [3]

Table 1: The measured mass of 1000 seeds

Alfalfa seeds		
No. Sample	**No. seeds**	**Seeds mass (g)**
1	1000	1.68
2	1000	1.72
3	1000	1.75
Average mass		**1.716**

Cuscuta seeds		
No. Sample	**No. seeds**	**Seeds mass (g)**
1	1000	0.86
2	1000	0.87
3	1000	0.89
Average mass		**0.87**

Table 2: The values of density, volume and equivalent diameter of alfalfa seed

No. Sample	N_{sem}	ρ_a **(g/cm^3)**	V_{sem} **(cm^3)**	V_p **(cm^3)**	ρ_s **(g/cm^3)**	d_e **(mm)**
1	330	0.958	0.501	0.00152	1.178	1.43
2	426	0.957	0.627	0.00147	1.101	1.41
3	518	0.957	0.888	0.00171	1.081	1.48
4	380	0.953	0.588	0.00151	1.139	1.42
Average			**0.651**	**0.00155**	**1.124**	**1.44**

Table 3: The values of density, volume and equivalent diameter of cuscuta seed

Cuscuta						
No. Sample	N_{sem}	ρ_a **(g/cm³)**	V_{sem} **(cm³)**	V_p **(cm³)**	ρ_s **(g/cm³)**	d_e **(mm)**
1	516	0.956	0.377	0.00073	1.194	1.12
2	368	0.957	0.303	0.00082	1.023	1.16
3	456	0.957	0.334	0.00073	1.257	1.12
4	317	0.954	0.273	0.00086	0.989	1.18
Average			**0.322**	**0.00079**	**1.116**	**1.15**

From the dates related in table 1 it is observed that the weight of 1000 seeds of alfalfa is higher than the weight of cuscuta seeds, and in tables 2 and 3, it is found that the average values of densities proper of alfalfa and dodder seeds does not differ significantly, while the volumes and equivalent diameters of alfalfa seeds are significantly higher than the dodder seed, explainable for the geometrical dimensions higher of the first, in accordance with the data in tabel 4.

From measurements made within the values seed of the width and length are given in table 4, where it is found significantly greater geometric dimensions of the alfalfa seeds compared to cuscuta seeds, in line with their volumes V_p .

Tabel 4: Limits values of size seed

The size limits for alfalfa seeds (m)		***The size limits for cuscuta seeds*** (m)	
Width	Length	Width	Length
1,91 – 2,94	2,90 – 4,57	2,02 – 2,50	2,18 – 2,83

Have been examined the surfaces of both types of seeds where has been found that the cuscuta seed has on the surface small roughness and hairs, compared with alfalfa seeds, which have a smooth surface, as can be seen from Fig. 7-9.

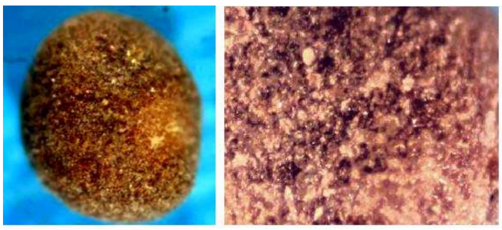


Figure 7: Cuscuta seed and surface detail [2]

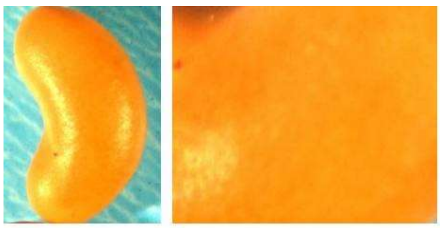


Figure 8: Alfalfa seed and surface detail [2]

Figure : 9 Detail - cuscuta seed hairs (40x)

This distinction between the two categories of surface seeds is fundamental in use as seed separation principle.

Further are presented several models of machines and technical equipment that are used to separate the cuscuta seeds from the mass of alfalfa seed depending on their physical properties.

4. CONSTRUCTIVE KINDS OF MACHINERY AND TECHNICAL EQUIPMENT TO ELIMINATE THE PARASITIC SEEDS

Beginning with the year 1925, the Frederic S. Lyman form USA, has patented a device with fixed helicoidal surface, destined to separate the seeding material by their geometrical form, such as flat seeds (alfalfa seeds) and spherical seeds (cuscuta seeds), in safest, rapidly and economic way. This devices is presented in the Fig.10.

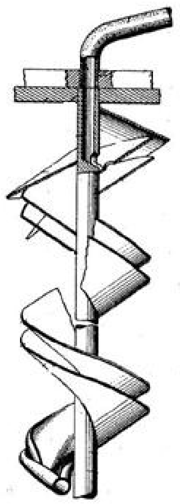


Figure 10: Helicoidal Separator [4]

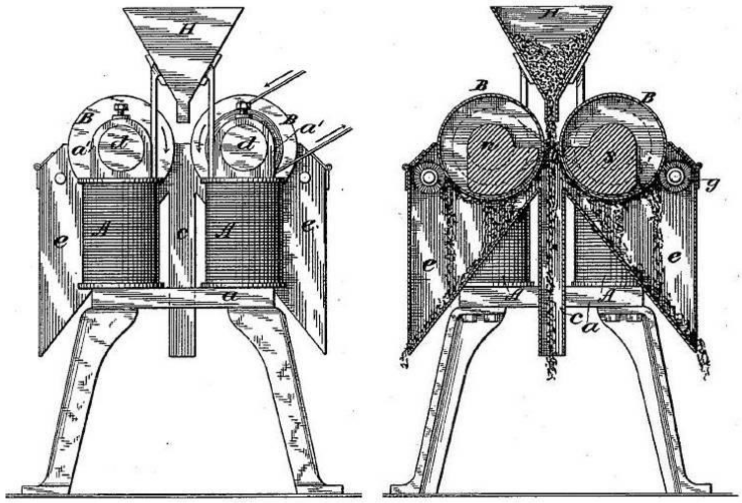
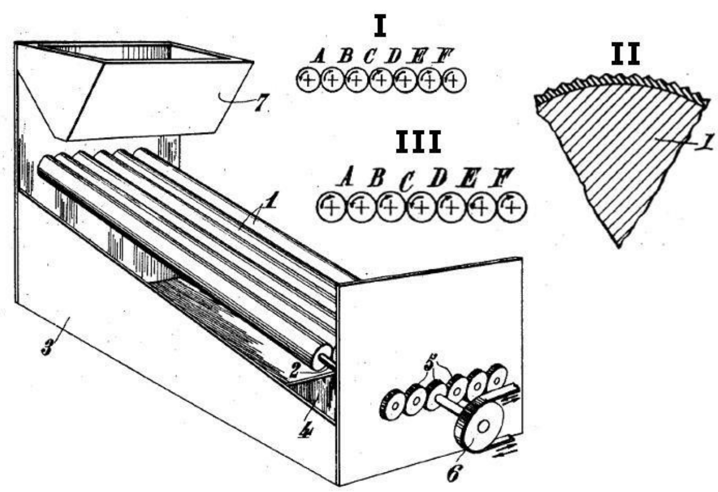


Figure 11. Magnetic Separator [5]

In Fig. 11, is presented an constructive model of the magnetic separation equipment, known from 1891, that works due to particle properties and capacity to be covered by fine iron powder (cuscuta seeds), that are separated using a electro-magnetic or magnetic drum.

The inventor C. BUSSARD, in 1929, has patented an separation equipment that works with rotating rollers arranged on an inclined plane, designed to separate the categories with smooth and rough seed surface, especialy the cuscuta seeds form the seeding material, Fig. 12. [1]



I – II Explanatory schemes
III Detail in section of one of the rollers

Figure 12: Equipment equipped with roller for cuscuta seed separation, [1]
1 - roll 2 - heads roll, 3-4 compartments, 5 - toothed pinion, 6 - wheel belt 7 bunker

A total separation of cuscuta seeds from mass of alfalfa seed is ensured by machinery equipped with electromagnetic / magnetic drums.

5. CONCLUSIONS

Following the determinations made significant differences have been identified appearing on the tegument of seeds namely dodder seeds have small cavities on their surface, asperities, roughness, contrary alfalfa seeds that have perfect tegument smooth and glossy.

Another characteristic that distinguishes the two types of seeds that can be used as a principle underlying the separation effective is form, the dodder seeds are spherical and alfalfa seeds are kidney-shaped and flat.

The difference concerning the size of the seeds is small, thus can not be used in the separation of the mixture of seeds.

Separation of cuscuta seeds from the seeds of alfalfa use the technical equipment that are based on differences that arise both on forms geormetrice, as well as the surface of the seeds.

Machines for separating by the method electromagnetic / magnetic are the most recommended because ensures total separation of cuscuta seed, requirement imposed in case of material for sowing.

6. ACKNOWLEGMENT

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STRUCTURAL AND KINEMATIC ANALYSIS OF SIEVE ACTUATING MECHANISM FROM CORN MILL TYPE MP42

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ABSTRACT

In this paper is made the structural and structural analysis of mechanism from sifting system of the corn mill MP42. For modules which comprises the actuating mechanism of sieves, were drafted kinematic calculation procedure, procedures that were called in a computing main program. The results were graphical transposed in charts, to give a clearer picture of kinematic parameters of the mechanism elements.

1. INTRODUCTION

Corn mill, type MP42 it is designed for grinding corn in order to transform them into different varieties of cornmeal for human food consumption. The mill may also be used in order to obtain grits of corn, wheat, barley, soybeans or other grains, for animal feeding. The mill is equipped with four grinding rollers for grinding of seeds, actuating mechanism of sifting sieves, a dosing feeder and a screw conveyor.

A well-functioning of sifting system it is closely related to kinematics and kinetostatic evaluation of mechanism. This can be achieved only by optimization of the parameters which determines the sifting process. In this sense, requires that functioning regime of the sifting system, regarding oscillation frequency, size and direction of velocities and accelerations of sieve points to be analysed in the requirements of the sifting process.

2. METHODOLOGY

In figure 1 it shows the kinematic scheme of sifting system with two sieves from the corn mill MP42. On item 4 of mechanism is mounted the first sieve, and on item 8 is mounted the second sieve.

To determine the kinematic parameters of mechanism elements, must be carried out, firstly, the structural analysis, [1,4,6].

A. Structural analysis of mechanism

If we take into account the relative movements between elements, it is noted that the mechanism has the following lower coupling: *A(0R1), B(1R2), C_{23}(2R3), C_{26}(2R6), D(3R0), E(3R4), F(4R5), G(5R0), H(6R7),*

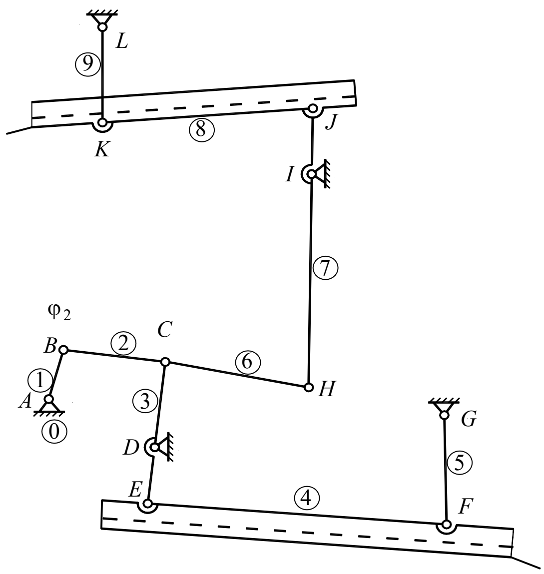

Figure 1. Kinematic scheme of sifting system, with highlighting sieves

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I(7R0), J(7R8), K(8R9) and L(9R0). Higher couplings number is zero. The mobile elements of the mechanism are: *1(A,B), 2(B,*C_{23}*,*C_{26}*), 3(*C_{23}*,D,E), 4(E,F), 5(F,G), 6(H,I), 7(H,I,J), 8(J,K), 9(K,L)*.

Considering the number of moving parts and number of kinematic couplings, results the mechanism degree of mobility, namely: $M = 1$, ie is necessary one driving engine, so that the mechanism elements to have determined movements.

In figure 2 are presented: *a*) structural scheme of mechanism, *b*) multipolar scheme and *c*) structural relationship. From the structural and multipolar scheme it is observed that the mechanism consists of base *Z*(0), motor group R(1) and dyads of appearance 1: *RRR(2,3), RRR(4,5), RRR(6,7), RRR(8,9)*.

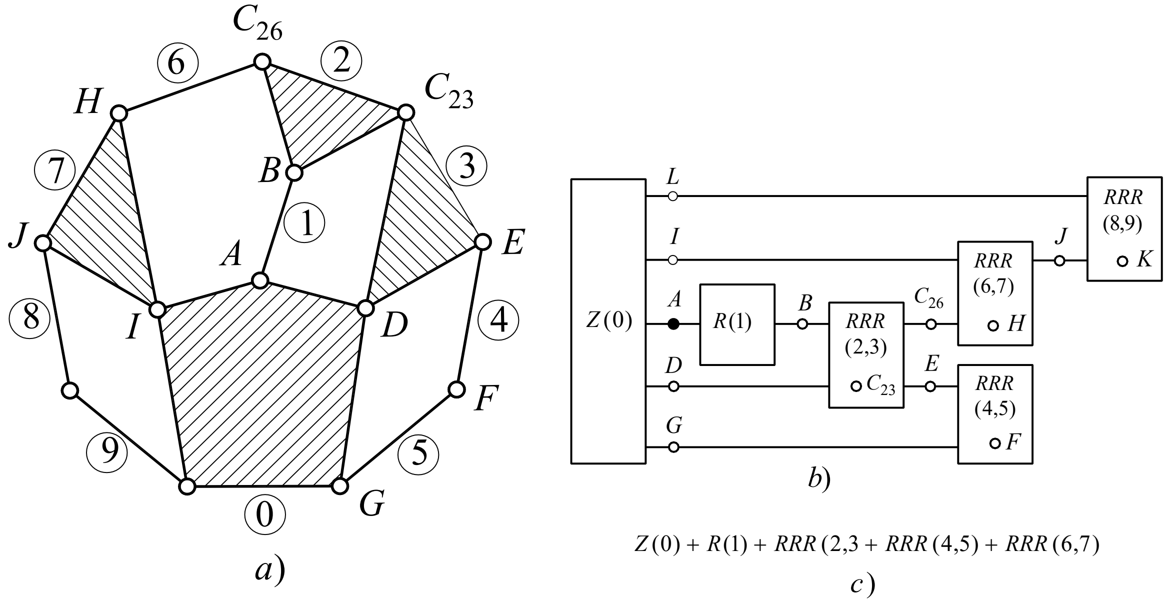


Figure 2. *a*) structural scheme of mechanism, *b*) multipolar scheme, *c*) structural relationship

B. Kinematic analysis of the mechanism

For kinematic analysis of the mechanism is undergoing several stages, namely, [2,3,5]:

a) Preparation of calculation program for determining kinematic parameters for the elements of mechanism, considering 36 equidistant positions of element 1 ($\Delta\varphi_1 = 0.1745329$ radians);

b) Tabular presentation of the values of the angles made by vectors $\overline{AB}, \overline{BC}, \overline{DC}, \overline{EF}, \overline{GF}, \overline{CH}, \overline{IH}, \overline{JK}$ and $\overline{LK}$, attached to mechanism elements, with the positive direction of the axis *AX,* [7,8];

c) Plotting diagrams of variation of angular velocities and accelerations of the mechanism elements, depending on the angle φ_1, [9,10];

d) Plotting the hodographs for velocities and accelerations, corresponding to points that marks the centre of couplers *A*, *D*, *E*, *F*, *J* and *K,* [9,10].

Kinematic analysis of the sifting system mechanism consists in determining the position parameters, velocities and accelerations, corresponding to all elements. For this, is defined the initial position of the mechanism (see figure 3), is called functions **A1R.m**, **A1RALFA.m** and **d1pva.m**, compiled by the authors in MATLAB syntax, for determining kinematic parameters and is plotted the charts of determined parameters.

In figure 4 it shows the kinematic scheme of the entire mechanism, with highlighting of position parameters.

C. Numerical example

For the analysis of the mechanism are known:

a) Kinematic scheme of the mechanism;
b) Size of elements and positions of couplers adjacent to base, as follows: AB = 0.020 m, BC = 0.200 m, CD = 0.16 m, DE = 0.11 m, EF = 0.620 m, FG = 0.340 m, CH = 0.450 m, HI = 0.800 m, IJ = 0.180 m, JK = 0.500 m, KL = 0.350 m, XA = 0.0 m, YA = 0.0 m, XD = 0.200 m, YD = -0.150 m, XG = -0.780 m, YG = -0.075 m, XI = 0.660 m, YI = 0.800 m; XL = 0.150 m, YL = 1.240 m; α = 3.141592 rad ($\alpha = \left|\angle(\overline{DC},\overline{DE})\right| = <(\overline{IJ},\overline{IH})$).
c) Initial position of mechanism: $\varphi_1 = \varphi_{10} = 0.03986$ [rad], (Figure 4);
d) Angular velocity of element **1**: $\omega_1 = 73.3\,\mathrm{s}^{-1}$;
e) Angular acceleration of element **1**: $\varepsilon_1 = 0.0\,\mathrm{s}^{-2}$;

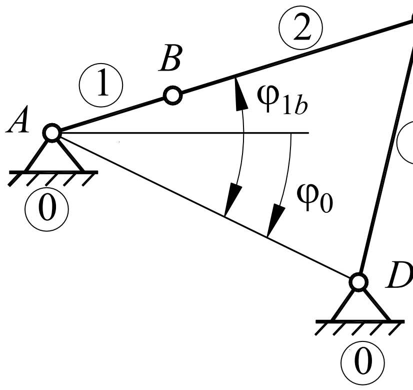


Figure 3. Defining the initial position of the mechanism

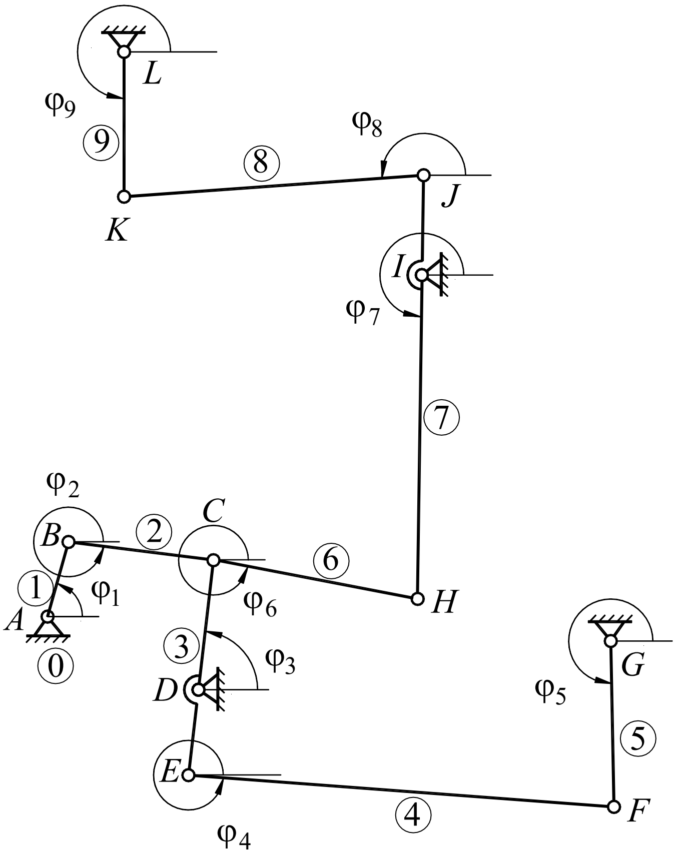


Figure 4. Defining the position kinematic parameters of the cleaning system mechanism

The calculations were made for 36 positions of the element **1**, starting from the initial position: $\varphi_1 = \varphi_{10} = 0.03986$ [rad].

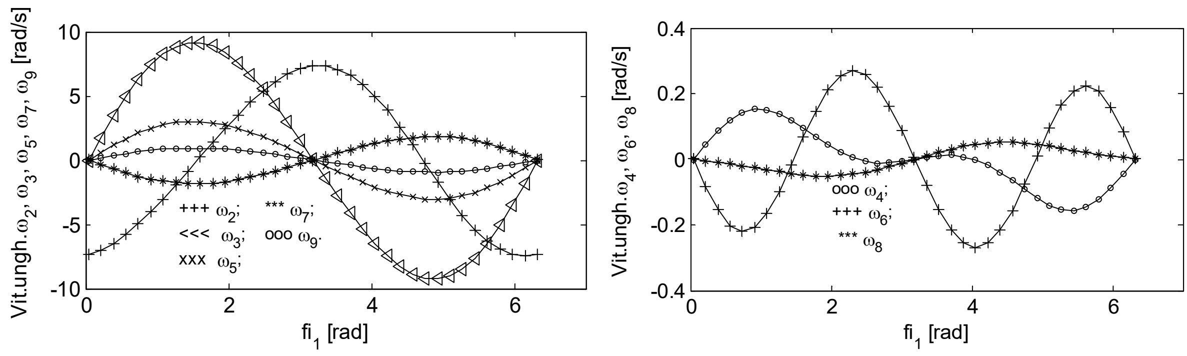
In table 1 is presented angles $\varphi_1, \varphi_2, \varphi_3, \varphi_4, \varphi_5, \varphi_6$, φ_7, φ_8 and φ_9, made by the vectors $\overline{AB}$, $\overline{BC}$, $\overline{DC}$, $\overline{EF}$, $\overline{GF}$, $\overline{IH}$, $\overline{JK}$ and $\overline{LK}$ with the positive direction of the axis AX (in the first column is presented the position of the mechanism).

From table 1 results that angles φ_4 and φ_8 have a very small variation ($\varphi_4 \in [6.029200, 6.032040]$, $\varphi_8 \in [3.320529, 3.321817]$), which means that the elements **4**, respectively **6** have approximately a circular translation movement.

Table 1 Angles $\varphi_1, \varphi_2, \varphi_3, \varphi_4, \varphi_5, \varphi_6$, φ_7, φ_8 and φ_9, made by the vectors $\overline{AB}$, $\overline{BC}, \overline{DC}, \overline{EF}, \overline{GF}$, $\overline{IH}$, $\overline{JK}$ and $\overline{LK}$ with the positive direction of the axis AX

poz	**fi1(1)**	**fi2(1)**	**fi3(1)**	**fi4(1)**	**fi5i(1)**	**fi6(1)**	**fi7(1)**	**fi8(1)**	**fi9(1)**
0	0.03986	0.03986	1.44657	6.02920	4.73145	6.26383	4.72457	3.32182	4.75785
1	0.21439	0.02277	1.44868	6.02925	4.73215	6.26373	4.72415	3.32181	4.75807
2	0.38893	0.00671	1.45490	6.02941	4.73422	6.26345	4.72291	3.32180	4.75870
3	0.56346	-0.00789	1.46496	6.02966	4.73757	6.26302	4.72090	3.32177	4.75973
4	0.73799	-0.02069	1.47846	6.02997	4.74206	6.26251	4.71821	3.32173	4.76110
5	0.91253	-0.03142	1.49487	6.03033	4.74752	6.26199	4.71493	3.32167	4.76278
6	1.08706	-0.03984	1.51362	6.03069	4.75374	6.26154	4.71119	3.32161	4.76469
7	1.26159	-0.04581	1.53406	6.03104	4.76051	6.26123	4.70710	3.32152	4.76677
8	1.43612	-0.04921	1.55553	6.03135	4.76760	6.26108	4.70281	3.32142	4.76896
9	1.61066	-0.04996	1.57734	6.03160	4.77479	6.26114	4.69844	3.32131	4.77118
10	1.78519	-0.04804	1.59884	6.03180	4.78185	6.26140	4.69415	3.32120	4.77336
11	1.95972	-0.04349	1.61940	6.03193	4.78857	6.26183	4.69004	3.32107	4.77544
12	2.13426	-0.03638	1.63844	6.03201	4.79477	6.26238	4.68625	3.32095	4.77737
13	2.30879	-0.02685	1.65545	6.03204	4.80029	6.26301	4.68286	3.32084	4.77908
14	2.48332	-0.01511	1.66998	6.03203	4.80499	6.26364	4.67997	3.32073	4.78054
15	2.65785	-0.00142	1.68168	6.03201	4.80876	6.26422	4.67765	3.32065	4.78172
16	2.83239	0.01387	1.69027	6.03198	4.81153	6.26468	4.67595	3.32058	4.78258
17	3.00692	0.03036	1.69556	6.03196	4.81322	6.26498	4.67490	3.32054	4.78311
18	3.18145	0.04759	1.69745	6.03195	4.81383	6.26508	4.67452	3.32053	4.78330
19	3.35599	0.06507	1.69591	6.03196	4.81333	6.26499	4.67483	3.32054	4.78314
20	3.53052	0.08224	1.69097	6.03198	4.81175	6.26472	4.67581	3.32058	4.78265
21	3.70505	0.09856	1.68277	6.03200	4.80912	6.26427	4.67743	3.32064	4.78183
22	3.87958	0.11347	1.67148	6.03203	4.80548	6.26371	4.67967	3.32072	4.78069
23	4.05412	0.12645	1.65735	6.03204	4.80091	6.26309	4.68248	3.32082	4.77927
24	4.22865	0.13700	1.64070	6.03201	4.79551	6.26246	4.68580	3.32094	4.77760
25	4.40318	0.14472	1.62192	6.03194	4.78940	6.26189	4.68954	3.32106	4.77570
26	4.57772	0.14927	1.60148	6.03182	4.78271	6.26144	4.69362	3.32118	4.77363
27	4.75225	0.15045	1.57994	6.03163	4.77564	6.26116	4.69792	3.32130	4.77144
28	4.92678	0.14819	1.55790	6.03138	4.76839	6.26108	4.70233	3.32141	4.76920
29	5.10132	0.14253	1.53607	6.03107	4.76117	6.26120	4.70670	3.32151	4.76697
30	5.27585	0.13370	1.51516	6.03072	4.75425	6.26151	4.71088	3.32160	4.76484
31	5.45038	0.12204	1.49592	6.03035	4.74787	6.26196	4.71472	3.32167	4.76288
32	5.62491	0.10802	1.47907	6.02999	4.74227	6.26249	4.71809	3.32173	4.76116
33	5.79945	0.09219	1.46525	6.02967	4.73767	6.26300	4.72084	3.32177	4.75976
34	5.97398	0.07514	1.45499	6.02941	4.73425	6.26344	4.72289	3.32180	4.75871
35	6.14851	0.05750	1.44869	6.02925	4.73215	6.26373	4.72414	3.32181	4.75807
36	6.32305	0.03986	1.44657	6.02920	4.73145	6.26383	4.72457	3.32182	4.75785

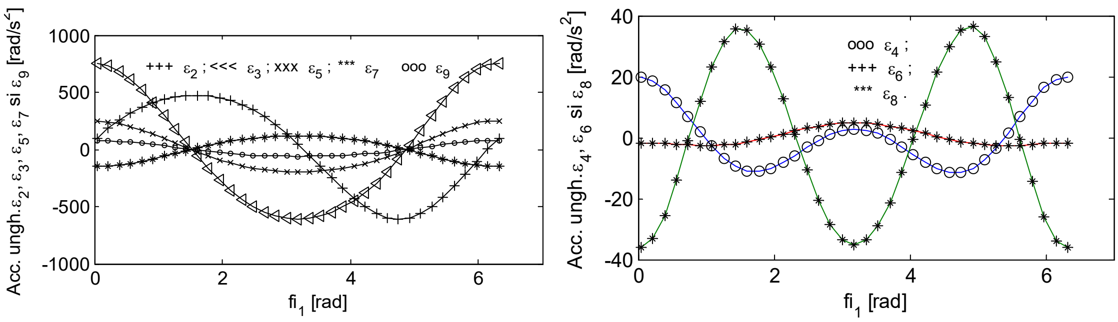
In figures 5.*a* and 5.*b* are presented charts of angular velocities of mechanism elements.



a) *b)*

Figure 5. Charts of angular velocities ω_2, ω_3, ω_4, ω_5, ω_6, ω_7, ω_8 and ω_9 of mechanism elements

In figures 6.*a* and 6.*b* are presented charts of angular accelerations of the same elements.



a) *b)*

Figure 6. Charts of angular accelerations ε_2, ε_3, ε_4, ε_5, ε_6, ε_7, ε_8 and ε_9 of mechanism elements

In figure 7 is presented hodograph of linear velocities of points *E* and *F*, and in figure 8 is presented hodograph of linear velocities of points *J* and *K*.

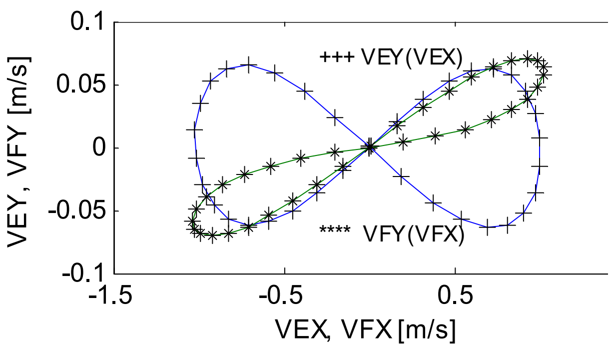


Figure 7. Hodograph of linear velocities of points *E* and F

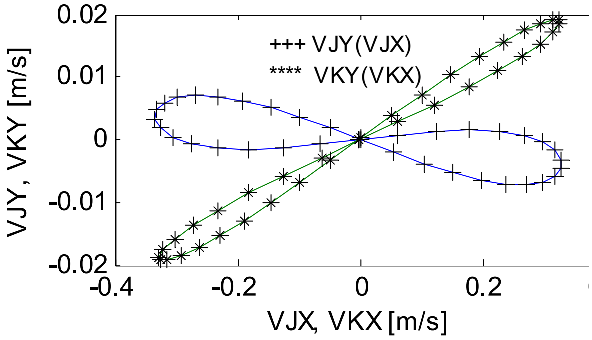


Figure 8. Hodograph of linear velocities of points *J* and *K*

In figure 9 is presented hodograph of linear accelerations of points *E* and *F*, and in figure 10 is presented hodograph of linear accelerations of points *J* and *K*.

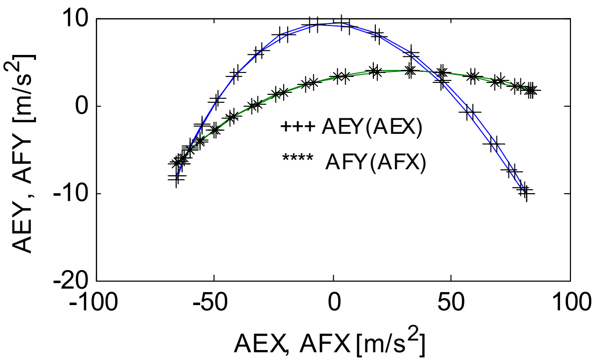


Figure 9. Hodograph of linear accelerations of points *E* and *F*

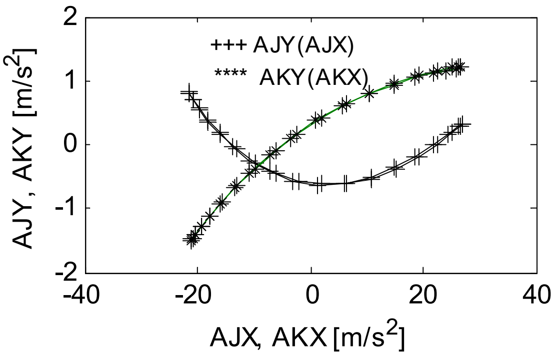


Figure 10. Hodograph of linear accelerations of points *J* and *K*

5. CONCLUSIONS

By analysing numerical data, as well as charts of distribution of velocities and accelerations results sizes and directions of speed and acceleration vectors, so that the sifting process to be more effective. Values of these parameters will be used in case of kinetostatic calculus of mechanism, to determine the reaction forces from kinematic couplings. Knowing reaction forces allows proper dimensioning of kinematic elements.

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NANOTECHNOLOGY FOR WASTEWATER TREATMENT

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ABSTRACT

The appearance and development of nanotechnology gave new and efficient possibilities for pollutants removal from wastewaters by using new compounds called nanomaterials which possess unique structural and morphological properties. In this paper are presented the main research directions regarding the application of nanotechnology in wastewater treatment field either for the pollutants compounds removal by adsorption or their decomposition by catalysis.

1. INTRODUCTION

The rapid population growth and intensive industrial activities development have conducted worldwide to the appearance of the big problem of limited fresh water resources. Wastewater treatment is one of the most important modalities which can overcome this problem.

Technology evolution has led us to the nanotechnology appearance which is having a tremendous scope for wastewater treatment field.

For example, pollution of water with heavy metal ions is a severe environmental and public health problem and the conventional wastewater methods used for the removal of these toxic metals from water, such as precipitation and flocculation, have various disadvantages such as expensive equipment requirement, constant necessity of chemicals and the existence of secondary pollution. Alternative method such as adsorption using nanomaterials, present several advantages in terms of the initial cost, simplicity of design, ease of operation, low quantity of residues generated, easy recovery of metals and the possibility to reuse the adsorbent [1]. Another relevant example for applying nanotechnology in wastewater treatment field is photocatalysis which consists of decomposition of the organic pollutants to carbon dioxide and water.

In this article, the main applications of nanotechnology in wastewater treatment field are described.

2. METHODOLOGY

In practice, till now, titanium dioxide (TiO_2) has been the most promising photocatalyst [2]. Their multiple applications are sustained by the following features: inexpensive, nontoxic, chemically stable [3].

TiO_2 particles naturally crystallize in three forms: rutile, anatase and brookite. Rutile is the most common, most stable, chemically inert and can be excited by both visible and ultraviolet (UV) light (wavelengths smaller than 390 nanometers) [4, 5]. Anatase is only excited by UV light and can be transformed into rutile at high temperatures. Both rutile and anatase have a tetragonal ditetragonal dipyramidal crystal system but have different space group lattices. Brookite is not excited by UV light but its orthorhombic crystal system can be transformed into rutile with the application of heat. The representations of the unit cell and characteristics of the different tetragonal lattice systems for rutile, anatase and brookite using ball and stick models are presented in Fig.1 and table 1 [4, 6]. The titanium atoms are gray (lighter) and the oxygen atoms are red (darker). Fig. 2 shows some examples of TiO_2 crystal.

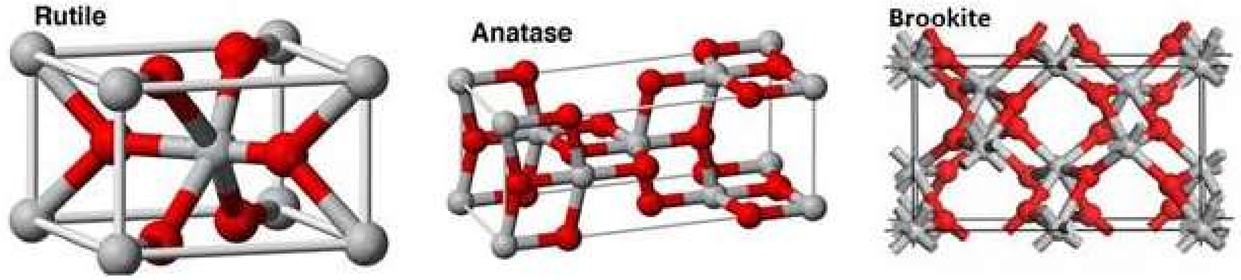

Figure 1: Crystal structures of rutile, anatase and brookite titanium dioxide [4,6]

Figure 2: Crystal images of rutile, anatase, and brookite, titanium dioxide [7]

Anatase is the most photochemically active and has a band gap of 3.2 eV. Rutile has a compact structure and a band gap of 3.0 eV , whereas brokite does not have a photocatalytic activity.

The photocatalytic effect in solid state catalysis takes place when the electron-hole pair (e^-h^+) formed by photon absorption interacts with molecules close to the surface of the catalyst. Besides the advantages of using TiO_2 as photocatalyst, it has few major limitations. One of them is that exciton creation (e^-h^+ precursor) is accomplished only using UV light representing just 5% of the solar spectrum (inefficient utilization of solar radiation) because of the large band gap value. Therefore many researches were conducted to improve efficient utilization of TiO_2 in photocatalysis by extending its optical absorption to the visible region [8,9].

A promising route to extend the optical absorption to the visible region is by doping of TiO_2 [8-11]. This would allow the use of sunlight in photocatalysis obviously increasing its potential of application in environmental engineering (e.g. wastewater treatment) and providing an advantage in terms of economy.

Tabel 1: Structural characteristics for TiO_2 crystal structures [5]

	Rutile	**Anatase**	**Brookite**
Crystal system	Tetrahedral	Tetrahedral	Orthogonal
Unit cell a (Å)	4.5845	3.7842	9.184
b (Å)			5.447
c (Å)	2.9533	9.5146	5.145
Volume (cm^3)			
Density (g/cm$^{3)}$	4.2743	3.895	4.123

Doping with nonmetal atoms [8,9] of TiO_2 has been proved to be more efficient than doping with transition metals [10,11]. Compared with doping using nitrogen [12,13], carbon-doped TiO_2 was not very studied, although was proved that it is five times more active than nitrogen-doped TiO_2 in the case of the decomposition of 4-chlorophenol [14].

Applying nanotechnology in adsorption process for wastewater treatment has resulted in development of different nanomaterials for removal of metals from solutions, these nanomaterials include: magnetic oxides, nano zerovalent iron, zeolites, aluminosilicate, carbon nanomaterials etc.[15-20].

As an example, the removal of Pb^{2+} from wastewater using nano zero valent iron is done according to the following reactions:

$Pb^{2+} + Fe^0 \rightarrow Pb^0 + Fe^{2+}$

If chlorinated hydrocarbons are present, the following reaction takes place:

$R\text{-}Cl + Fe^0 + H_2O \rightarrow R\text{-}H + Fe^{2+} + Cl^- + OH^-$

The 70% efficiency removal of Cd (II) toxic ions from wastewater was obtain using a magnetic nanomaterial with the following structural formula [20]:

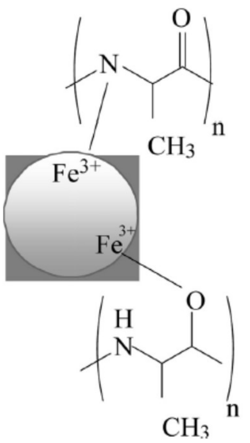

Figure 3: Fe_2O_3 –poly-DL-alanine magnetic nanomaterial.

6. CONCLUSIONS

Rising demands for clean and safe water in order to prevent environment and public health problems impose us the development of more efficient technologies for pollutants removal from wastewater. One suitable solution is nanotechnology which is offering various types of nanomaterials having the capacity of efficient removal of various toxic pollutants from wastewaters.

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CONSIDERATIONS REGARDING INSPECTION AND CALIBRATION OF PESTICIDE APPLICATION EQUIPMENT IN PROFESSIONAL USE

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ABSTRACT

The paper presents considerations regarding inspection and calibration of pesticide application equipment in professional use because according to D 2009/128/EC, in view of ensure the inspection of pesticide application equipment at least once before end of 2016.

1. INTRODUCTION

In general, a pesticide is a chemical or biological agent (such as a virus, bacterium, antimicrobial, or disinfectant) that deters, incapacitates, kills, or otherwise discourages pests. Although pesticides have benefits, some also have drawbacks, such as potential toxicity to humans and other species. [4]

Pesticides are the only toxic substances released intentionally into our environment to kill living things, meant for attracting, seducing, and then destroying any pest. The most common use of pesticides is as plant protection products (also known as crop protection products). [3, 10]

There are two basic types of pesticide application equipment used to apply pesticides: powered and unpowered.

Typical unpowered equipment for liquid pesticides includes the some backpack and tank sprayers. These sprayers sometimes have a continuously operated pump lever to maintain pressure in the pesticide tank. Others are pumped up by hand until pressure reaches a certain point. The pesticide then can be sprayed until the pressure drops below the level where the sprayer works effectively. Then it must be re-pressurized.

For large-scale pesticide applications, powered equipment is essential. This type of equipment ordinarily is mounted permanently in terrestrial or aquatic vehicles, or is attached to fixed- or rotary-wing aircraft. On the other hand, not all powered equipment is large. Some backpack sprayers may use small 2-cycle engines as a power source.

All power equipment works by pumping or blowing product from a storage tank through a distribution line or hose to various types of control mechanisms. The control mechanisms may be mounted on various devices such as guns, booms, or cylinders that can be aimed. For liquid products, the pesticide is applied through nozzles which control the shape of the spray pattern, the rate of flow of the spray, and the size of individual spray droplets. Nozzles are available in many sizes and configurations. [8]

The type of pesticide application equipment to be used for a specific job should be selected after careful consideration of the location and size of the area to be treated and the pest to be controlled.

Pesticide application equipment must dose and distribute products exactly and function without error. In order to achieve this, pesticide application equipment should be inspected regularly to be able to identify and eliminate any technical defects. However, there are three main arguments for the inspection:

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- good control of the pest with the minimum possible input of crop protection product;
- less potential risk of environmental contamination by crop protection products;
- safety hazards for the operator. [12]

2. METHODOLOGY

Since Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery will provide for rules on the placing on the market of pesticide application equipment ensuring that environmental requirements are met, it is appropriate, in order to minimize the adverse impacts of pesticides on human health and the environment caused by such equipment, to provide for systems for regular technical inspection of pesticide application equipment already in use. Member States should describe in their National Action Plans how they will ensure the implementation of those requirements.

According to Chapter III (Pesticide Application Equipment), Article 8 (Inspection of equipment in use) of Directive 2009/128/EC: by 14 December 2016, Member States shall ensure that pesticide application equipment has been inspected at least once.

In Romania, Phytosanitary National Authority has made the necessary arrangements for adopting the EN ISO 16122:2015 - Agricultural and forestry machinery - Inspection of sprayers in use, as Romanian Standard. According to the inventory of Phytosanitary County Offices, there are recorded approx. 17500 sprayers.

EN ISO 16122 consists of the following parts, under the general title Agricultural and forestry machinery - Inspection of sprayers in use:

- Part 1: General
- Part 2: Horizontal boom sprayers (machines for spraying plant protection products, along a boom or in bands, with a spray generally directed downwards onto/into target)

Figure 1: Horizontal boom sprayers [11]

- Part 3: Sprayers for bush and tree crops

Figure 2: Vertical sprayers [9]

Sprayer for bush and tree crops is defined as a machine for spraying plant protection products on bush and tree crops such as grapes, fruits or hops (including annual plants/crops), the application being mostly directed sideways and/or upwards to the target.

- Part 4: Fixed and semi-mobile sprayers

Figure 3: Semi-mobile sprayers [5]

Fixed sprayer is defined as a machine primarily for spraying plant protection products in covered structures, and where the pump/tank unit and/or application unit do not move.

Semi-mobile sprayer is defined as a machine primarily for spraying plant protection products on crops grown in covered structures, and where the pump/tank unit and/or application unit are moveable.

Part 2 and 3 of EN ISO 16122:2015, when used together with EN ISO 16122 - 1, specifies the requirements and test methods for the inspection of horizontal boom sprayers and sprayers for bushes and trees, when in use. The requirements relate mainly to the condition of the sprayer with respect to its potential risk for the environment and its performance to achieve good application. Requirements for the protection of inspectors during an inspection are given in EN ISO 16122 - 1.

Figure 4: Stand for measuring the liquid distribution under a spray boom

The standards for new sprayers are EN ISO 16119 series which consists of the following parts, under the general title Agricultural and forestry machinery - Environmental requirements for sprayers:

- Part 1: General
- Part 2: Horizontal boom sprayers
- Part 3: Sprayers for bush and tree crops
- Part 4: Fixed and semi-mobile sprayers

EN ISO 16122 and EN ISO 16119 are harmonised standards. A harmonised standard is a European standard developed by a recognised European Standards Organisation: CEN

(European Committee for Standardization), CENELEC (European Committee for Electrotechnical Standardization), or ETSI (European Telecommunications Standards Institute). It is created following a request from the European Commission to one of these organisations. Manufacturers, other economic operators, or conformity assessment bodies can use harmonised standards to demonstrate that products, services, or processes comply with relevant EU legislation. The references of harmonised standards must be published in the Official Journal of the European Union.

CEN was requested by European Commission to develop European standars for the inspection of all types of equipment used by professionals that will enable equipment to comply with the essential health and safety and enviromental requirements listed in Annex 2 to the Framework Directive on the sustainable use of pesticides:

The inspection of pesticide application equipment shall cover all aspects important to achieve a high level of safety and protection of human health and the environment. Full effectiveness of the application operation should be ensured by proper performance of devices and functions of the equipment to guarantee the following objectives are met.

The pesticide application equipment must function reliably and be used properly for its intended purpose ensuring that pesticides can be accurately dosed and distributed. The equipment must be in such a condition as to be filled and emptied safely, easily and completely and prevent leakage of pesticides. It must permit easy and thorough cleaning. It must also ensure safe operations, and be controlled and capable of being immediately stopped from the operator's seat. Where necessary, adjustments must be simple, accurate and capable of being reproduced.

Inspection procedure will include the following steps [2]:

1. preparation by the farmer;
2. registration data owner and sprayer;
3. pre-inspection by inspector according to EN ISO 16122:1;
4. inspection of the sprayer according to EN ISO 16122:2,3,4;
5. conclusion;
6. certificate (report and sticker).

Calibration of pesticide application equipment is voluntary. The objective of calibration procedure is to select the most adequate working parameters to obtain an uniform and precise distribution of the intended amount of pesticide over the target.

The parameters for a good calibration process can be classified as [1]:

Assumed:

- spray volume;
- plant protection products type and characteristics;
- air flow volume;
- air flow range/direction.

Measured:

- boom width;
- boom height;
- forward speed;
- tree height and with;
- row spacing.

Determined;

- nozzle flow rate;
- nozzle size;
- working pressure;
- nozzle type;
- number of nozzles;
- nozzle orientation.

In order to obtain a good calibration process there are different tools and methods like:

- calibration disks;

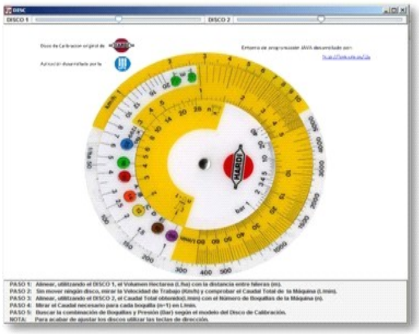

Figure 5: Digital version of the sprayer calibration disk developed designed by Hardi [6]

- software

Figure 6: Calibra software [6]

An adequate calibration will lead to an optimal adjusment and in the end less drift losses. According to ISO 22866 spray drift is the quantity of plant protection product that is carried out of the sprayed (treated) area by the action of air currents during the application process.

Figure 7: Examples of spray drift [7]

The consequence of the dispersion of part of the spray mixture out of the applied field may include the contamination of water courses, sensitive areas (e.g. natural parks, children's playgrounds etc) urban areas or the unintended spray deposition on adjacent crops. This latter may result in residues of not allowed active ingredients or direct damage on adjacent crops.

7. CONCLUSIONS

The main objective of periodical inspection of sprayers is to improve condition/state of maintenance of sprayers.

The benefits for the farmer after a periodical inspection of sprayer are:

- Lower costs of plant protection products;
- Better spray-quality which leads to obtain more uniform crops;
- Lower maintenance costs;
- Safer operations.

For the environment the benefits after a periodical inspection of sprayer are:

- Lower input of plant protection products;
- Lower emissions of plant protection products.

The benefits for the consumer after a periodical inspection of sprayer are:

- Safer food;
- Less residues.

The benefits of the calibration procedure, when it is developed prior the application task are:

- Less pesticide use;
- Increase of efficiency/efficacy of pesticide application process;
- Less investment (pesticide, water, time);
- Less risk of contamination (less environmental problems).

ACKNOWLEDGMENT

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MATHEMATICAL MODELLING IN ANAEROBIC DIGESTION PROCESS AND BIOGAS PRODUCTION

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ABSTRACT

Anaerobic digestion process is a microbial decomposition of organic matter into methane and carbon dioxide in the absence of oxygen. Lately, current trends in the development of methods for monitoring, modelling and control of microbial growth that characterizes the process of anaerobic digestion and biogas production, are of particular interest. In the same time with experimental research, substantial efforts have been put into the mathematical modelling of anaerobic digestion process used for biogas production. This paper presents a literature review regarding the mathematical models used in anaerobic digestion process optimization for biogas production.

1. INTRODUCTION

Anaerobic digestion is considered to be the most optimum process to treat organic wastes because produces sustainable energy and agricultural fertilizers [1].

Anaerobic digestion process for biogas production involves four steps, namely: hydrolysis, acidogenesis, acetogenesis and methanogenesis, steps that occur under the action of several types of bacteria [2, 3]. In the first stage, cellulose, hemicellulose and lignin are liquefied by extracellular enzymes and then are treated by acidogenic bacteria. After that, the products of hydrolysis are converted into organic acids, alcohols, hydrogen and carbon dioxide by acidogens. The products of the acidogenenesis are converted into acetic acid, hydrogen and carbon dioxide. Methane is produced by methanogenic bacteria from acetic acid, hydrogen and carbon dioxide [4, 5].

Moreover, biogas obtained through the anaerobic digestion process is considered to be one of the high promising alternatives to fossil fuels due to the environmentally and economically significant advantages [6].

In order to describe anaerobic digestion process in a more detailed way, numerous model studies on anaerobic digestion have been conducted [7-9]. The process models are supposed to describe the qualitative and quantitative aspects of microbial reactions, in different reactor configurations under different environmental and operational conditions [10].

Several types of bioreactors are currently in use but there are three major groups of bioreactors commonly in use, namely: batch reactors, a one stage continuously fed system and a two stages or multi-stage continuously fed system. The two-stage reactor is considered a promising process to treat organic wastes with high efficiency in term of degradation yield and biogas production [2, 11].

Microbial enzymes play a significant role in the degradation process and in Figure 1 it can be seen the enzyme activity during the anaerobic digestion stages [12].

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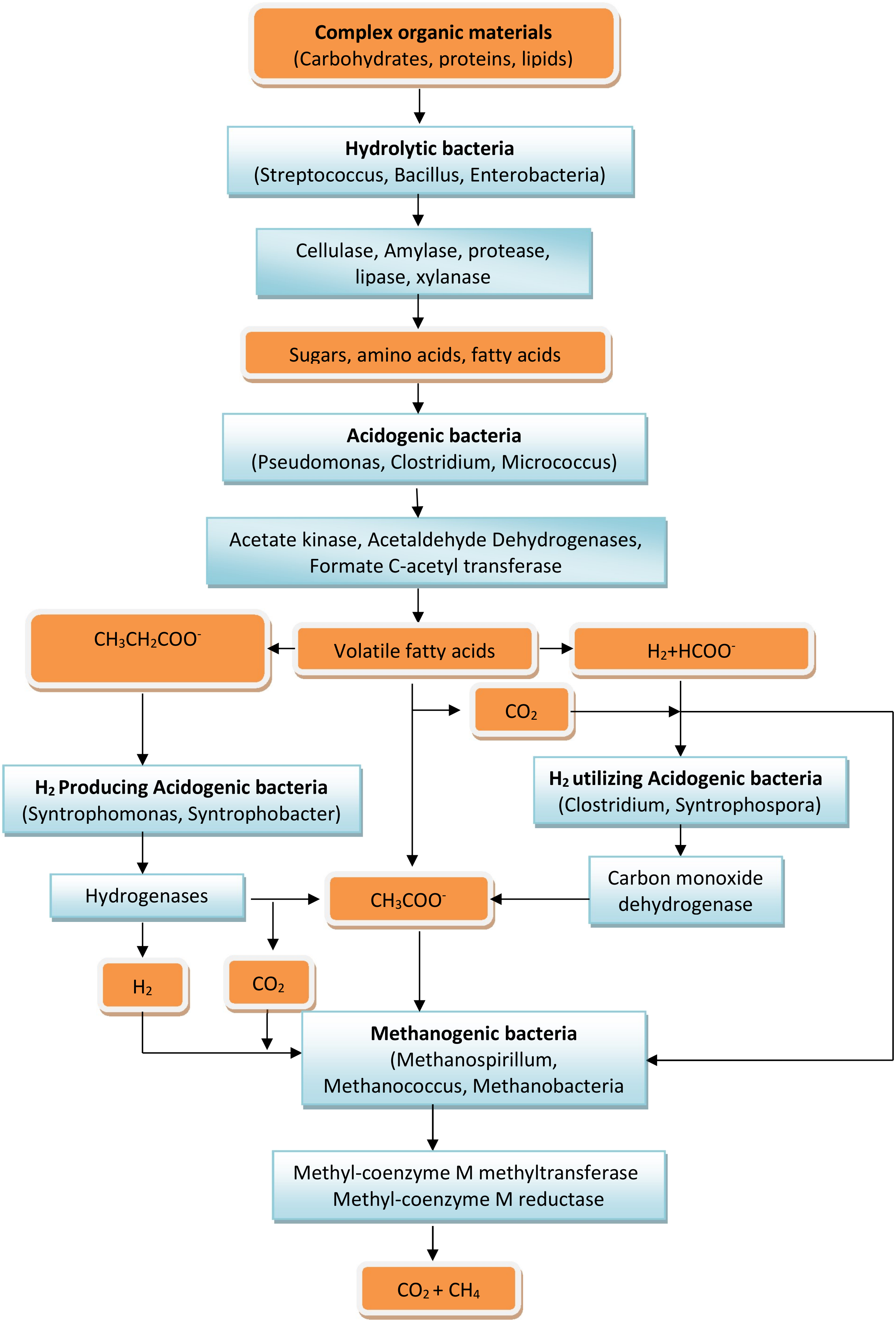


Figure 1: Enzyme activity during the anaerobic digestion stages (Adapted from [12])

2. METHODOLOGY

The IWA Task Group for Mathematical Modeling of Anaerobic Digestion Processes developed the generic Anaerobic Digestion Model No.1 (ADM1) [13]. The ADM1 model is one of the most comprehensive anaerobic digestion models and describes the dynamics of 24 species and includes 19 bioconversion processes [14].

Because of the complexity of anaerobic digestion process, the number of variables included in a model can be very high (a large variety of carbohydrates, proteins and amino acids, fats, long chain fatty acids, volatile fatty acids, alcohols, esters, and aldehydes are typically present) and in most cases it is impossible to include all the parameters that may be influencing the digestion [15].

Biological kinetics for many models is based on the elementary microbial growth and substrate consumption rates which depend on a growth-limiting substrate concentration [10]. The mathematical models found in literature differ in structure and level of complexity. The equations (1-4) are some common kinetic expressions describing anaerobic digestion processes:

First order kinetic model [16]:

$$\mu = \frac{K_{S,\max}S}{S_0 - S} - b\,;\ -\frac{dS}{dt} = K_{S,\max}S\,;\ S = \frac{S_0}{1 + K_{S,\max}t_{SR}} - b \tag{1}$$

Grau et al kinetic model [17, 10]:

$$\mu = \frac{\mu_{\max}S}{S_0} - b\,;\ -\frac{dS}{dt} = \frac{\mu_{\max}XS}{YS_0}\,;\ S = \frac{S_0(1 + bt_{SRT})}{\mu_{\max}t_{SRT}} \tag{2}$$

Contois kinetic model [10]:

$$\mu = \frac{\mu_{\max}S}{K_X X + S} - b\,;\ -\frac{dS}{dt} = \frac{\mu_{\max}XS}{Y(K_X X + S)}\,;\ S = \frac{K_X YS_0(1 + bt_{SRT})}{K_X YS_0(1 + bt_{SRT}) + t_{SRT}(\mu_{\max} - b) - 1} \tag{3}$$

Chen & Hashimoto kinetic model [18, 10]:

$$\mu = \frac{\mu_{\max}S}{KS_0 + (1-K)S} - b\,;\ -\frac{dS}{dt} = \frac{\mu_{\max}XS}{(KX + YS)}\,;\ S = \frac{KS_0(1 + bt_{SRT})}{(K-1)(1 + bt_{SRT}) + \mu_{\max}t_{SRT}} \tag{4}$$

where μ is the specific growth rate; $\mu_{\max}$ is the maximum specific growth rate; S_0 and S are the concentrations of the growth – limiting substrate; X is the microorganism concentration; $K_{S,\max}$ is the maximum specific substrate use rate; b is the specific microorganism decay rate; t_{SRT} is the solid retention time; Y is the growth yield coefficient; K_X is the Contois kinetic constant; K is the Chen & Hashimoto kinetic constant.

The Monod equation is the most used kinetic models describing microbial growth, which shows a functional relationship between the specific growth rate and an essential substrate concentration [19].

$$\mu = \mu_{\max}\frac{S}{K_s + S} \tag{5}$$

where: $\mu_{\max}$ is the maximum specific growth rate; S is the substrate concentration; K_s is the Monod constant.

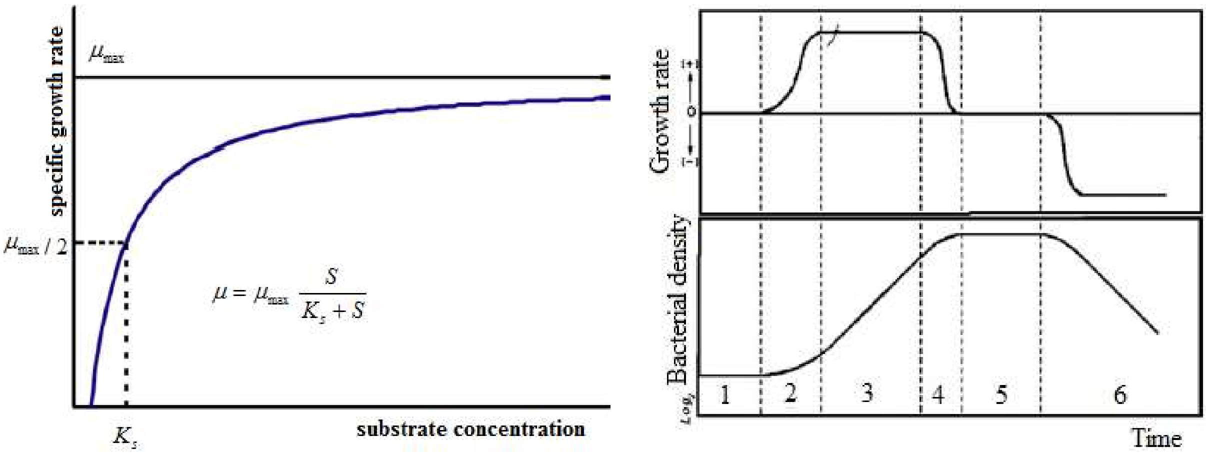


Figure 2: Specific growth rate depending on substrate concentration according to Monod equation and phases of growth of a bacteria culture [20]

1 – lag phase (zero growth rate); 2 – acceleration phase (increasing growth rate);
3 – exponential phase (constant growth rate); 4 – retardation phase (decreasing growth rate);
5 – stationary phase (zero growth rate); 6 - phase of decline (negative growth rate)

The Monod equation can be modified for each stage of anaerobic digestion, such as [21]:

- *Acidogenesis*

$$\mu_a = \frac{\mu_{ma} S_a}{(K_{Sa} + S_a)(1 + (P_a / K_{Pa}))} \quad (6)$$

where: μ_a is the specific growth rate of acidogens; μ_{ma} is the maximum specific growth rate of acidogens; S_a is the substrate concentration for acidogens; P_a is the volatile fatty acid concentration; K_{Sa} and K_{Pa} are the saturation and product inhibition constants.

- *Acetogenesis*

$$\mu_{ac} = \frac{\mu_{mac} S_{ac}}{(K_{Sac} + S_{ac})(1 + (S_{ac} / K_{Iac}))(1 + (P_{ac} / K_{Pac}))} \quad (7)$$

where: μ_{ac} is the specific growth rate of acetogens; μ_{mac} is the maximum specific growth rate of acetogens; S_{ac} is the substrate concentration (volatile fatty acids except acetic acid) for acetogens; P_{ac} is the product (acetic acid) concentration; K_{Sac}, K_{Iac} and K_{Pac} are the saturation, substrate inhibition and product inhibition constants.

- *Methanogenesis*

$$\mu_m = \frac{\mu_{mm} S_m}{(K_{Sm} + S_m)(1 + (S_m / K_{Im}))} \quad (8)$$

where: μ_m is the specific growth rate of methanogens; μ_{mm} is the maximum specific growth rate of methanogens; S_m is the substrate concentration (acetic acid) for methanogens; P_m is the product (methane) concentration; K_{Sm} and K_{Im} are the saturation and substrate inhibition constants.

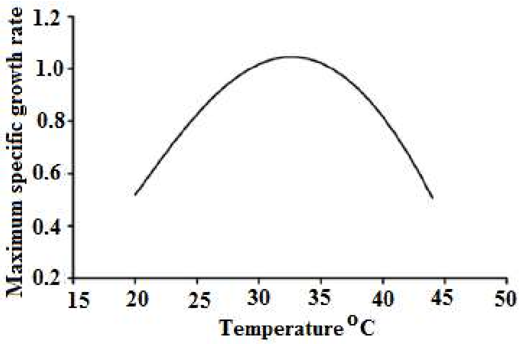
Temperature is one of the most important parameter in the anaerobic digestion process, this influencing the activity of enzymes and co – enzymes, the production of methane and also the digestate [22]. Since temperature can affect biochemical reactions and bacterial growth in a number of ways, it is an important parameter in anaerobic treatment [23]. In the cases when temperature is integrated in mathematical models, the Arrhenius equation is used [24]:

$$k = k_{\max} \cdot \exp\left(- \frac{E_a}{R \cdot T} \right)$$

where: k is the rate constant; $k_{\max}$ is the maximum rate constant; T is the temperature; R is the molar gas constant; E_a is the activation energy.

The pH is also an important parameter in the anaerobic digestion process and the optimum pH range in the mesophilic domain is between 6.5 and 8, and the process is inhibited if the pH value falls below 6.0 or increases over the 8.3 [25]. In most cases the pH is included in mathematical models through the ionic equilibrium. At a pH of 7 most acetic acid is dissociated in biogas [20].

In Figure 3 [20] can be seen the maximum specific growth rate depending on temperature and on substrate concentration for different pH values.



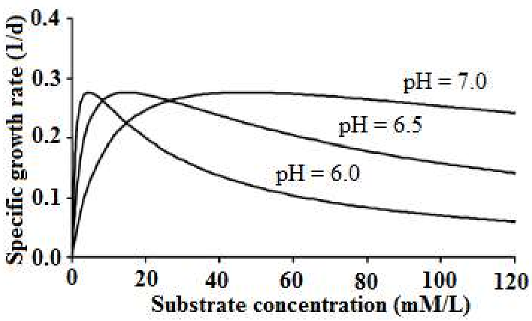


Figure 3: Specific growth rate depending on temperature and on substrate concentration for different pH values [20]

3. CONCLUSIONS

Anaerobic digestion process is considered to be one of the most effective processes used for treating animal manure, agro-industrial wastes and municipal solid wastes. On the other hand, anaerobic digestion is a very complex process involving various bacterial populations and substrates.

Mathematical modelling is applied in anaerobic digestion process in order to increase the profitability and efficiency of biogas plants. Moreover, mathematical models based on simulation of bioreactor runs, can explain the changes that can appear in the process variables, such as temperature and pH changes inside of bioreactor.

Mathematical models can be used to optimize the anaerobic digestion process in order to maximize the biogas production at the end of each batch. Also, it can be observed the evolution of a bioreactor's parameters and the effects of its geometric characteristics, on its performance.

ACKNOWLEDGMENT

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ENERGY LOSS REDUCTION IN HYDRAULIC SYSTEMS WITH FIXED PUMP IN AGRICULTURAL MACHINERY

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ABSTRACT

Reducing energy losses, which means, ultimately, reducing consumption to primary energy source, accompanied by diminishing pollution, is a problem in both the industrial field, and in the bioeconomy. Extending hydraulic drives in the latter area, favored by the potential to provide great strengths and torques in a relatively simple manner, it is challenge for the specialists in this domain to improve the energy balance by optimizing the functional schemes.

1. INTRODUCTION

Technology evolution was one of the engines of development of human society, and within it a very important role it has played by the developement of mechanical, electrical, hydraulic and pneumatic drives. Further will be analyzed how the hydraulic drive past from movements required in order to achieve the role of agricultural machinery to technical means of making movements with energy losses as low as possible. This shift towards energy saving was made in time, in several stages, each stage being represented by a specific technology.

In the first stage, with fixed pump systems, initial achievements were oriented toward movements' realization and only secondarily to reducing energy consumption by reducing losses [1].

In the second stage, adjustable stage pump systems, was pursued to modify the displacement of the pumps (and thus power consumption) during operation, by means of mechano-hidraulic means like controllers.

The third stage, the energy consumption approach one (from the primary source) to the requirements of each phase of the cycle of operation, is dominated by equipping adjustable pumps with devices controlled with servo equipment or loadsensing [2].

In the fourth stage, the digital hydraulics, was passed from the regulation of the pump, in order to reduce losses, to the use of several units of the system to close the primary energy consumption to energy needs of the driven machinery.

2. LOSSES IN ENERGY SYSTEMS WITH FIXED PUMPS

2.1. Analysis of energy losses in a system with two active phases and two actuators

Traditionally, the simplest hydraulic drive systems are composed of a fixed pump, two distribution elements and two linear hydraulic motors (hydraulic cylinders) included in a scheme like the one in fig. 1.

Consider only two phases; the first phase is the movement of the C_1 actuator rod outwards to outcome S_1; for this it takes the pressure p_1. In this phase is selected distributor D_1.

In the second phase, selected by distributor D_2, Q_2 flow is needed to achieve V_2 speed and to overcome S_2 load, which requires pressure p_2. As a result, there is a need for phase 1 of the power N_1, where $N_1 \cong \frac{P_1 Q_1}{600\eta}$, and for stage 2 is needed N_2 power, where N_2 has the expression $N_2 \cong \frac{P_2 Q_2}{600\,\eta}$.

Pump selection is done to ensure functional parameters Q_1 and P_2, admitting that $Q_1 = 2Q_2$ and $p_2 = 3p_1$, so that the pump will have the displacement such that trained with the speed of the electric motor, to provide Q_1, and p_2 is ensured by regulating general valve of the system S_G at the pressure p_2.

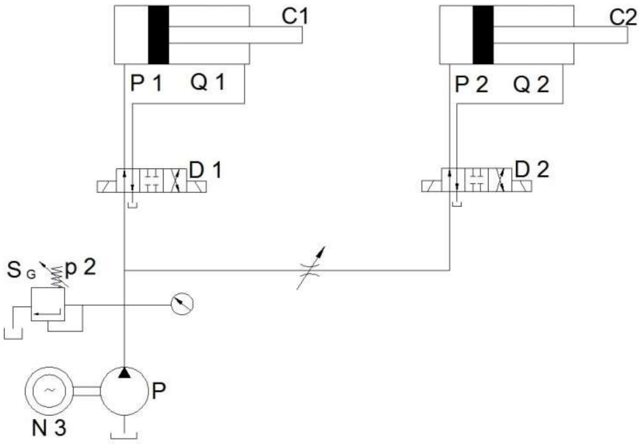

Figure 1: Working scheme with liniar hydraulic motors

In these conditions, and starting from the figure 1, the power consumed from the network is power N3.

$$N_3 \cong \frac{P_2 \cdot Q_1}{600\,\eta} = \frac{P_2 2Q_2}{600\,\eta} = 2\,N_{u2} = \frac{3P_1 \cdot Q_1}{600\,\eta} = 3N_{u1}, \text{ or}$$

$$N_{u1} = \frac{N_3}{3};\ N_{u2} = \frac{N_3}{2}\quad N_{u1} = \frac{2N_{u2}}{3} = \frac{2}{3}\,N_{u2}$$

2.2. The analysis of energy losses in the actuator

It starts from the diagram in figure 1, in which is discussed only branch with cylinder C_1 [3], which will be permanently supplied with nominal flow $Q_n = Q_1$, and general valve of the system will be set to $p_{max} = p_2$.

Notations that will be used are: N_u - output power; N_e - excess power (power installed but unused); N_p - lost power, converted into heat; N_i - installed power.

In this situation, the operation of the actuator can be schematising on these four situations shown in figure 2. [4]

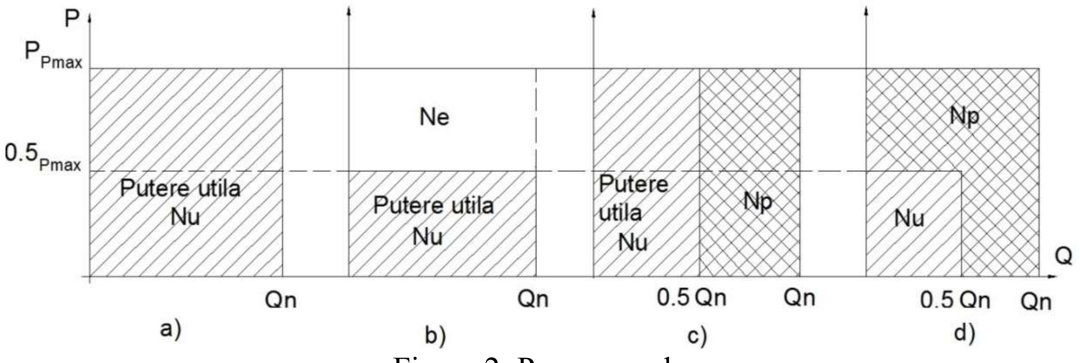

Figure 2: Power graphs

a) The actuator needs all pump flow $Q_a = Q_n$ to achieve speed V_1.

To overcome the load S_a, pressure in the actuator must reach $p_a = p_{max}$. In this situation:

$$N_{ua} = \frac{p_a\ \cdot\ Q_a}{600\,\eta} = \frac{p_{max}\ \cdot Q_n}{600\,\eta} = N_c$$

b) The actuator needs all flow $Q_b = Q_n = Q_1$ to achieve speed V_1.

This time the load S_b is less than S_a load. $S_b = 0,5S_a$, hence the pressure p_b is: $p_b = 0,5p_a = 0,5p_{max}$

Since it utilizes all pump delivery flow, power output is:

$$N_{ub} = \frac{p_b \cdot Q_b}{600\,\eta} = \frac{0,5\,p_{max}\ \cdot\ Q_n}{600\,\eta} = 0,5\,N_c$$

The remaining power (0,5 N_c), although it is installed, it is not used and therefore, the power in excess is $N_{eb} = 0.5\ N_c$, without losses and warming.

c) The actuator needs half flow ($Q_c = 0,5Q_n$) to achieve speed V_c and must work at pressure $p_c = p_{max}$ in order to overcome load S_c. In this case half the pump flow will be discharged through the relief valve of the circuit, so lost power is:

$$N_p = \frac{p_{max} \cdot 0,5\,Q_n}{600\,\eta} = 0,5\,N_C$$

d) The actuator needs half the flow rate to achieve speed V_d and must work at half the maximum pressure in order to overcome load (S_d): $p_d = 0.5\ p_{max}$ and $Q_d = 0.5\ Q_n$.

In this situation, output power $N_{ud} = \frac{p_d \cdot Q_d}{600\,\eta} = \frac{0,5\,p_{max} \cdot 0,5\,Q_n}{600\,\eta} = 0,25\,N_c$ turns mostly into heat, but lately have been made [5] more interesting systems to recover energy that would be lost.

3. IMPROVING THE ENERGY BALANCE BY IMPROVEMENT OF THE HYDRAULIC SCHEME

3.1 The introduction of pressure control valves in each circuit.

Whereas the system shown in figure 1 uses the same safety valve for both phases, reach very high losses such as those in figure 2.d.

A first solution to reduce losses, used in the course of time, was achieved by placing pressure valves (discharge valves) on each circuit, as can be seen in figure 3, wherein besides a general valve S_G, in the installation are introduced valves S_1 and S_2. There are many other solutions to improve energy efficiency [6] by new schemes of agricultural machinery driving.

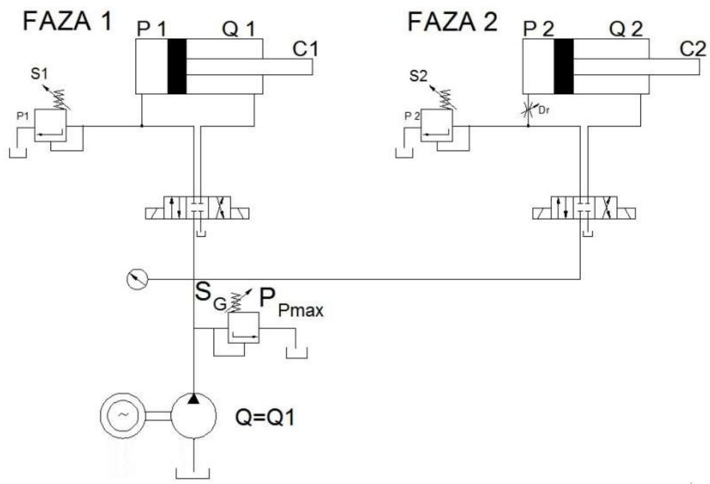

Figure 3: Driving scheme with safety valves on each circuit

In the second phase it can be seen that losses are reduced, but also appears a small part of installed power as unused.

Starting from the situation in which: $p_2 = 3p_1$; $Q_1 = 2Q_2$ and $p_{max} \cong 1,25p_2$; $p_{max} = 1,25p_2 = 1,25 \cdot 3p_1 = 3,75p_1$, it follows that the installed power is:

$N_i = N_3 = \frac{Q_1 \cdot p_{max}}{600\,\eta}$

In phase 1: $N_{u1} = \frac{p_1 \cdot Q_1}{600\,\eta} = \frac{2Q_2 \cdot 1/3p_2}{600\,\eta} = \frac{2}{3}\frac{Q_2 \cdot P_2}{600\,\eta} = \frac{2}{3}N_{u2}$

It finds that much of the power is not used: $N_{e1} = N_3 - N_{u1} - N_{p1}$, and if we admit that $N_{p1} = 0$ $\Rightarrow N_{e1} = \frac{Q_1 \cdot p_{max}}{600\,\eta} - \frac{Q_1 \cdot p_1}{600\,\eta} = \frac{Q_1 \cdot 2{,}75\, p_1}{600\,\eta} = 2{,}75\, N_{u1}$, it proves that there is a poor use of installed power, but at least with energy losses reduced.

In phase 2: $N_{u2} = \frac{Q_2 \cdot p_2}{600\,\eta}$

This time energy loss is: $N_{p2} = \frac{(Q_1 - Q_2)p_2}{600\,\eta} = \frac{Q_2 \cdot p_2}{600\,\eta} = N_{u2}$

Resuming: $N_3 = N_{u1} + N_{p1} + N_{e1} = N_{u2} + N_{p2} + N_{e2}$.

3.2. Using pressure compensator

Using three pressure valves in the system can be replaced by using a pressure compensator, which is actually a pressure valve remotely piloted valve, and instead valves for every circuit are inserted pilot valves, which are valves with small nominal diameter Dn.

In this way, the scheme in figure 3 turns into scheme in figure 4.

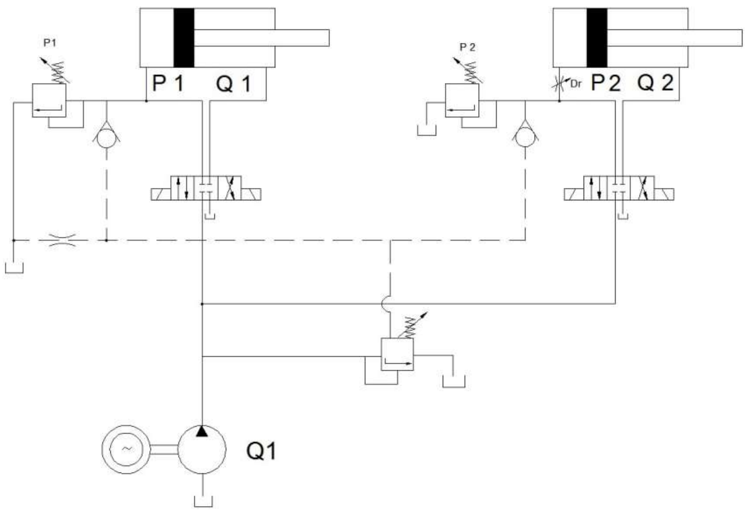

Figure 4: Driving diagram with two pilot valves

The difference in the power consumption of the scheme of figure 4 and the diagram of figure 3, consists primarily in reducing N_3 energy to the N_2 level by limiting the system pressure to the value of the phase with the higher pressure p_2.

4. IMPROVING THE ENERGY BALANCE BY USING MULTIPLE PUMPS

4.1. Using double pumps.

One of the traditional solutions adopted to reduce energy losses in the systems where phases selection are difficult is the use of two coaxial pumps, as seen in figure 5. The solution is most often used in hydraulic presses, which have at least 3 standard phases.

The standard phases are:

1. Phase of rapid approach. This phase requires a maximum flow and a low pressure ($Q_1 + Q_2$ and $p_1 \cong 0{,}1\, p_2$).
2. Full pressure phase. This phase requires low flow (for low speed) and maximum pressure ($Q_2 \cong 0{,}1\, Q_n$ and $p_2 = p_{max}$).
3. Phase of rapid retraction. This phase requirea high flow and low pressure. Load is determined by the weight of the mobile part plus frictional forces [7].

Solving the problem with one single pump would lead to the situation that in the second phase (pressing one), the pressing power losses to be as in figure 4 variant c, where the flow lost through the valve would be about 90%.

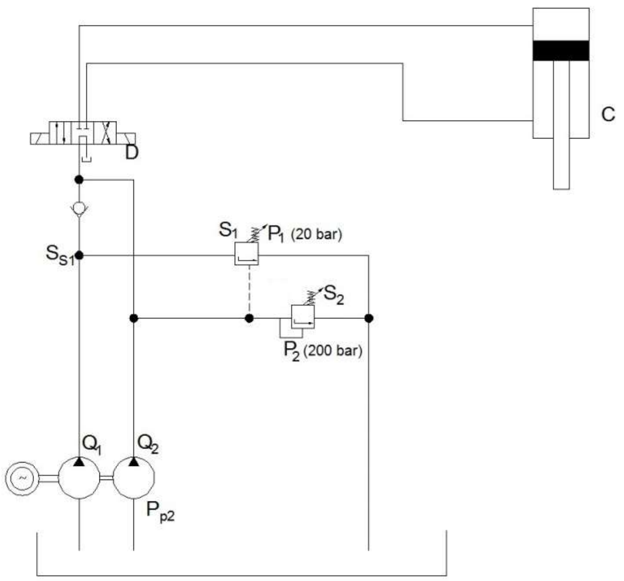

Figure 5: Hydraulic system with double pump

By using the hydraulic system shown in figure 5 with guideline values for each phase, the energy losses will look like in the graphs in figure 6.

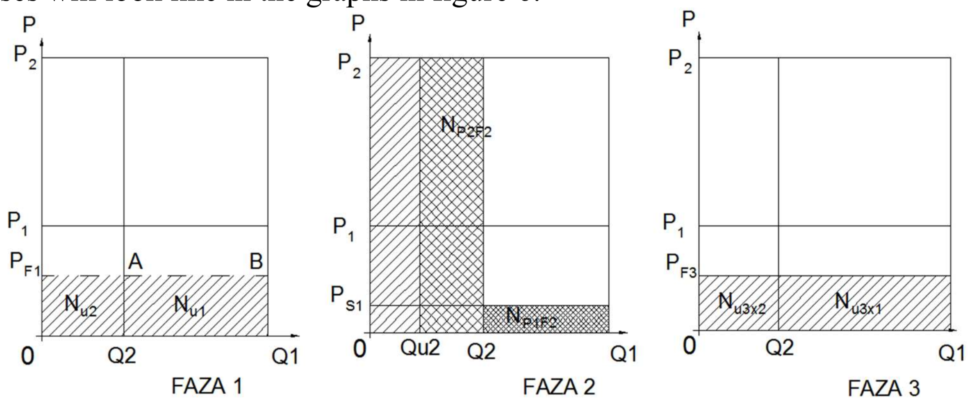

Figure 6: Energy consumption to double pump systems

● **In phase 1** – Output power – $N_{uF1} = N_{u1} + N_{u2} = \frac{p_{F1} \cdot Q_{F1}}{600\,\eta}$

$Q_{F1} = Q_1 + Q_2$, and the pressure is established by the load and is $p_{F1} < p_1 < p_2$

Power consumption $N_{cF1} \cong N_{uF}$

N_{u1} – it is represented by the rectangle O – p_{F1} – B – Q_1, and

N_{u2} – it is represented by the rectangle O – p_{F1} – A – Q_2

● **In phase 2** –due to increased pressure in the system above P_1, valve S_1 opens and S_{S1} check valve is locked; in this way the whole flow Q1 goes to the tank to minimum set pressure by valve S_1 (p_{S1}). This lost power has value $N_{p1F2} = \frac{Q_1 \cdot p_{S1}}{600\,\eta}$ where p_{S1} is about 3 ÷ 6 bar, thus $p_{S1} < p_1$.

In this phase it is possible that some of the Q_2 flow to be discharged through pressure valve S_2 at p_2 pressure, and to use only Q_{u2}.

$N_{p2F2} = \frac{KQ_2 \cdot p_2}{600\,\eta}$ where K < 1 depending on the speed of work in phase 2.

$N_{pF2} = N_{p1F2} + N_{p2F2} \cong N_{p2F2}$, $N_{u2} = \frac{p_2 \cdot Q_{u2}}{600\,\eta}$

● **In phase 3** – rapid retraction phase uses the entire pump flow p_{P1}, pressure resulting from the weight and friction. Pressure pump is established on both circuits.

4.2. Using systems with 3 or more pumps. Hydraulic pumping units with 3 coaxial pump (figure 7) or 3 pumps driven by independent electric motors (or thermal) were the first steps towards digital hydraulics [8]. Each pump has its own flow (Q1, Q2, Q3) of which we can select for the system one, two or even all three, getting rates: Q_1; Q_2; Q_3; $Q_1 + Q_2$; $Q_1 + Q_3$; $Q_2 + Q_3$ or $Q_1 + Q_2 + Q_3$.

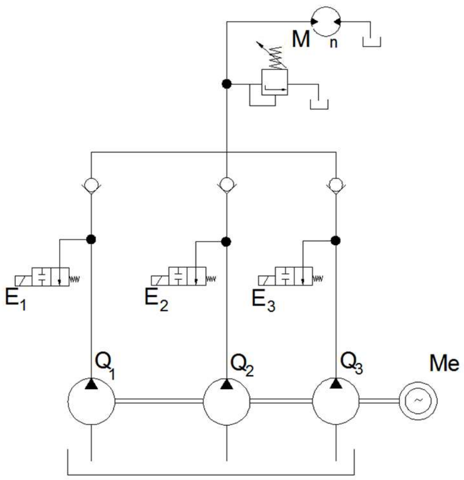

Figure 7: Hydraulic system with 3 fixed displacement pumps

Using electric automation system is selected one of the seven variants of flow (9), which can provide one of the seven different speeds for the hydraulic engine M.

5. CONCLUSIONS

The article presents some simple directions for action to reduce consumption to agricultural machines which have hydraulic drive made with fixed displacement pumps. The results so far lead to conclusion that the possibilities of energy efficiency, in this case, are limited; in this context, must be taken into account, for superior results, using variable flow pumps and modern concept of digital hydraulic.

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MODELLING THE DRIVING WHEEL OF THE TRACTOR FOR A MODEL WITH A DEGREE OF FREEDOM

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Begea Mihaela, Rusănescu Carmen-Otilia
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ABSTRACT

The paper presents the modelling of the driving wheel of a tractor for two types of tires, one manufactured in Romania and the other one a wheel manufactured by Good Year, making an analysis of the results obtained for the two types of wheels. For this were followed: oscillation of drive wheel on agricultural land and at low speeds, oscillation of driving wheel on agricultural land at fast tractor speeds, oscillating motion of the drive wheel when moving on country road for low speeds of the tractor U-650M, oscillatory movement of driving wheel when driving on the country road at fast speeds of the U-650M tractor.

1. INTRODUCTION

Using, the modelling program were achieved two drive wheels used for the U-650 M tractor and namely:

- a drive wheel with the tyre manufactured in Romania;
- a drive wheel with Good Year tyre.

For each drive wheel, for a pressure of 1.2 bar and a load of 12000 N, was measured the contact surface with the soil, the wheel's free radius, the radial and lateral deformation. The results obtained are presented in table 1:

Table 1: Characteristics of the drive wheel studied

Tyre	Pressure [bar]	Load [N]	Supporting surface [cm^2]	Free radius [m]	Radial deformation		Lateral deformation	
					[mm]	[%]	[mm]	[%]
16.9 – 38 Romania	1.2	12000	1470	0.838	33.2	3.96	37	8.5
16.9 – 38 Good Year	1.2	12000	1365	0.838	27.3	3.25	12	2.8

From the experimental data presented in table 1, it results that the surface of contact between the wheel and the soil, measured by planimetry, is larger in the case of the wheel manufactured in Romania, the radial and lateral deformations and bigger in the case of the Good Year wheel.

The elastic constants and the amortization coefficients for the two wheels are:

- drive wheel Romania: $k = 350700$N/m; $c = 8000$;
- drive wheel Good Year: $k = 427300$N/m; $c = 8827$.

2. METHODOLOGY

The modelling program for the tractor wheel was run for low and high speeds of the U-650M tractor, and for the types of driveways: agricultural land and country road.

The speeds of the tractor are:

- low speeds:

$$v_1 = 2{,}58\ km/h; v_2 = 4{,}16\ km/h; v_3 = 5{,}78\ km/h; v_4 = 7{,}68\ km/h; v_5 = 18{,}18\ km/h$$

- high speeds:

$v_1 = 3{,}83\ km/h; v_2 = 6{,}17\ km/h; v_3 = 8{,}56\ km/h; v_4 = 11{,}38\ km/h; v_5 = 26{,}94\ km/h$

The characteristics of the agricultural land are:

- height of irregularities $h_0 = 0{,}025$ m
- length of irregularities $l = 0{,}208$ m.

The profile of the driveway for low speeds of the tractor is presented in figure 1.

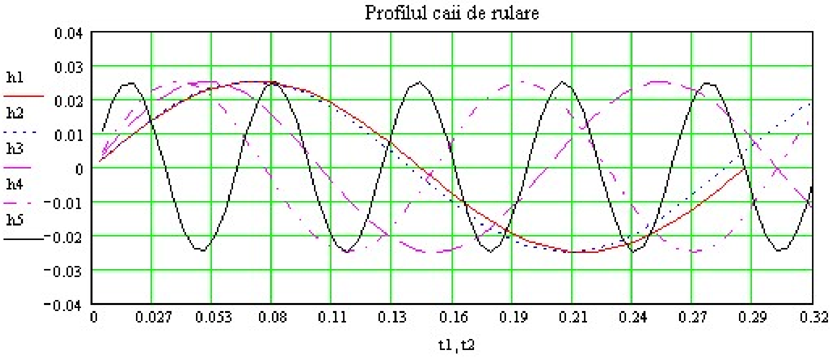

Figure 1. Profile of agricultural land for low speeds of the U-650M tractor

The movement of the drive wheel manufactured in Romania is presented in figure 2, and that of the Good Year wheel in figure 3.

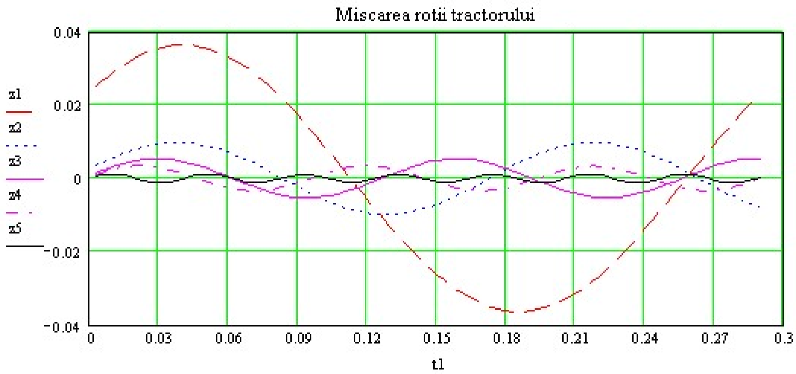

Figure 2. Oscillation of drive wheel manufactured in Romania on agricultural land at low speeds

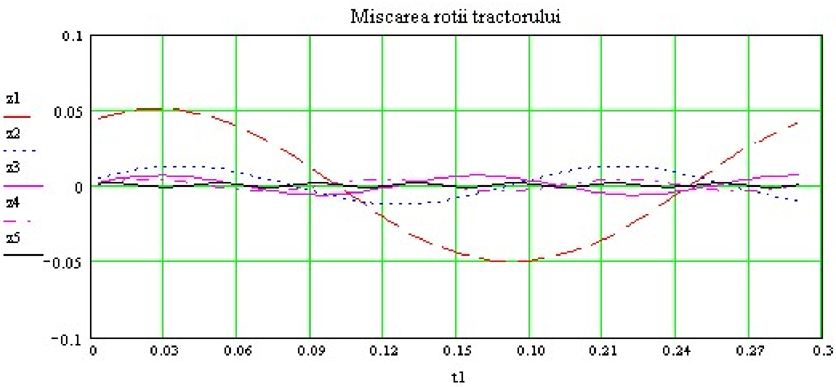

Figure 3. Oscillation of Good Year drive wheel on agricultural land at low speeds

For high movement speeds of the tractor, the profile of the driveway is presented in figure 4.

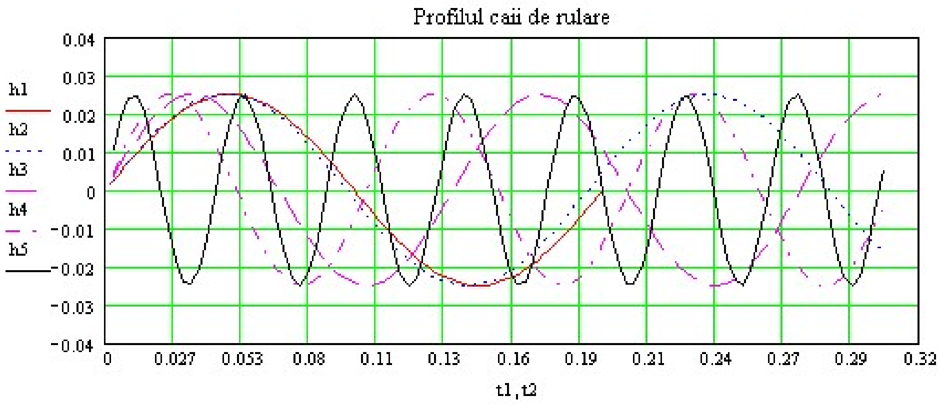

Figure 4. Profile of the agricultural land for rapid speeds of movement of the U-650M tractor

The oscillatory movement of the drive wheel manufactured n Romania when moving on agricultural land at high speeds of the U-650M tractor is represented in figure 5, and the one for the Good Year drive wheel in figure 6.

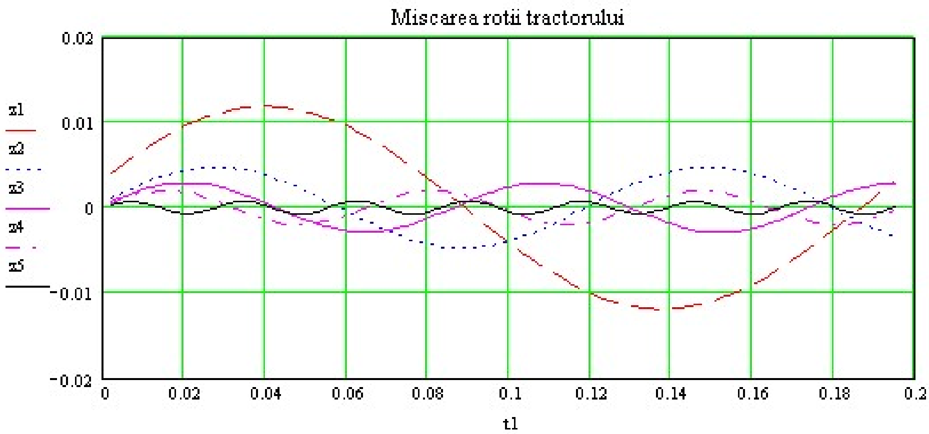

Figure 5. Oscillation of drive wheel manufactured in the country on agricultural land at high tractor speeds

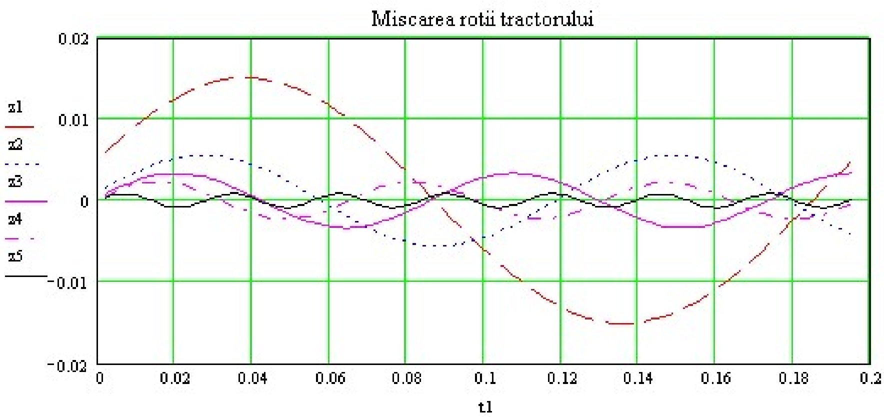

Figure 6. Oscillation of Good Year drive wheel on agricultural land at high tractor speeds

The oscillatory movement of the drive wheel, for high speeds of the U-650M tractor, when moving on country road, is presented in figure 7 for the wheel manufactured in the country and in figure 8 for the Good Year drive wheel.

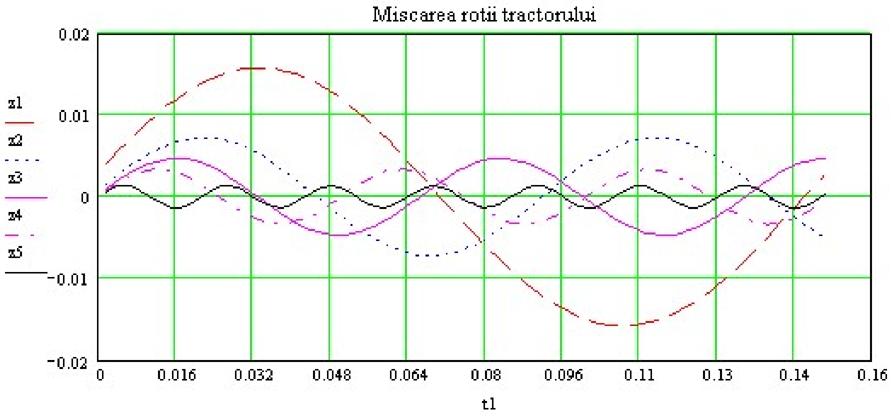

Figure 7. Oscillatory movement of the drive wheel manufactured in the country when moving on country road at low speeds of the U-650M tractor

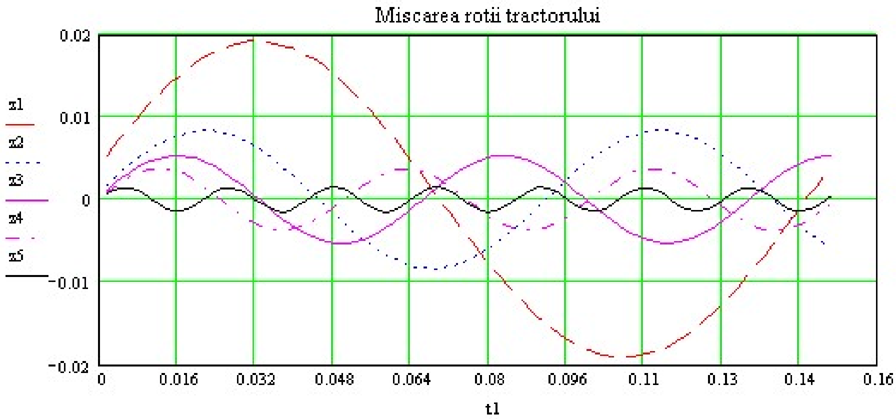

Figure 8. Oscillatory movement of the Good Year drive wheel when moving on country road at low speeds of the U-650M tractor

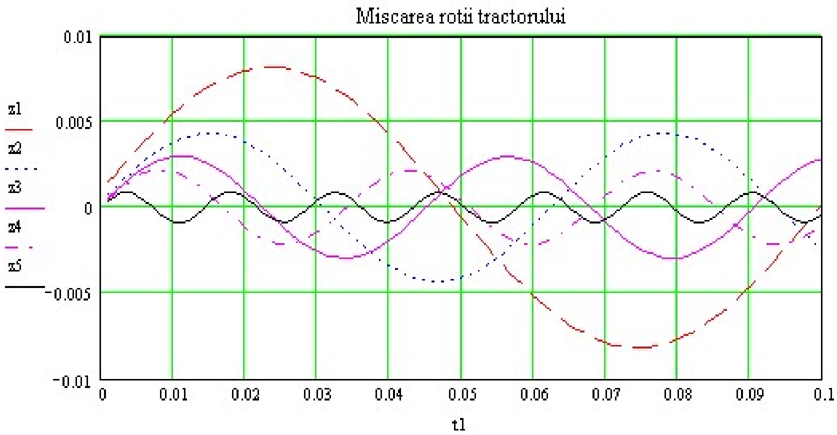

Figure 9. Oscillatory movement of the drive wheel manufactured in the country when moving on country road at high speeds of the U-650M tractor

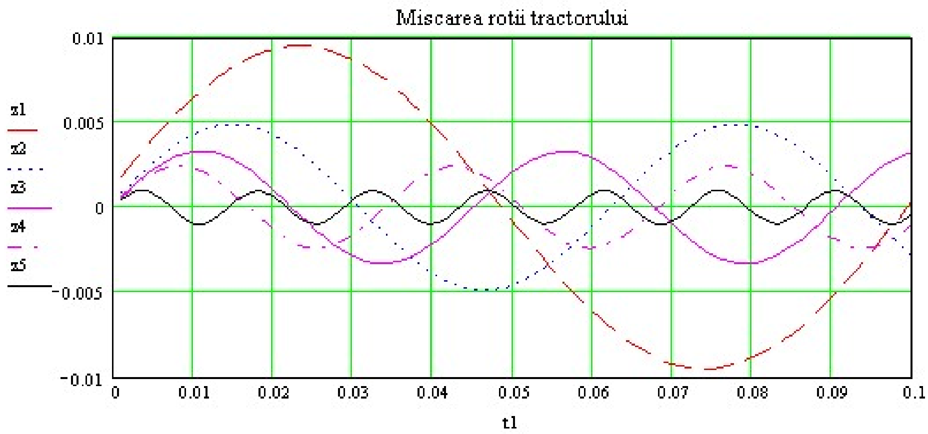

Figure 10. Oscillatory movement of the Good Year drive wheel when moving on country road at high speeds of the U-650M tractor

In figure 11 is presented the oscillation of the two types of wheels, when moving on country road, for the minimum, respectively the maximum speed of wheel movement ($v_{\min} = 2{,}58\ km/h,\ v_{\max} = 26{,}94\ km/h$).

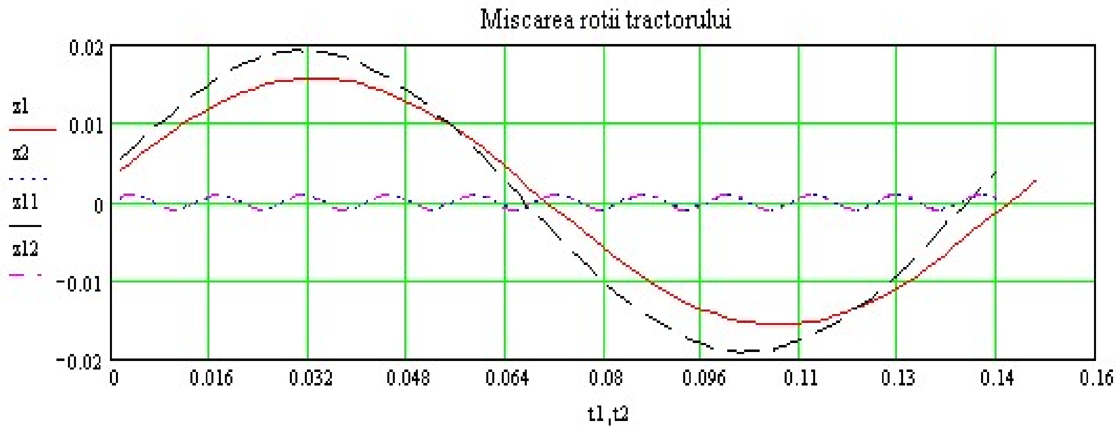

Figure 11. Comparison between the oscillations of the two types of drive wheels when moving on country road

3. CONCLUSIONS

At the movement of the drive wheels with low speeds of the U-650M tractor, it is found that the amplitude of oscillation is higher for the Good Year wheel at the minimum speed $v = 2.8\ km/h$, and in the case of the other four speeds, the amplitudes of oscillations of the two wheels tested are very similar. By running the modelling program for $v_{\min} = 2.58\ km/h,\ v_{\max} = 26.94\ km/h$, for the two types of wheels, it is found that the amplitude of oscillations of the wheel manufactured in Romania is smaller than in the case of the Good year wheel at minimum speed and that they are identical at maximum speed.

The amplitude of oscillations of the drive wheel manufactured in the country is higher when moving on country road than when moving on agricultural road, and in the case of the Good Year drive wheel, the amplitude of oscillations when moving on country road is smaller than when moving on the other road.

In the case of moving the drive wheels on country road with high tractor speeds, the amplitude of oscillations for the drive wheel manufactured in the country (z_1 at minimum speed, z_2 at maximum speed), for the minimum speed is smaller than the amplitude of oscillations of the Good Year wheel (z_{11} at minimum speed and z_{12} at maximum speed), and for the other speeds the amplitudes of oscillations are very similar.

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GREENHOUSE GAS REDUCTION POTENTIAL OF MICROALGAE: A REVIEW

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ABSTRACT

Algae are most promising biofuel type regarding renewable energy share in fuel market. Algae can metabolize waste streams for production of the products with wide variety of uses and compositions. The products include lipids, carbohydrates and proteins. These products can be used for biodiesel production, ethanol production and human or animal consumption. Microalgae cultivation can contribute towards CO_2 fixation. This paper includes a review towards CO_2 capture by microalgae and its usage as fuel in internal combustion engine. Microalgae biofuel can be used in diesel engine to reduce NO_x emissions. Microalgae research and pilot scale CO_2 biocapture plant in Romania has shown its economic feasibility as well as sustainably regarding environmental impacts.

1. INTRODUCTION

Predominantly, fossil fuels are responsible for greenhouse gas emissions. These emissions are responsible for environmental pollution and climate change [1], [2]. Several technologies are developed in order to decrease these emissions [3]. Carbon capturing is technology in which carbon dioxide is separated and long-term isolated from atmosphere. Algae are organisms which grow under aquatic environment and use carbon dioxide and light to generate algae biomass. Algae biomass is used to generate energy in several ways [4]. Algae cultivation combined with CO_2 sequestration from flue gas emissions is economically viable [5], [6]. Microalgae have promising potential of CO2 storage and capture. CO_2 fixation via microalgae has advantages of rapid growth rate, environmental adaptability, high photosynthesis rate and low operational costs. CO_2 from flue gases and nutrients from wastewater for microalgae provide environmental advantages as well as cost benefits [7].

This paper provides a review of CO_2 capturing technologies that use microalgae biofuel production in order to achieve this goal. The tolerance level varies not only between the species but within single specie as well. Microalgae species, cultivation techniques, harvesting, lipid extraction and biofuel production are discussed here. The prospects of commercialization for these technologies are also discussed in this paper.

2. TYPES OF MICROALGAE AND CO_2 CAPTURE

Microalgae can be divided into CO_2 sensitive (species with 2-5% CO_2)and CO_2 tolerant (≥20% CO_2) groups. CO_2 tolerance is becoming more and more important with increasing amount of CO_2 in atmosphere. Algal biomass consists of carbon from 40 to 50% of carbon. 1.5 to 2 kilograms of CO_2 is required in order to produce 1kg algal biomass. Supply of carbon is one of the technological issues regarding algae biomass production. On one hand, it should not exceed upper limit of CO_2 and on the other it should not fall below a level where growth will stop. High tolerant species and CO_2 levels are shown in table 1.

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Table 1: CO_2 tolerance of microalgae species [8]

Microalgae species	Maximum CO_2 tolerated (%v/v)
Cyanidium caldarium	100
Scenedesmus sp.	80
Chlorococcum littorale	60
Synechococcus elongatus	60
Euglena gracilis	45
Chlorella sp.	40
Eudorina spp.	20

3. PHOTOSYNTHEISIS

Oxygen is released during photosynthesis process in microalgae and can be named as "oxygenic photosynthesis. CO_2 is converted into hydrocarbons and lipids during process. Oxygen is released after hydrolysis and water is electron donor. Equation can be expressed as given by following equation 1.

$$H_2O + CO_2 + Photons(light) \rightarrow [CH_2O]_n + O_2 \tag{1}$$

The reaction can be divided into two parts, light dependent and light independent part. Light dependant reaction involves both redox and photochemical reaction steps. Overall equation for light reaction can be written as following,

$$2H_2O + 2NADP^+ + 3ADP + 3P + light \rightarrow 2NADPH + 2H^+ + 3ATP + O_2 \tag{2}$$

NADP, ADP, P, NADPH and ATP a represent nicotinamide adenine dinucleotide phosphate, adenosine diphosphate, phosphate, nicotinamide adenine dinucleotide phosphate and adenosine triphosphate. ATP and NADPH are energy storage molecules and light is used to synthesize them. Ribulose bisphosphate carboxylase/oxygenase enzyme captures CO_2 from atmosphere during light independent reaction. Sugars produced by carbon metabolism results in carbon skeletons which can be used for production of amino and lipids. The light independent reaction is expressed by following equation [9].

$$\begin{aligned} &3CO_2 + 9ATP + 6NADPH + 6H^+ + light \rightarrow C_3H_6O_3 - Phosphate + 9ADP + 8P \\ &+ 6NADP^+ + 3H_2O \end{aligned} \tag{3}$$

4. CO_2 FIXATION

Microalgae can produce carbon dioxide overnight but net uptake of CO_2 remains positive. Fixation rate of carbon dioxide is directly related to utilization efficiency of light and cell density of microalgae. Carbon dioxide fixation by microalgae involves photoautotrophic growth in which anthropogenically derived carbon dioxide can be used as carbon source. Biomass growth and measurements are critical in accessing the potential of CO_2 fixation potential of microalgae. Removal efficiency of photo bioreactor can be determined by difference of CO_2 concentrations of incoming and outgoing effluents. Following formula can be used for determining removal efficiency.

$$\text{Re}moval efficiency(\%) = \frac{Influent of\ CO_2 - Effluent of\ CO_2}{Influent of\ CO_2} \times 100 \quad (4)$$

Removal efficiency for closed systems depends on microalgae species, carbon dioxide concentration, photo bioreactor design and operating conditions. CO_2 fixation rate can be determined by following expression.

$$R_{CO_2} = C_C \times \mu_L \times \left(\frac{M_{CO_2}}{M_C} \right) \quad (5)$$

R_{CO_2} and μ_L represent fixation rate (gCO_2/m^3h) and volumetric growth rate (g dry weight/m^3h) respectively. M_{CO_2} and M_C are molecular weights of carbon dioxide and carbon respectively. C_C is average carbon content measured by elemental analysis [10].

5. ALGAE AS FUEL

Production of biofuels from algae greatly depends on algal culture, methodology (open pond or photo bioreactor), reactor type (batch, fed batch or continuous operation) and culture technique (heterotrophic or autotrophic). Algae are cultivated for the production of biomass which is further used as feedstock to produce biofuel. Algae biomass production is higher than many energy crops. High productivity of algae biomass has advantage of using smaller land area. High lipid content and productivity make it promising future biofuel.

Biodiesel can be defined as monoalkyl ester of long chain fatty acid which satisfies ASTM D6751 standard in order to use in diesel engine. Transeterification process can transform lipids into biodiesel [11]. Characteristics of algae biodiesel are shown in table 2 below.

Table 2: Characteristics of algae biodiesel [12]

Properties	Algal biodiesel	Standard limits ASTM 6751
Flash points (°C)	166	>160
Kinematic viscosity at 40 °C (mm^2/sec)	4.33	1.9-6
Water and sediment (vol. %)	0.005	0.050 max.
Density at 15 °C (kg/m^3)	878.47	n/a
Cetane number	58.5	47 min.
Acid value (mg KOH/g)	0.43	0.8
Carbon residue	0.01%	0.050%
Sulfur	0.00056%	0.05%
Distillation temperature	346	360
Phosphorus	0.0004	0.001

Genetically modified algae can be used for generation of alcohol. Petroleum-like end products are obtained from microalgae. A laboratory scale experiment has shown the production of hydrogen from microalgae which can further be used as a source of heat, fuel and electricity [13].

6. ENVIRONMENTAL IMPACTS

Microalgae biofuels have the environmental benefits over conventional fuels. It needs research in order to find out potential disadvantages of these biofuels. Emissions regarding cultivation of microalgae are largely unknown. CO_2 has its role in algae growth for biofuel production. CO_2 sequestration can lead towards more neutral levels of carbon dioxide emissions as compared to that of fossil fuels. Microalgae biofuel production also has potential for wastewater treatment. Sustainable production of algae biofuel faces challenges but shows promising future [14], [15].

Tsaousis *et al.* used raw algal oil in an internal combustion engine which had shown lower NO_x emissions [16]. Jayaprabakar and Karthikeyan used algae biodiesel in diesel engine and concluded that brake thermal efficiency was higher for microalgae biodiesel blends than that of diesel fuel. Carbon emissions were lower for biodiesel blends. Transesrification process determines the properties of biodiesel which further effects the combustion process. B10 and B20 can be alternatives for CI engine [17].

Tuccar *et al*. had conducted experiments to evaluate the diesel engine performance by using algae biodiesel blends with butanol. They found that cetane number, viscosity and density were compatible with fuel standards. Butanol addition improved NO_x and CO emissions. Finally, they concluded that butanol can be used as additive for microalgae-diesel blends to improve engine emissions [18].

Wood *et al*. used emulsified biodiesel blends of microalgae, yeast and bacteria biodiesels. They concluded that NO_x emissions can be reduced by using these blends. NO_x emissions were recorded lower for microalgae biodiesel blends [19]. Life cycle of algae biofuels is demonstrated by figure 1.

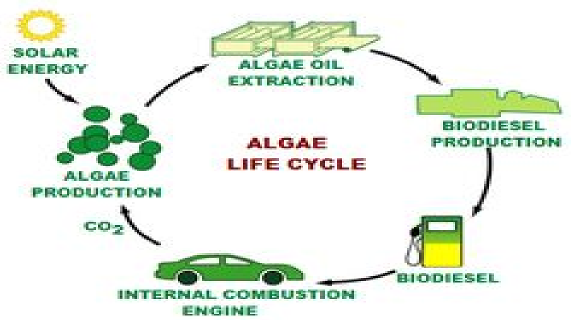

Figure 1. Algae biofuel life cycle [20]

7. ROMANIAN MICROALGAE STATUS

Wastewater treatment with the help of microalgae is major breakthrough in this technology where not only the growth rate is higher but helpful in cleaning waste. Salinity and temperature plays an important role for green microalgae near Romanian costal line. Entoromorpha intestinalis is resistant to change in water salinity and ulwa lactuca can grow in areas where salinity is not affected by danube floods. There is possibilty of using wastewater in order to grow microalgae biomass at Constanta and Mangalia [21].

Iancu *et al.* had used a pilot scale plant to demontrate CO_2 capture from industrial flue gas which can be seen in figure 2. Furthermore, they assessed its sustainability and economic viability. Algae culture, CO_2 photobioreactor, biomass harvesting and oil extraction are main technological aspects of experimentation. The simulation results showed 1400 CO_2/year biocapture with 45% yield and 200kg of algal production. Production cost was estimated by simulator of 24000 €/year. It had proved sustainable assessment [22].

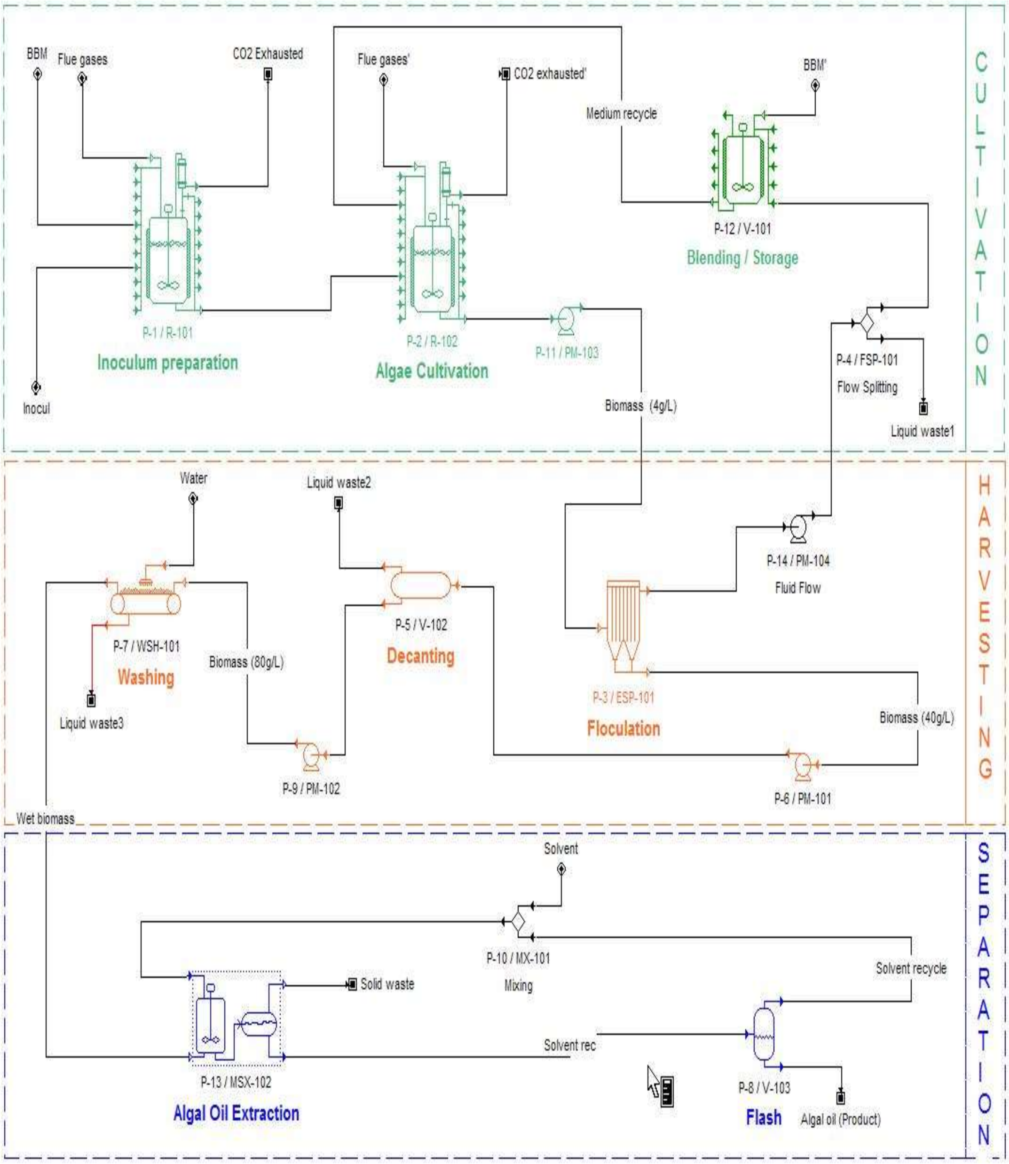

Figure 2. CO_2 Photo biocapture schematic diagram [22]

8. CONCLUSIONS

Technological advancements in area of microalgae biofuel production and uses have following advantages.

- Microorganisms based technology of biofuel production has the ability to reduce greenhouse gas emissions.
- Microalgae has promising ability of CO_2 fixation with the help of photosynthesis and its species has the ability of carbon tolerance up to 100%
- Algae biodiesel has compatible fuel properties to ASTM standard
- Usage of algae biodiesel in diesel engine has shown lower carbon and NO_x emissions. Algae biodiesel blends have shown improved engine performance
- Romanian costal line has ability to produce green algae. A pilot scale CO_2 photobiocapture plant has shown economic viability as well as sustainability in order to capture CO_2 and algae biofuel production.

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INHIBITORY EFFECT OF SIX ESSENTIAL OILS AGAINST FOOD CONTAMINANT BACTERIAL SPECIES

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ABSTRACT

The essential oils have a potential interest in the pharmacological field and in food preservation technology for its antimicrobial effects and receive particular attention as agents suitable for prophylactic and medical treatment. The aim of this paper was to demonstrate the *in vitro* the static and/or cidal activity of essential oils extracted from six aromatic plants found in the local flora: thyme, mint, basil, dill, sage, oregano. These oils were tested against four bacterial strains: *E. coli* ATCC 8738, *Salmonella enteritidis* ATCC 13076, *Staphilococcus aureus* ATCC 6538, and *Pseudomonas aeruginosa* ATCC 9027 through agar well diffusion method. All microbial strains were completely or partially inhibited by the volatile oils. The most effective antibacterial were oregano and thyme oils that inhibit the growth of *E. coli* and *S. aureus*. The lowest effect was recorded in the case of sage and basil oils for all tested germs. *P. aeruginosa* was the most resistant bacterial species.

1. INTRODUCTION

Nowadays aromatic herbs are considered of great interest for their flavors and for their medicinal properties, along with human consumption, animal foodstuff and ornamental uses. Compounds isolated from this plants presents the biological activity, eliminating pathogenic microorganisms because of the resistance that many microorganisms have built up to antibiotics [1,2].

Essential oils represent volatile, natural, complex compound mixtures characterized by a strong odor. They arise from the secondary metabolism of the plant, normally formed in special cells or groups of cells or in glandular hairs found on many leaves and stems. These secondary metabolites serve to protect plants against pathogens. Essential oils are composed principally of terpenoids, including monoterpenes and sesquiterpenes, and their oxygenated derivatives. Substances like aliphatic hydrocarbons, acids, alcohols, aldehydes, acyclic esters or lactones, nitrogen- and sulphur-containing compounds, coumarins and phenyl-propanoid homologues are found in essential oils [3,4].

Their antiseptic (bactericidal, fungicidal), medicinal properties and their fragrance are well known and for that reason these oils are used embalmment, preservation of foods and as antimicrobial, analgesic, sedative, anti-inflammatory, spasmolytic and local anesthetic remedies. The essential oils are considered antimicrobial agents in pharmacology, pharmaceutical botany, phytopathology, medical and clinical microbiology and food preservation [5].

Thymus species comprise an important genus in the *Lamiaceae* family and contain volatile oils as the main chemical compounds thymol and carvacrol are the most important constituents of volatile oils. Other chemical constituents of the *Thymus* species include flavonoids (e.g. thymonin, cirsilineol and 8-methoxycirsilineol), "Labiatae tannin" (rosmarinic acid), caffeic acid, triterpenoids, long-chain saturated hydrocarbons and aliphatic aldehydes [6,7].

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In basil, (*Ocimum* species), the major essential oil components include phenyl-propanoids (methyl chavicol, methyl cinnamate, eugenol, and methyl eugenol) and terpenes (linalool, geraniol, geranial, camphor and neral). The experimental studies demonstrated that the basil oil has antibacterial activity against *Staphylococcus aureus, Salmonella enteritidis, Escherichia coli, Proteus vulgaris, Bacillus subtilis, Salmonella typhi, Shigella sonnei, S. bodyii, Pseudomonas aeruginosa* and *Salmonella paratyphi* [8].

Sage, *Salvia officinalis* (*Lamiaceae* family) is a perennial low shrub native of the Mediterranean region and its family reported to comprise more than 900 species. Sage essential oil is also effective against several bacteria, including *Listeria monocytogenes, Bacillus cereus, Bacillus subtilis, Escherichia coli* and *Staphylococcus aureus*, all recognized foodborne pathogens.

Anethum graveolens L. or dill, (*Apiaceae*) family, is an annual aromatic herb known for culinary and medicinal use since ancient times. The typical flavour of herb dill oil is due to α-phellandrene, limonene and dill ether (anethofuran) [9].

The genus *Mentha* belongs to the *Lamiaceae* family and includes a large number of herbaceous species. The composition of the essential oil varies a lot among the varieties, during the year and at different stages of its development, but is mainly composed of monoterpenes as menthol (70% -90%), which is the major substance [5].

Oregano essential oils have been shown to possess antioxidant, antibacterial, antifungal, diaphoretic, carminative, antispasmodic and analgesic activities and, among these, the antimicrobial potential is of special interest. In recent years, a large number of researches have reported the efficacy of essential oils from several *Origanum* species against a panel of bacterial strains, and The authors identified carvacrol as the main responsible for this biological activity [1].

2. METHODOLOGY

Microorganisms were obtained from the Department of Biotechnical Systems, Faculty of Biotechnical Systems Engineering, “Politechnica” University of Bucharest. Four strains of bacteria (*Escherichia coli* ATCC 8378, *Staphylococcus aureus* ATCC 6538, *Pseudomonas aeruginosa* ATCC 9027 and *Salmonella enteritidis* ATCC 13076) were used. The cultures of microorganisms were maintained in appropriate nutritive agar slants at 4ºC throughout the study. They were used as stock cultures for the preparation of the 24 - 48 hours old cultures intended for the inoculation of Petri dishes. The essential oils are produced by SOLARIS company and are purchased from the market.

The used culture medium was Plate Count Agar from Oxoid.

The agar was seeded with 0.1 ml cell suspension (approximately 10^7 CFU/ml) that was spread on the medium surface.

Wells of 6 mm in diameter were cut and the essential oils were added. The plates were then incubated at 37ºC for 24 hours. The antimicrobial activity was assayed by measuring the diameter of the inhibition zones formed around the well. Each plate had 3 wells containing: 5 microliters of oil and 25 microliters of water in the first well, 10 microliters of oil and 20 microliters of water in the second well and 15 microliters of oil and 15 microliters of water in the third one.

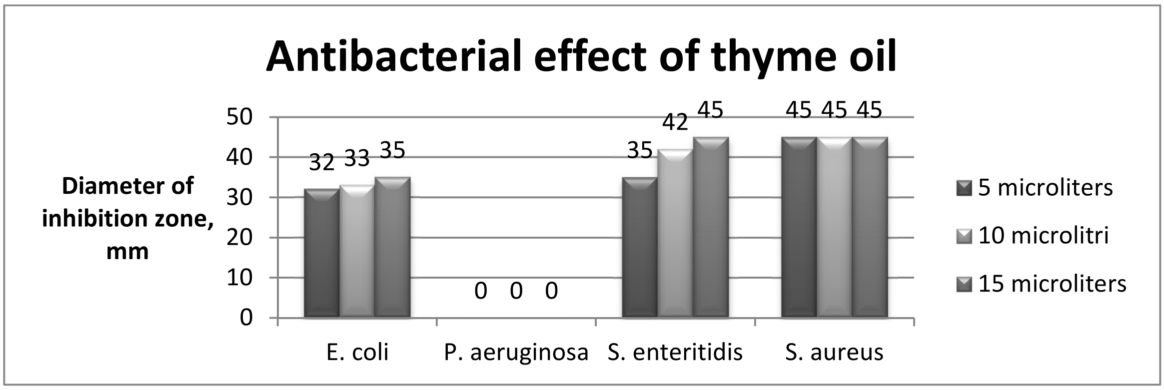
For each bacterial strain a control plate with a well containing 30 μg chloramphenicol (15 microliters of 2 mg/ml chloramphenicol solution) was prepared. Studies were performed in triplicate, and mean value was calculated.

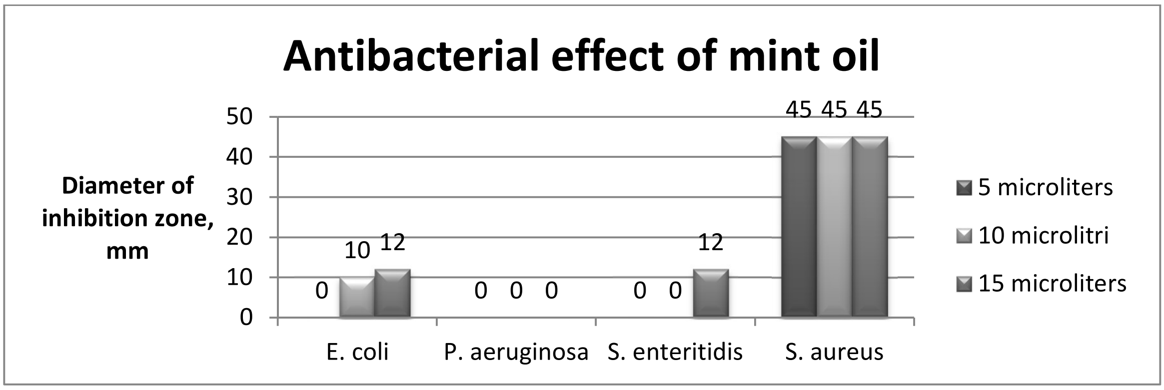
3. RESULTS AND DISCUSSION

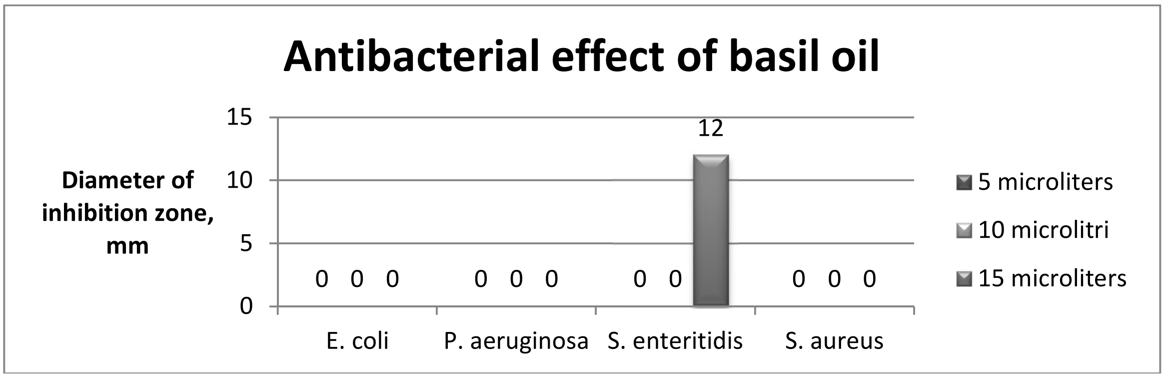
The antibacterial effect of essential oils was highlighted using four bacterial strains, responsible for food and water contamination and possible pathogens, producing of toxins which cause ilness. The action of essential oils was different for the selected bacteria. In figures 1 and 2 the diameters of inhibition zones depend on the type of oil, the added volume, and the bacterial strain. The most resistant species was *Pseudomonas aeruginosa* which was only partially inhibited by mint and oregano oils when 15 microliters were added in the well. *Staphilococcus aureus* and *Salmonella enteritidis* were the most sensitive microorganisms. *S. aureus* was total inhibited by mint, oregano and thyme. For *S. enteritidis* a maximum inhibition zone was recorded for thyme and oregano. The sage and basil oils had the lowest action against the bacterial strains, being effective only against *S. aureus* and *S. enteritidis* for 15 microliters added in the wells, when the inhibition zone had 12 millimeters in diameter.

The most effective oils were thyme and oregano which inhibited the growth of *E. coli, S. enteritidis* and *S. aureus* but not *P. aeruginosa*.

For all bacterial strains, the inhibitory effect was compared with chloramphenicol (30 μg). The oregano and thyme oils have similar action with chloramphenicol against *E. coli* and *S. enteritidis*, higher effect against *S. aureus*, but lower effect against *P. aeruginosa*.







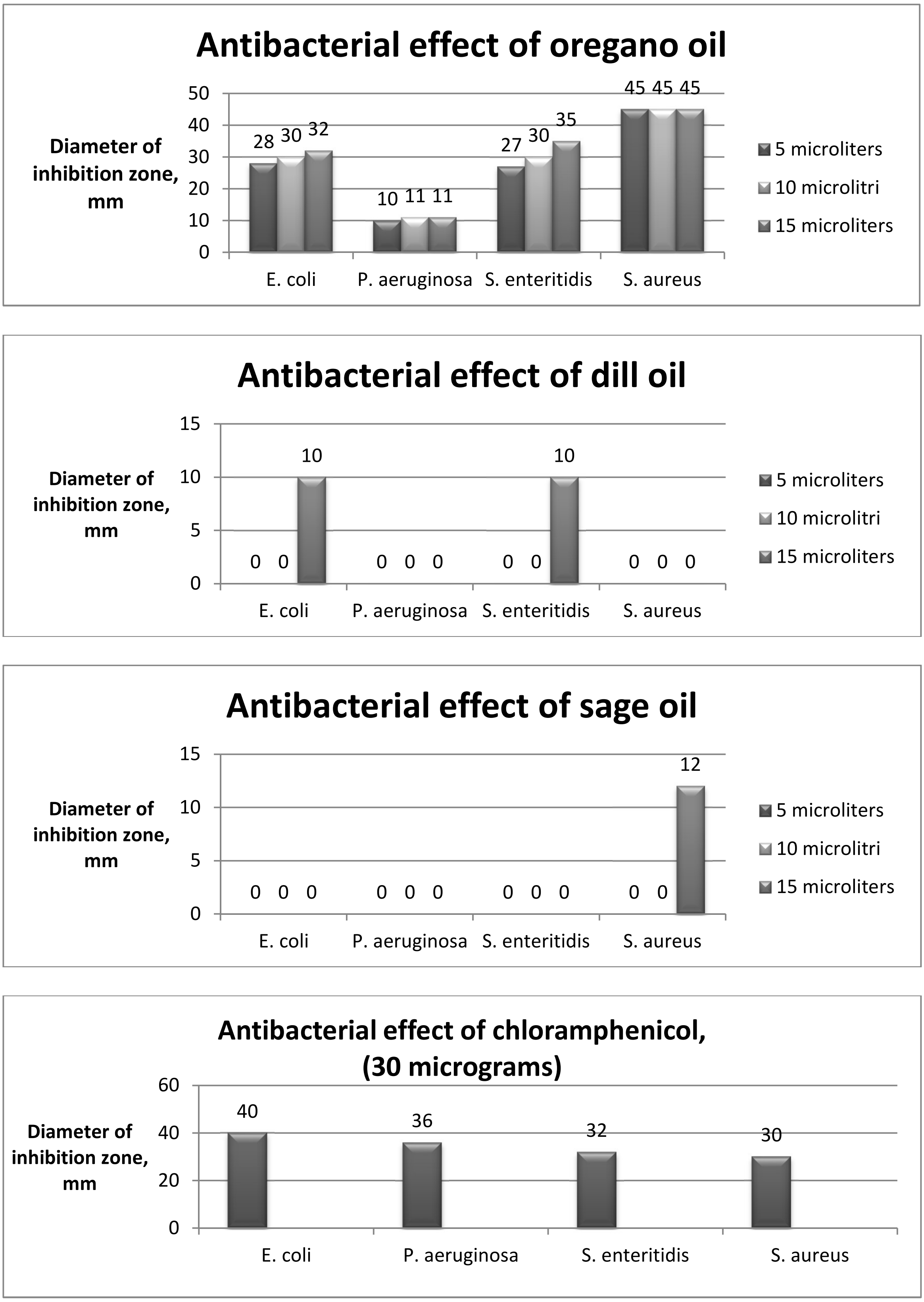
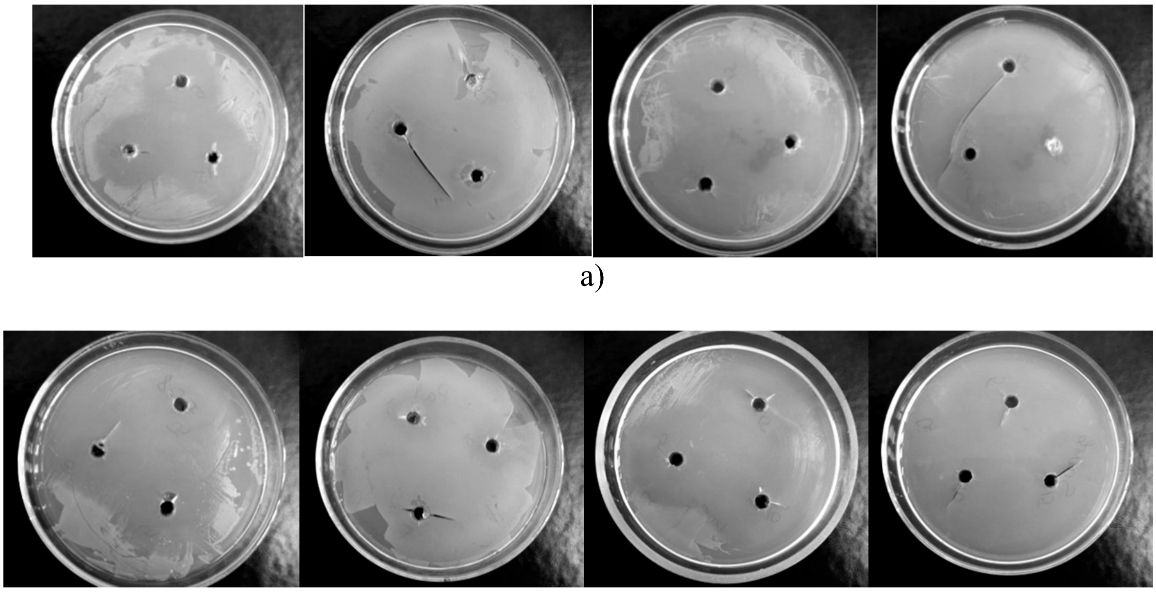


Figure 1: Antibacterial effect of essential oils and chloramphenicol against *E. coli, P. aeruginosa, S. enteritidis, S. aureus*

The results illustrated in figure 2 showed that the essential oils possessed different antimicrobial activity. Compared with 30 micrograms chloramphenicol, the oils of mint, basil, dill and sage have a lower effect against all the pathogens. The oregano and thyme oils produced the largest inhibition zones in the cultures of *E. coli, P. aeruginosa, S. enteritidis, S. aureus* when 5, 10, 15 microliters are added in the wells.

Dusan et al. (2006) reported, similar to the present study that the antimicrobial activity of essential oils of *Origanum vulgare* L., *Thymus vulgaris* L., *Syzygium aromaticum* L. and *Cinnamomum zeylanicum* against *E. coli* was dose dependent. The oils of thyme and sage showed the most effectiveness and widest activity spectrum against tested microorganisms (*E. coli*, *L. monocytogenes*, *S. aureus* and *C. albicans*). The authors established that essential oils of thyme, sage, lavender, peppermint, rosemary, sweet basil, lemon balm and oregano of different Lamiaceae species had antibacterial effects both on Gram positive (*Staphylococcus aureus*) and Gram negative bacteria (*Escherichia coli, Salmonella enteritidis* and *Pseudomonas aeruginosa*) [8].



a)

b)

Figure 2: Aspect of inhibition zones for a) oregano oil against *E. coli, P. aeruginosa, S. enteritidis, S. aureus* and b) thyme oil against *E. coli, P. aeruginosa, S. enteritidis, S. aureus*

4. CONCLUSIONS

The inhibitory action of essential oils of thyme, mint, basil, dill, sage and oregano has been evaluated against four bacterial strain: *Escherichia coli* ATCC 8378, *Staphylococcus aureus* ATCC 6538, *Pseudomonas aeruginosa* ATCC 9027 and *Salmonella enteritidis* ATCC 13076. The essential oils exhibited different effects on bacterial 24-days old cultures using well-diffusion method.

The study demonstrates that the effect of essential oils varies depending on the amount of sample and the microbial strain. The diameters of inhibition zones are ranging between 0 and 45 millimeters and show different levels of inhibition for 5 µl, 10 µl and 15 µl essential oils added in the culture medium wells. The effectiveness of essential oils was compared with 30 micrograms of chloramphenicol added in the wells.

The essential oils exerted varying levels of antimicrobial effects against microorganisms. Oregano oil at all concentrations inhibited microorganisms. Thyme oil inhibited the growth of *E. coli, S. aureus, S. enteritidis but not P. aeruginosa*. The sage and basil oils sowed the lowest inhibitory effect against the tested bacterial strains.

This study is in agreement with the work of several researchers which found that the essential oil of oregano and thyme were some of the most effective antimicrobial essential oils.

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EXPERIMENTAL RESEARCH ON VARIOUS TYPES OF BIOMASS PELLETS

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ABSTRACT

Due to the inevitable depletion of fossil fuels and the increased energy requirements caused by the rapid growth of the population in the last 50 years, it was necessary to find alternative sources of energy. One of the most important alternative sources of energy is biomass (wood, straws, sawdust, husk, branches, etc.). The main disadvantage of raw biomass is that it has very low density, which leads to difficulties in the process of handling, transport, storage. These drawbacks can be improved by compacting (densifying) biomass at very high pressures, thus obtaining solid biofuels with a uniform structure and humidity, such as pellets. The paper presents a series of experimental researches conducted on several types of compacted biomass in the form of pellets, to assess the possibility to efficiently use secondary products from agriculture (husk, cobs, straws, even alfalfa and rapeseed that are unsuitable for animal consumption) to produce high quality biofuels.

1. INTRODUCTION

The main resource of alternative energy exploitable in Romania is biomass, whose potential for recovery is found in a wide range of categories of resources such as: forestry wood, agricultural and animal waste (especially manure), residues from crops and trees, municipal waste and energy crops. [3, 6]

Currently, only some of these residues are used as an alternative energy source. For example, in a household, where at an average per year are available about 3,000 kg. of biomass, it is used mainly as animal feed or is abandoned or burned in the field. This amount of biomass could serve as raw material for the production of solid fuels such as pellets. [2, 4]

The chemical composition of biomass can be differentiated in several types. Usually, plants contain 25% lignin and 75% carbohydrates (cellulose and hemicelluloses) or sugars. Lignin appears in plants as something similar to glue, binding the cellulosic molecules between themselves. The energy stored in biomass (fig. 1) can be released through various methods, which, in the end, represent the chemical process of burning (chemical transformation in the presence of molecular oxygen, an exergonic process) [1].

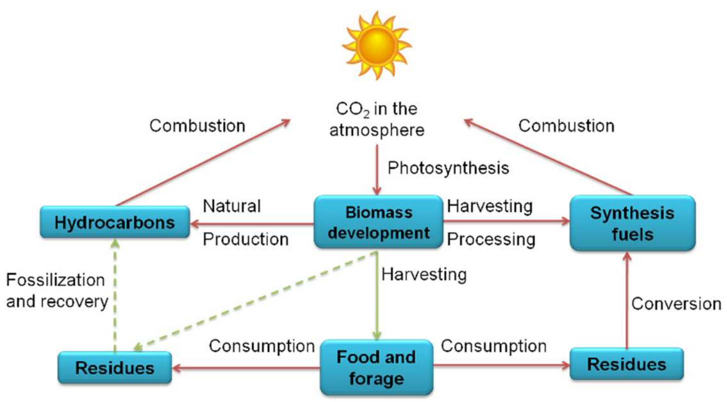

Figure 1: The circuit of energy from biomass [3]

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The main advantages of biomass densification are:

- Increasing the density of the compressed material (from 80-150 kg/m^3 for straws or 200 kg/m^3 for sawdust to up to 600-700 kg/m^3 for final products);
- A higher calorific value and a homogeneous structure of compressed products;
- A low humidity (below 10%).

Pellets represent the biofuel produced from wood waste, agricultural waste, etc. They are standard cylindrical granules of sizes ranging between Ø-5-8 mm (sometimes up to 30 mm with variable length approx. 50 mm). They have increased mechanical resistance and good burning characteristics. Pelletizing process consists in the fact that grinded biomass passes through small orifices (holes) in a special die. Pellets are used most often when it is necessary to automate the process of boiler feed.[4, 5, 7]

2. METHODOLOGY

The pellets analysed in this article (figure 2) were produced using the same pellet mill with the same die diameter (6 mm) and were stored for the same period of time (60 days) in the same environmental conditions (in closed cardboard boxes, at a constant temperature of around 18-20 ºC). Pellets were produced with raw material having the same particle sizes, except for dust pellets, those being produced using the dust that was collected from the production and storage of the other types of pellets.

Figure 2: Sample of the pellets analysed

The first analysis was represented by a visual inspection on each of the pellet types (fig. 3) (surface characteristics, length) and an assessment of the quantity of pellet dust resulting from handling.

It was found that pellets produced from deprecated corn husk, dust and the ones from corn cobs produced the most dust during storage and handling, indicating that they are not suitable for long term storage. Also, the same types of pellets showed the most cracks (possible rupture points) and the most uneven surface.

The best quality in terms of surface characteristics was found in pellets produced from alfalfa, straws and corn husk. They presented a very smooth surface, with no cracks, a good length, very good resistance in time and also from these pellets has resulted the smallest quantity of dust.

Another aspect noticed was that pellets from corn cobs and from alfalfa + straws had the tendency to expand and to break after they were produced.

a b c d e f g h

Figure 3 – Close up of the pellets analysed to observe surface characteristics
a) corn husk; b) alfalfa; c) straws; d) rapeseed; e) corn cobs; f) deprecated husk; g) alfalfa + straws; h – mix

The second and most important analysis concerned most important quality indexes for biomass pellets aimed to be used as solid biofuel. The main quality parameters of the pellets analyzed ware determined using the following laboratory equipment:

The results from pellet analysis are shown in table 2 and their values compared in figure 4.

Table 1: Equipment used for tests

Name/type	Measuring range / Precision	Series
High precision weighing apparatus /AW 220, with self-calibration	0÷200 g / 0.1 mg	D440100161
Oven with temperature control /MEMMERT-UFE 500	0÷260 ºC / 1 ºC	G 507.1422
Calorimeter /CAL 2k;	0.001 Mj/kg	04-15/11-06/063

Table 2: Results from the analysis conducted on pellets

Sample	Sample type	Moisture, M [%]	Lower calorific value, q_i [Mj/kg]	Ash content [%]
1.	Corn husk	10.88	15.455	9.36
2.	Alfalfa	7.67	18.311	3.42
3.	Straws	9.81	16.545	6.88
4.	Rapeseed	10.30	16.549	7.57
5.	Corn cobs	10.81	18.220	2.49
6.	Dust	19.74	-	-
7.	Deprecated corn husk	9.29	13.867	14.39
8.	Alfalfa + straws	13.73	15.938	3.98
9.	Mix: rapeseed + straws + alfalfa + husk + cobs	11.50	16.258	4.13

After analysing the most important quality characteristics of pellets, it was found that:

- The smallest moisture content was calculated for alfalfa pellets, combined a low percentage of ash (unburned combustible substance) and the highest calorific value;
- Pellets from dust did not ignite in the bomb calorimeter, although the test was repeated 3 times, with one of the samples dried in the oven in order to decrease moisture. This shows that this of pellets did not have enough volatile substances, components that initiate the combustion process;
- The highest ash content was registered for pellets from deprecated corn husk, along with smallest calorific value, making this type o pellets inefficient to be used as fuel, because they can damage the installations where they would be used, due to the high share of residues that remains after combustion;

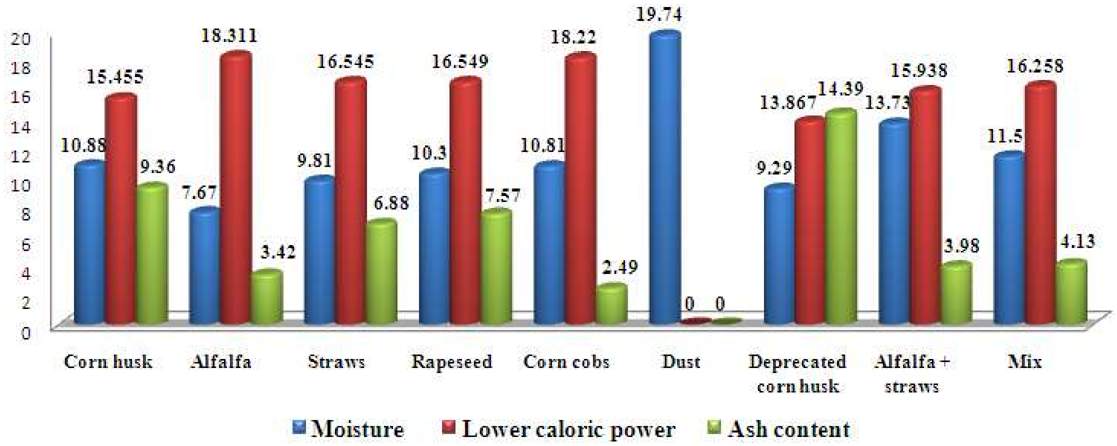

Figure 4: Comparison between the results of pellets from various types of biomass

4. CONCLUSIONS

Nowadays, in order to increase the density of solid biomass fuels and to allow the automation of the burning process, biomass is transformed into pellets or other types of solid biofuels.

Densification is critical for the production of dense material with good flow qualities, uniform, with improved handling, answering to the predetermined specifications based on the constraints of the supply system and of the conversion technologies, with low cost for storage, handling, transport and logistics.

Every year, a very important quantity of biomass is wasted, especially the one represented by secondary products in agriculture and by animal feed that is no longer suitable.

The present article showed that it is possible to use these types of biomass to produce pellets and use them as solid biofuels, some of the pellets analysed in this paper showing characteristics comparable to those of pellets produced from wood sawdust.

ACKNOWLEDGMENT

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THE BENEFITS OF USING FILMS FOR SOIL MULCHING

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ABSTRACT

In this review are presented advantages and disadvantages about films used in mulch, the main improvements properties of the soli and crops. Using biodegradable films at the expense of polyethylene help to improve the wellfare of plants and human lives. Decreased poisoning the soil and air, reducing greenhouse emissions by eliminating some stages to maintenance of cultures and reducing the effort of gatherin the film because it's decompose.

1. INTRODUCTION

Food security is challenged by increasing global population, climate change, and resource shortages [1,2]. In particular, severe water scarcity occurs in 45% of the global land resources [3].

Mulching the soil is a new and efficient way to create a healthy environment for plants. Mulch is actually a cover layer of soil from the sun, erosion and drying. This is represented by any material which is applied to the soil surface, the result is modification of the microclimate in particular on the surface or in the first centimeters of the soil.

Depending on the material used and the time of year, mulching prevents weed growth, reduce the loss of soil moisture, reduce fertilizer washing, keeps a constant temperature reduces the risk of pests and diseases. Also mulch increases productivity, and improves the quality of most crops.

Materials that are used for mulching can be classified into organic and synthetic materials. The first mulching was realize with organic type of straw, grass, leaves. It has been prove that the most effective organic mulch materials are wheat straw, hay and chaff. Organic mulch have the following advantages: keeping soil moisture, adding organic matter in soils after harvest and incorporation. The major disadvantages are reduced heating organic mulching the soil when applied too early, the need to fertilizer with nitrogen to compensate decomposition of vegetal material. In addition to this, the application of organic mulch requires a considerable amount of work.

The advantage of mulching film is the duration of its life. This attribute can be a problem at the end of its use, as the need for collecting and recycling them. The biggest problem with mulching film is its removal from cultivated land at the end of the season. Polyethylene mulch film does not decompose. The processing of mulching film along with the land is an environmental hazard and over time will degrade the quality of land. Biodegradable films have a limited lifespan and can be processed along with the land. Using biodegradable mulch film, removing it from the cultivated land at the end of the season, it is no longer necessary. The film is completely biodegrade in the soil. At the end of the disintegration process, the film is an integrated part of the soil without damage to its quality.

2. METHODOLOGY

This paper reviews a limited academic literature and many sites of companies producing films and equipments for mulching.

First review is about an experiment who was performed in 2014 and 2015. Soil temperature to 5 cm depth in the early crop growth stage, crop growth, crop yield, and water use of different treatments (plastic film-mulched raised bed (RF) and flat field without plastic film mulching (CK) in 2014; RF, plastic film-mulched flat field (FF), and CK in 2015) they measured or calculated and compared. Soil temperature in the film-mulched treatments was consistently higher than that in CK (1.6–3.5ºC in average) during the early growth stage. Crops in plastic film-mulched treatments used 214 fewer growing-degree days (GDDs) in 2014 and 262 fewer GDDs in 2015. In 2014, the RF treatment yielded 32.7% higher biomass than CK, although its 9.4% higher grain yield was not statistically significant. Also, RF used 17.9% less water and showed 33.1% higher water use efficiency (WUE) than CK. In 2015, RF and FF showed 56.2% and 49.5% higher yield, 15.0% and 4.5% lower water use (ET), and 63.4% and 75.7% higher WUE, respectively, than CK (Table 3). RF markedly increased soil temperature in the early crop season, accelerated crop growth, reduced ET, and greatly increased crop yield and WUE. Compared with FF, RF had no obvious effect on crop growth rate, although soil temperature during the period between sowing and stem elongation was slightly increased. However, RF resulted in lower ET and higher WUE than FF [4].

Plastic film mulching increases air and soil temperatures below the mulch and reduces evaporation from soil [8].

Transparent film allows solar radiation to reach the soil surface with little reflection [9], and water droplets attached to the inner side of the film together with higher air moisture content beneath the film impede the escape of long-wave radiation from the soil to the open air, thereby delaying soil temperature decrease after sunset. Those effects are greater when temperature is low in a growing season [6,10].

Plastic film mulching had the greatest effect on conserving soil water at the early crop growth stage, and the earlier the greater. The biomass WUE of film-mulched maize crop could be 5.61–7.67 times that in the open field before stem elongation. There was no appreciable difference in ET, but mulched crops maintain higher biomass WUE after stem elongation. Plastic film mulching improved crop nitrogen uptake and increased apparent nitrogen recovery rate and output/input ratio [5,7].

In another experiment, also in China, make an experience about influence of colored light-quality selective plastic films (red, yellow, green, blue, and white) on the content of anthocyanin, the activities of the related enzymes and the transcripts of the flavonoid gene was studied in developing strawberry fruit. The results indicated that colored films had highly significant effects on the total anthocyanin content (TAC) and proportions of individual anthocyanins. Compared with the white control film, the red and yellow films led to the significant increase of TAC, while the green and blue films caused a decrease of TAC. Colored film treatments also significantly affected the related enzyme activity and the expression of structural genes and transcription factor genes, which suggested that the enhancement of TAC by the red and yellow films might have resulted from the activation of related enzymes and transcription factor genes in the flavonoid pathway. Treatment with red and yellow light-quality selective plastic films might be useful as a supplemental cultivation practice for enhancing the anthocyanin content in developing strawberry fruit.

Anthocyanins are major pigments found in many plants and, combined with carotenoids or chlorophylls, are responsible for the red, purple, and blue coloration of some fruits, leaves, and seeds. In addition to their colorant properties, anthocyanins contribute to a wide range of biological activities, exhibiting anticancer, anti-inflammatory, antioxidant, pharmacological, and chemoprotective effects. Because anthocyanins are one of the principle bioactive components of strawberries, food scientists have conducted comprehensive analyses to quantify and characterize them. The anthocyanins and flavonoid biosynthetic pathway has been extensively elucidated in strawberry at the genetic, biochemical and molecular levels [11,12,13]. The key structural enzymes, such as phenylalanine ammonia-lyase (PAL), cinnamate-4-hydroxylase (C4H), 4-coumarate: -CoA ligase (4CL), chalcone isomerase (CHI), chalcone synthase (CHS) and anthocyanidin synthase (ANS), leading to different intermediates and different flavonoid classes are well known [14].

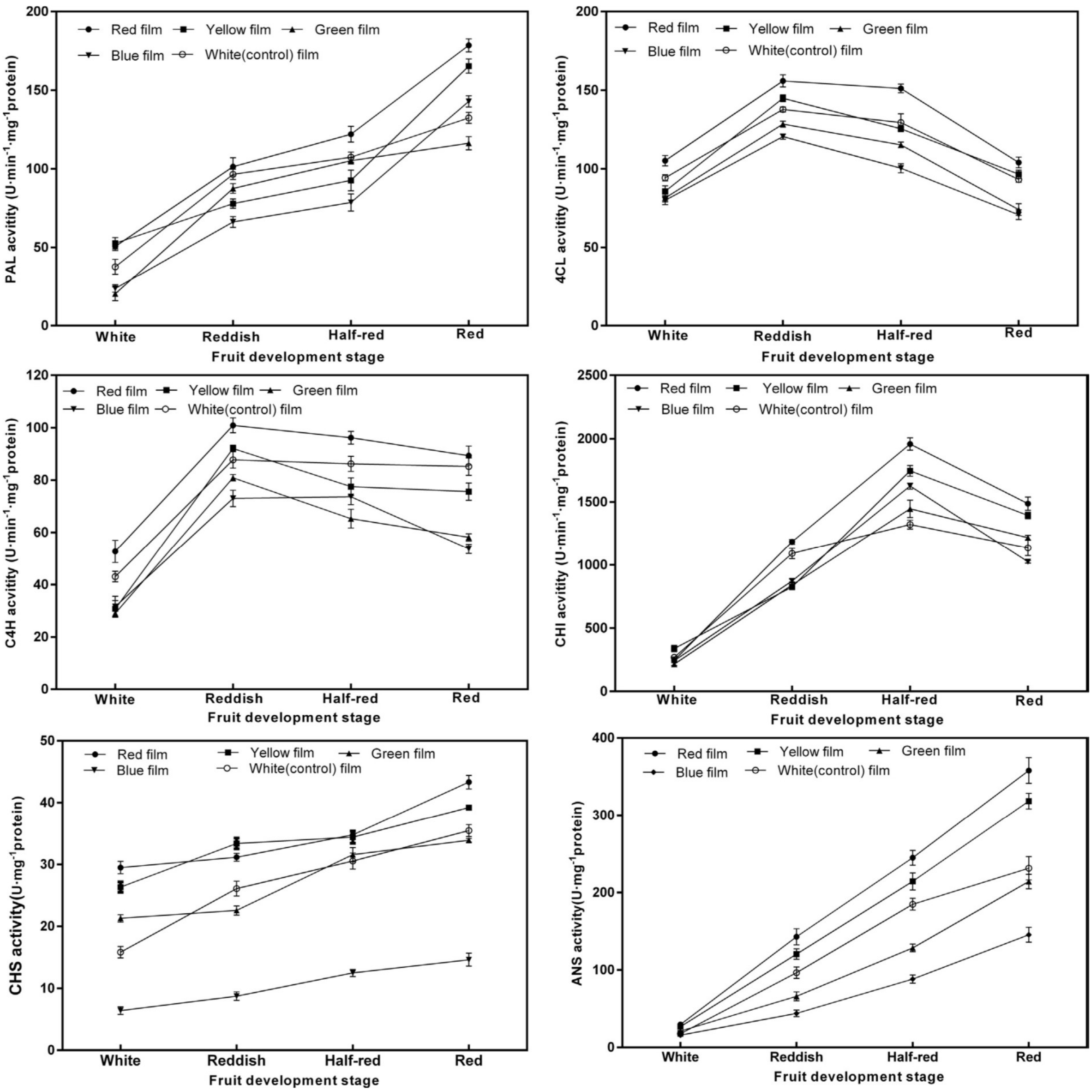

Fig.1. The effect of red, yellow, green, blue, and white (as the control) film treatments on PAL, C4H, 4CL, CHI, CHS and ANS activity in strawberries during fruit development. Each value is shown by means ± standard deviation SD. Vertical bars represent the SD of the means.[15]

While in America, a company developed an equipment with specifical films and make some experience about this films. The machine sows the seed under a degradable film, creating a green house effect. It keeps the young seedlings in a warm, humid environment for up to 4 - 6 weeks. The plants are protected from cold temperatures and the risk of soil capping during the first month. All films have ventilation systems (Fig.2). It limits high temperatures under the film during warm spring days. The film degrades with UV energy and temperature to allow the film to be broken down and eaten by the micro organisms in the soils.

When the maize plant is developed, it comes through the film and continues growing. During the stage of plant growth where the plant touches the film, the root system is developing more rapidly and deeper to sustain the plant in the later growth stage.

Fig.2. Ventilation systems from films [16]

Through this process, earlier planting is possible. There is no need to wait until the optimum soil temperature is reached. As soon as the soil is dry, you can start to prepare the seed bed. The system makes it possible to grow maize corn in areas where the crop cannot be grown traditionally. In warmer areas, varieties with more genetic potential can be chosen to increase yield at harvest time.

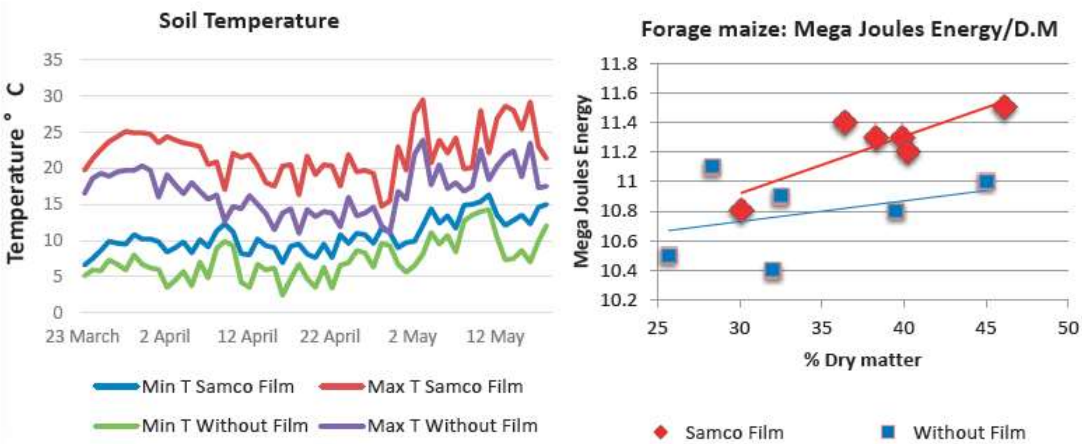

Fig.3. Differences between seeding with films and without film [16]

To avoid overheating of the young plant under the film, a firm has developed and patented three aeration systems (Fig.4). These are placed on the crop rows reducing the risk of extreme temperatures under the film, and also helping the plants to break through the film.

Fig.4 Aeration systems of different films [16]
a) Pin Hole b) MD Slots c) TD Slots

Pin Hole is a pin perforation of the film just above the rows of maize. This system traps the maximum amount of heat under the film. It is suitable for early sowing in all the geographical areas where the outside temperatures do not exceed 25°C during the firsts weeks after sowing. The pin hole is the type of ventilation that keeps the plant under the film longer but it depends on the type of film used.

To MD Slots, aeration is ensured by many small slots, 2 cm in size above the planted maize. The slots allow more air circulation around the plant at the early stages. It is suitable for all seedlings in he geographical areas where the outside temperatures do not exceed 30°C during the first weeks after sowing.

The last, TD Slots Aeration is provided by slots 9 cm in length above the planted rows. Sustained ventilation around the plant is assured due to the large movement of air. It is suitable for all late planting where the risk of frost is minimal. The plant breaks through the TD type film much easier than MD and Pin Hole. The greenhouse effect can reduce evaporation and maintain a higher temperature in the soil.

At the end of the season, the film has degraded, allowing clear soil for the next crop.

3. CONCLUSIONS

In the last 23 years, the area under maize has remained relatively constant at a value of about 3-3.4 million hectares. As we know this culture requires at least two hoeing which often is done by hand, no mechanized, requiring a large number of people, high cost and time.

In this regard any solution that reduces or eliminates the costs and consumption of materials having a polluting effect on the environment is a forward direction when the maize crop and other row crops.

The primary advantage of this system culture is to provide soil heating 3-4 ° C to a depth of 10 cm, which allows a explosive germination. Also, by mulching with plastic degradable, keep the soil moist longer by preventing evaporation and combating weeds. In zone with good climates for corn growth, the system allows early sowing varieties productive. Sowing begins in late March / early April. The advantage is significant, yields greater than 12 tonnes / ha, and the advance in vegetation front of a witness is particularly.

ACKNOWLEDGMENT

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MATHEMATICAL MODELING OF OIL EXTRACTION PROCESS BY DIMENSIONAL ANALYSIS

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ABSTRACT

Vegetable oil industry is one of the most important industries in the world, due to the large number of uses of vegetable oil in different fields. Thus, the vegetable oil obtaining from oilseeds, it is a very important operation in the industry. The most common methods of obtaining oil are mechanical pressing and solvent extraction, from which the mechanical pressing operation presenting several important advantages. This led to intensive study of pressing process and more specifically to the study of factors that influence the efficiency of the press, characterized in especially by the recovered oil from the oleaginous material. In this study it is presented a mathematical model of oil extraction process using a screw press obtained by dimensional analysis. The mathematical model it is validated by the experimental data obtained at sunflower seeds pressing with a screw press, using regression analysis.

1. INTRODUCTION

Oil products industry produces edible and inedible oils. About 2/3 of total oil products are the edible oils, which are used directly in foods or in the manufacture of margarine, mayonnaise, bakery and pastry products, cooking fats, preserves etc. The remaining 1/3 of the total volume of produced oil are the technical oils, used in the production of various products, such as: detergents, paint, glycerin, fatty acids, varnish, pharmaceuticals or cosmetics, [5].

The raw materials for vegetable oils industry are the oilseeds which represent an important component of modern agriculture. There are a wide range of raw materials for oils industry. In the vegetable reign are more than 100 oleaginous plants, but only 40 of them can be are used for oil expression. The other plants are unprofitable, as they have low oil content in their seeds or as they require a difficult expression process. The most important oleaginous plants are: sunflower, soya, rape, cotton, poppy, almond, sesame, nut, palm, coconut, olive, flax, castor, [1].

For the oil obtaining from oleaginous seeds, there are two important methods that can be applied: expression and extraction. Expression is the process of mechanically pressing liquid out of liquid containing solids whereas extraction refers to the process of separating a liquid from a liquid-solid system, [2,7]. There are several types of machine commonly used in mechanical pressing method, i.e. hydraulic press machine and screw press machine. Hydraulic press machine is classified as batch mechanical pressing machine while screw press machine is considered as continuous pressing machine, [10]. One of the oldest and most popular methods of the oil production in the world is considered to be the mechanical expression of oil from the seeds using a screw press, [9]. The use of mechanical oil expellers presents several important advantages, that determine the popularity of this method: the equipment is simple and sturdy in construction, can easily be maintained and operated by semi-skilled supervisors, can be adapted

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quickly for processing of different kinds of oilseeds, the oil expulsion process is continuous with product obtained within a few minutes of start of the processing operation, [11]. Also, using the mechanical pressing it is obtained a chemical free protein rich cake, unlike the solvent extraction method, [3,12]. The disadvantage of the mechanical screw pressing method is that it is recovered about 86-92% of oil from oilseeds, [12]. Mechanical screw-press performance, characterized by the oil recovery, for a given oilseed, depends on the preparation method of the raw material, which consists of a number of unit operations [13,16,4] and on the operating parameters of the pressing machine, [6,4].

2. METHODOLOGY

At the study of oleaginous materials pressing process the dimensional analysis theory was applied, for mathematical modeling of this process, in order to anticipate the oil flow extracted from oleaginous material when using mechanical screw presses. From the dimensional analysis theory, the π theorem, set by Buckingham, was applied, [14,15].

From the theoretical and experimental research of oil pressing process of the oleaginous materials by mechanical screw presses, were considered in the study a number of 7 main parameters that influence the pressing process: material feed rate, Q_a (kg/s); the moisture content of the material, u (%); the shelling degree of the material, q_c (%); the chamber press temperature, θ (°C); the screw speed, n (s^{-1}); the diameter of the nozzle for cake discharge, d (m); the pressure from the pressing chamber, p (Pa). The pressing process efficiency is assessed by the extracted oil flow, Q_u (kg/s), [4].

The default function that dimensionally describes pressing process, where all the terms in relation to fundamental SI units (L, M, T) are dimensionally homogeneous is:

$$f(Q_u, Q_a, p, d, n, u, q_c, \theta) = 0 \tag{1}$$

Considering as determinant units the group (Q_a, p, n), based on π theorem, it will be determined dimensionless complexes (similarity criteria) of the pressing process. Dimensionless units u, q_c, θ are entered directly in the criteria equation, without being taken into account in drafting the dimensionless complexes. For the physical units Q_u and d dimensionless complex will be developed:

$$\pi_1 = \frac{Q_u}{Q_a^{x_1} \cdot p^{x_2} \cdot n^{x_3}} \quad \text{and} \quad \pi_2 = \frac{d}{Q_a^{x'_1} \cdot p^{x'_2} \cdot n^{x'_3}} \tag{2}$$

where the exponents x_1, x_2, x_3 și x'_1, x'_2, x'_3 can be determined from the conditions that π_1 and π_2 to be dimensionless, in relation to the fundamental units L (length), M (mass), T (time).

Dimensional matrix of the 5 units in relation to fundamental units L, M and T is given below:

	x_1	x_2	x_3		
	Q_a	p	n	Q_u	d
L	0	-1	0	0	1
M	1	1	0	1	0
T	-1	-2	-1	-1	0

By putting the condition that π_1 is dimensionless, relative to the three fundamental units L, M, T, was obtained from the above matrix, the following system of linear equations:

$$\begin{cases} -x_2 = 0 \\ x_1 + x_2 = 1 \\ -x_1 - 2x_2 - x_3 = -1 \end{cases} \quad (3)$$

By solving the system, have been found the solutions: $x_1=1$, $x_2=0$, $x_3=0$, thus resulting the expression of the dimensionless complex π_1:

$$\pi_1 = \frac{Q_u}{Q_a^1 \cdot p^0 \cdot n^0} = \frac{Q_u}{Q_a} \quad (4)$$

Using the same procedure, was put the condition that π_2 to be dimensionless, relative to the three fundamental quantities L, M, T and was obtained from the above matrix, the following system of linear equations:

$$\begin{cases} -x_2 = 1 \\ x_1 + x_2 = 0 \\ -x_1 - 2x_2 - x_3 = 0 \end{cases} \quad (5)$$

By solving the system, was found the solutions: $x_1' = 1, x_2' = -1, x_3' = 1$, and then the π_2 dimensionless complex expression:

$$\pi_2 = \frac{d}{Q_a^1 \cdot p^{-1} \cdot n^1} = \frac{d \cdot p}{Q_a \cdot n} \quad (6)$$

With these dimensionless units, the criteria equation was obtained in the implicit form, namely:

$$\varphi\left(\frac{Q_u}{Q_a}, \frac{d \cdot p}{Q_a \cdot n}, u, q_c, \theta\right) = 0 \quad (7)$$

To determine the extracted oil flow equation at the pressing process using a screw press, it was separated the Q_u term from the criteria equation and was obtained:

$$\frac{Q_u}{Q_a} = \varphi_1\left(\frac{d \cdot p}{Q_a \cdot n}, u, q_c, \theta\right) \quad (8)$$

$$Q_u = Q_a \cdot \varphi_1\left(\frac{d \cdot p}{Q_a \cdot n}, u, q_c, \theta\right) \quad (9)$$

To a first approximation it was proposed the mathematical model of the powers product of the other dimensionless units, namely:

$$Q_u = k^* \cdot Q_a \cdot \left(\frac{d \cdot p}{Q_a \cdot n}\right)^{\alpha_1} \cdot u^{\alpha_2} \cdot {q_c}^{\alpha_3} \cdot \theta^{\alpha_4} \quad (10)$$

where: k^*, α_1, α_2, α_3, α_4 are constant coefficients, respectively exponents calculated by linear regression based on experimental data. Disregarding, in certain circumstances, of the last three factors, can be written:

$$Q_u = k \cdot Q_a \cdot \left(\frac{d \cdot p}{Q_a \cdot n}\right)^{\alpha_1} = k \cdot \frac{Q_a}{Q_a^{\alpha_1}} \cdot \left(\frac{d \cdot p}{n}\right)^{\alpha_1} = k \cdot Q_a^{1-\alpha_1} \cdot \left(\frac{d \cdot p}{n}\right)^{\alpha_1} \quad (11)$$

$$Q_u = k \cdot Q_a^{1-\alpha_1} \cdot \left(\frac{d \cdot p}{n}\right)^{\alpha_1} \tag{12}$$

For $\frac{d \cdot p}{n} = const.$ and $Q_a \neq const. \Rightarrow$

$$Q_u^* = k_1 \cdot Q_a^{*(1-\alpha_1')} \cdot \left(\frac{d \cdot p}{n}\right)^{\alpha_1'} \tag{13}$$

By making the notation $\frac{d \cdot p}{n} = A$ (constant), the relation becomes:

$$Q_u^* = k_1 \cdot Q_a^{*(1-\alpha_1')} \cdot A^{\alpha_1'} = \left(k_1 \cdot A^{\alpha_1'}\right) \cdot Q_a^{*(1-\alpha_1')} \tag{14}$$

Further, with the notation $k_1 \cdot A^{\alpha_1'} = A^*$, it will be obtained:

$$Q_u^* = A^* \cdot Q_a^{*(1-\alpha_1')} \tag{15}$$

For $Q_a = const.$ and $\frac{d \cdot p}{n} \neq const$, it results:

$$Q_u^{**} = k_2 \cdot Q_a^{(1-\alpha_1'')} \cdot \left(\frac{d \cdot p}{n}\right)^{\alpha_1''} \tag{16}$$

$$Q_u = a \cdot Q_a^{(1-b)} \cdot d^b \cdot \left(\frac{p}{n}\right)^b \tag{17}$$

where $\left(\frac{p}{n}\right)^b = const.$

In the thesis [8], experimental determinations were made with a screw press PU-50, whose speed is 1.453 rot/s, using different diameters of the nozzle for cake outlet, between 8 and 10 mm.

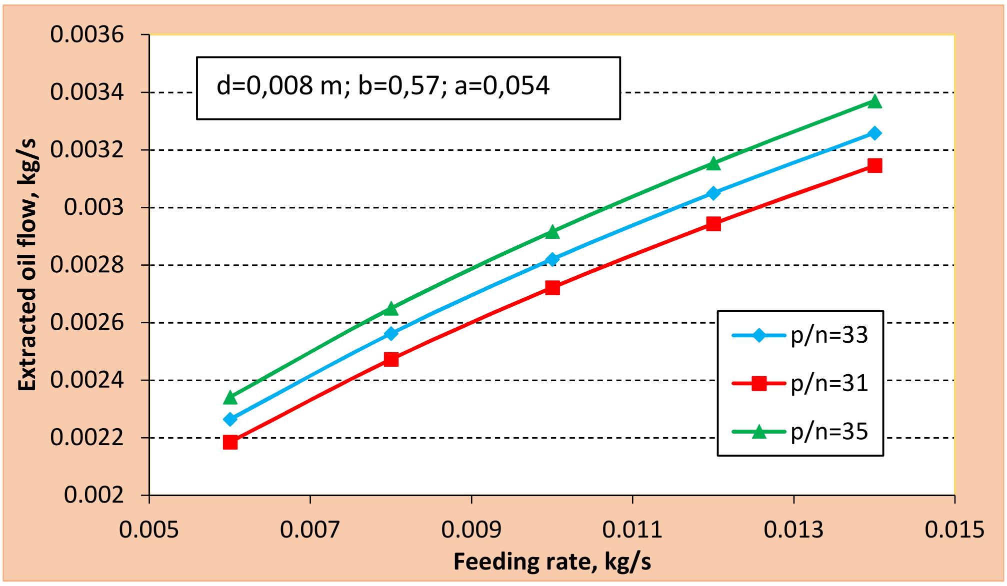

Figure 1: Variation curves of the extracted oil flow depending on the pressure applied on the material, for 8 mm nozzle diameter, [8]

It was found that for these conditions, the pressure in the pressing chamber will be between 46 to 48.5 MPa, while the material feed rate ranged around 0.01 kg / s.

Assuming that the constants values of the (17) function are a=0,054, b=0,57 (according to data obtained by regression analysis realized with the experimental data), [8], and p/n varies in the limits of 31-33 MPa, for the Q_a value in the range of 0.006-0.014 kg/s, using a 8 mm nozzle diameter, it is obtained the curves of the extracted oil flow depending on the pressure applied to the material, as shown in Figure 1, [8].

If a=0,046 and b=0,55, [8], for the same values of the applied pressure (31-33 MPa) and the same feeding rates, in the case of the 10 mm nozzle diameter, the variation curves of the extracted oil flow depending on the applied pressure show as presented in Figure 2, [8].

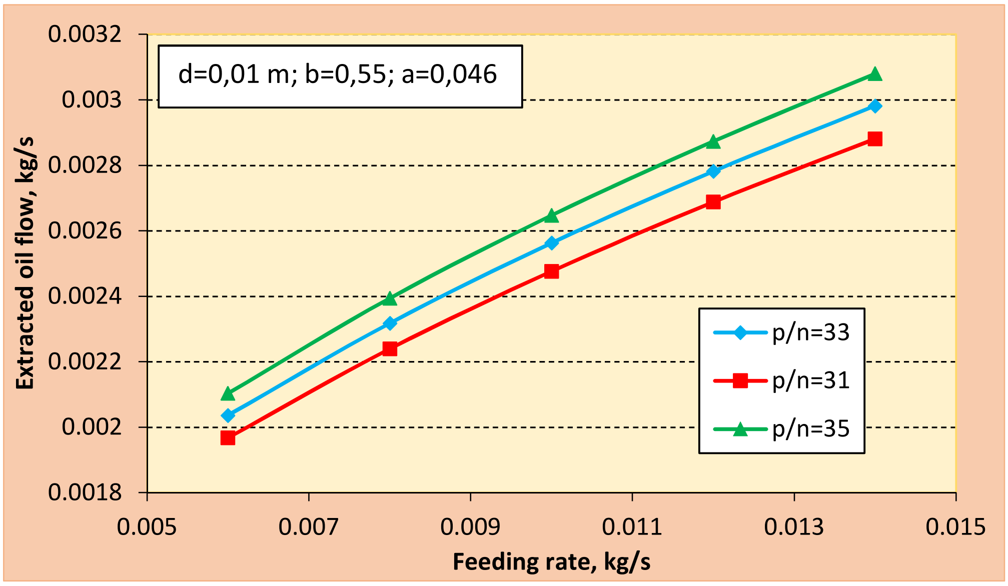

Figure 2: Variation curves of the extracted oil flow depending on the pressure applied on the material, for 10 mm nozzle diameter, [8]

3. CONCLUSIONS

Vegetable oil industry is one of the most important industries in the world, due to the large number of uses of vegetable oil in different fields.This led to intensive study of pressing process and more specifically to the study of factors that influence the efficiency of the press, characterized in especially by the recovered oil from the oleaginous material.

Mechanical screw-press performance, characterized by the oil recovery, for a given oilseed, depends on the preparation method of the raw material, which consists of a number of unit operations and on the operating parameters of the pressing machine.

In this study, a mathematical model was obtained using the π theorem from dimensional analysis theory. The mathematical model describes the extracted oil flow taking into account the following parameters: material feed rate, the moisture content of the material, the shelling degree of the material, the chamber press temperature, the screw speed, the diameter of the nozzle for cake discharge, the pressure from the pressing chamber.

Analyzing the graphs obtained based on the mathematical model and the regression analysis of the experimental data, it can be seen that the extracted oil flow increases with the increasing of the feeding rate in the range of 0.006-0.014 kg/s. The increases of the p/n ratio determined as well an increases of the extracted oil flow. Another conclusion that can be deducted is that, the use of a nozzle with a smaller diameter leads to an increase of the extracted oil flow.

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RESEARCH ON WIRELESSLY CONTROLLED CONVEYOR BELT WITH ANDROID APPLICATION

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ABSTRACT

The objective of this research is to design a control system for the conveyor belt in order to meet a set of practical engineering requirements. Wireless control system is designed to provide safety and comfort during use of the conveyor belt. The proposed system is based on both hardware and software. This project uses Bluetooth module that connects the hardware with a mobile device. Using Bluetooth, the conveyor belt can be operated without the need for obstructive cables up to a range of 100 metres. The software used in the project is Arduino IDE which is used for coding and as an interface between Arduino microcontroller and Mobile App. This model includes Mobile App with the hardware components such as Arduino microcontroller, Step Motor and Bluetooth Module. The proposed system works in standalone mode without the necessity of PC if once programmed. We used the rapid prototype technique approach of a step motor control for real-time applications using Arduino support package meant for Arduino microcontroller. The time response characteristics for this system are sufficiently slow such that control theory for dynamic control applications is not needed. In addition, the conveyor belt controller has the ability to accept input from a variety of optional sensors, such as: IR reflective sensors, colour detecting sensors, temperature sensors, load sensors, etc.

1. INTRODUCTION

In almost all manufacturing industries where there are fully automated assembly lines such as dosing systems, mining, food industry, packaging industry or agriculture belt conveyors are used. Trials are conducted on one or more conveyors. From start to finish the products are moving on belt and the processes are done in between, while they are moving.
Nowadays, wireless control of the machine plays an important role that is to reduce the manual work and save funds for the enterprise [1]. One particular example is available in paper [2] who describes the wireless control and monitoring of automation processes using a Microcontroller and Zigbee Wireless Protocol. Loker et al [3] provides a detailed listing of the engineering requirements for the conveyor control system, the functional test procedure for verifying proper operation of the system, and results for a PLC-based control system.
The main objective of this project is to develop a prototype control system for the conveyor belt. This will offers at low cost and very easy to implement [4]. This hardware equipment will be very useful for the operating the conveyor belt in extreme conditions. For implementing this project we used the components such as Arduino MEGA 2560, Oled display, HC-06 Bluetooth module, 28BYJ48 Step Motor for driving the conveyor belt and an android tablets. Arduino programming and App inventor programming are used for implementing the process. The central module for controller is the Mega2560 board which contains all the basic conveyor control and connections for the standard I/O and peripheral equipment. This is a standalone device and can operate with no user interface (as a “blackbox”). Alternatively this may be connected to the available wireless user interface assemblies, providing the user direct interaction with the conveyor. This project has the advantages as: gadget is small in size, low cost and power consumption, flexible in design. Therefore, this project will contribute to the

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creation of a new system, modular, multi-purpose, easily accessible and with the possibility to be assembled by anyone interested on the machine control field.

2. OPERATION AND THEORY

The stepper motor is a special category of synchronous machines, characterized by the construction and operation of a system of adequate power discrete, that "the steps". The stepper motor is an electromagnetic device that converts digital pulses into mechanical shaft rotation. Many advantages are achieved using this kind of motors, such as higher simplicity, since no brushes or contacts are present, low cost, high reliability, high torque at low speeds, and high accuracy of motion. Stepper motors are built today in a wide range of construction types various powers and speeds. The criterion relates to construction and the geometry of the magnetic structure of the motor. There are three basic types of step motors: variable reluctance (VR), permanent magnet (PM) and hybrid [5].

Some principal features of stepping motors are: digital control of speed and position; an open loop system with no position feedback required; excellent response to acceleration, deceleration and step commands; noncumulative positioning error (± 5% of step angle); excellent low speed/high torque characteristics without gear reduction; inherent detent torque; bidirectional operation. Stepper motor construction is schematically shown on figure 1 and figure 2 shows rotor construction.

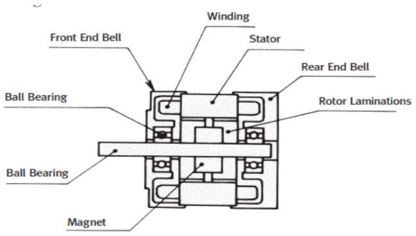

Figure 1. Stepping Motor Construction [5]

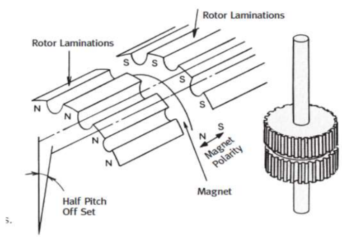

Figure 2. Rotor Construction [5]

The operation of a step motor is dependent upon an indexer (pulse source) and driver. To create rotational motion in a stepper motor, the current thru the windings must change in the correct order. This is obtained using a driver that gives the correct output sequence when subjected to a pulse and a direction signal [6]. The indexer feeds pulses to the driver which applies power to the appropriate motor windings. The number and rate of pulses determines the speed, direction of rotation and the amount of rotation of the motor output shaft. The selection of the proper driver is critical to the optimum performance of a step motor. To select the proper step motor must be determined load conditions (friction load, load inertia) and dynamic load conditions (drive circuit, maximum speed, and acceleration/deceleration pattern). The diagram represented in figure 3 synthesizes the overall architecture of the control scheme of a stepper motor [7].

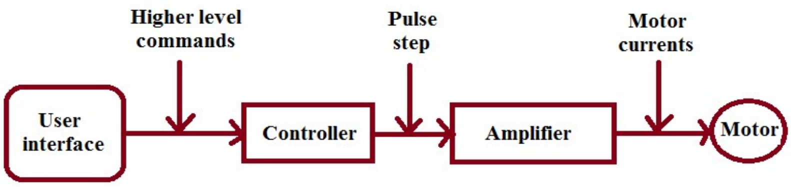

Figure 3. Block diagram of stepper motor control

The controller is a microprocessor that generates pulses of steps and direction signals to the driver. Driver (amplifier) converts control signals from the controller to the power required to power the motor windings. Performance speed and torque of stepper motor based on transition current driver to the motor windings. And when the current value current windings

are limited reach of windings inductance value. Forthe effect of reducing inductance, driver circuits are designed to supply at a higher voltage than nominal voltage.
Bluetooth is a wireless protocol utilizing short-range communications technology facilitating data transmission over short distances from fixed and/or mobile devices, creating wireless personal area networks (PANs). Development of digital wireless protocols Bluetooth enabled connecting multiple devices and overcoming problems arising from synchronization of these devices. Bluetooth provides a way to connect and exchange information between devices over a secure, globally unlicensed industrial and scientific 2.4 GHz range radio frequency bandwidth.

3. SYSTEM IMPLEMENTATION

This section presents the experimental results obtained for the conveyor belt wirelles control problem. The proposed system has two main parts: Hardware and Software. The control system works such as described in figure 4, where the controller only calculates a control signal when an event happens.

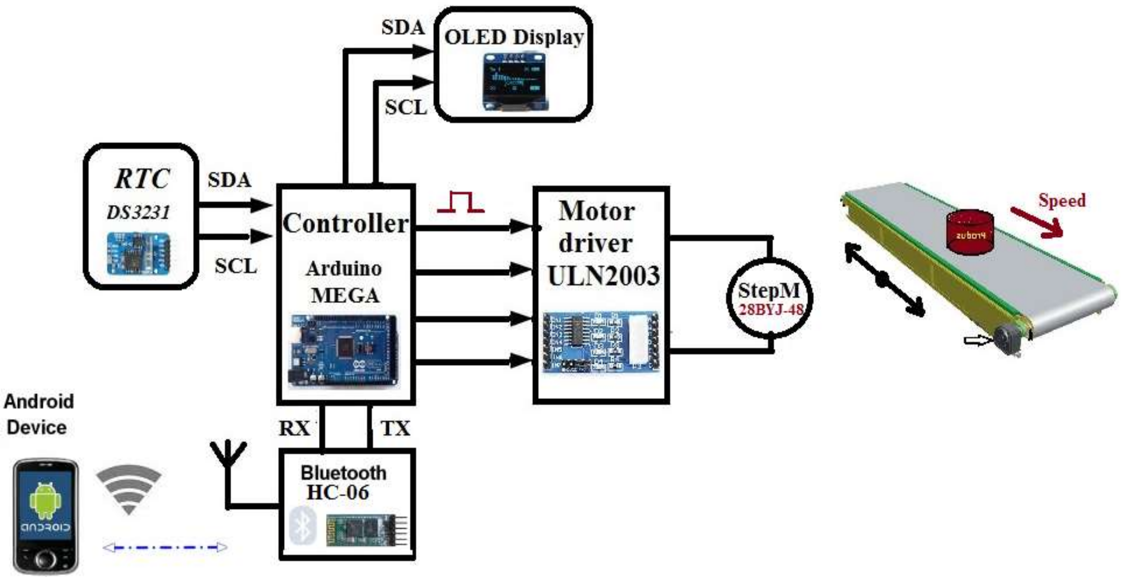

Figure 4. Block system diagram

HARDWARE. The main component of this section is the **Arduino Mega2560**. The Arduino Mega is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.
The DS3231 RTC chip is a low-cost, extremely accurate I²C real-time clock (RTC) with an integrated temperature-compensated crystal oscillator (TCXO) and crystal. The device incorporates a battery input, and maintains accurate time keeping when main power to the device is interrupted. The integration of the crystal resonator enhances the long-term accuracy of the device as well as reduces the piece-part count in a manufacturing line.
The ***OLED display*** provides extensive status monitoring, diagnostic information and controls capability. Are small, only about 1" diameter, but very readable due to the high contrast of an OLED display. This display is made of 128x64 individual white OLED pixels, each one is turned on or off by the controller chip. Because the display makes its own light, no backlight is required. This reduces the power required to run the OLED and is why the display has such high contrast. This breakout can be used with an I2C interface and is one of many user interface options for the conveyor belt controller. There are two lines of process information shown on the screen (figure 5), and these may be configured by the user. The value in the upper right

corner shows the current step number. The value in the lower right is the ambient temperature send by the DS3231 RTC chip.

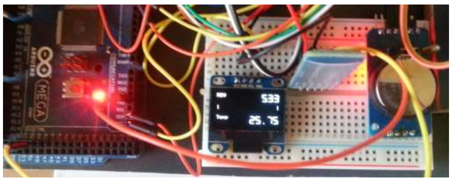

Figure 5. OLED Display

HC-06 Bluetooth module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Blue core 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm.
ULN2003 Driver is small size and easy to use. This are used to amplify the control signal from the Arduino board. So if we give stepper driver a certain pulse signal, it will drive step motor to a certain angle. We can control the angle the stepper moved by the number of the pulse. And we also can control the speed of the stepper rotate by the frequency of the pulse.
Step motor 28BYJ48 is the machine who converts pulse to angle displacement and move the belt. We adopted this hybrid type step motor design because it has some of the desirable features of both the VR and PM, are both permanent magnet and variable reluctance. It has high resolution, excellent holding and dynamic torque and can operate at a high stepping rate.

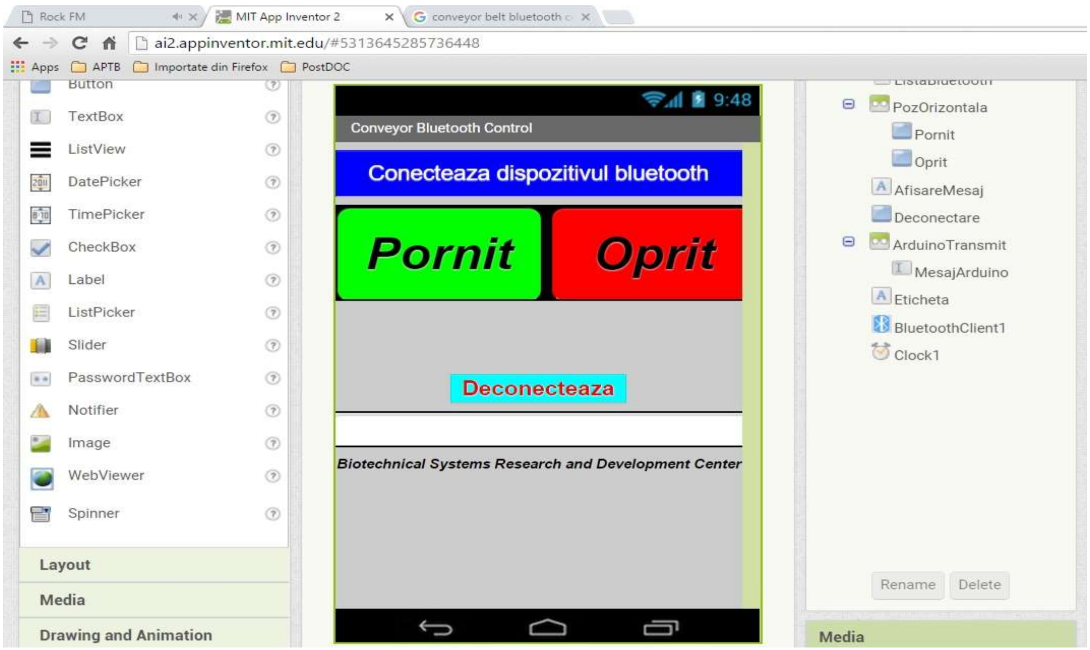

Figure 6. App design view

SOFTWARE. Software implementation of our control system uses Arduino software and MIT App inventor. The program code is writing in Arduino Software, which supports the Arduino packages. The MIT App inventor software is used to develop the Android apps. The belt conveyor is controlled by using the mobile app which is designed for this project.The software implementation is done in two steps.
The ArduinoCode is implemented in the Arduino software. Firstly, we initialize the variables that control the input pins of the driver motors and declare variables that will be used for

communication with the mobile app. Then we define the pins which are used to serial communication. Next the communication must setup to 9600bps because we configured the Bluetooth module to that speed. Check whether the information is coming through serial port or not. Now checks the serial port data that to identify which comand the application asks. When the Arduino receives char "P" the motor must start. And when char "O" is received the motor must stop. After this, in the loop(), we just compare state value with "P" or "O", and perform respective operation.

MIT App Inventor apps implementation. To implement and test this sample code we use an old Archos 7.0 Internet tablet running Android 2.2.1. We also tested this code using an Samsung Galaxy Young 2 smart phone running Android 4.4.2.

The main components of the client interface design shown in figure 6 are:

Connect to device button - to accept a connection from another device; ***Pornit and Oprit button*** – the commands is sent to the other Bluetooth device; ***Disconnect button***; ***MesajArduino*** – shown on the display status about the communications link and messages received from the other device; ***Non-visible components*** – The apps use a "Clock1" component to cause activities to occur at a preset interval. The "BluetoothClient1" component are located in the Connectivity section of the Designer palette.

Initially, we need to connect the app with Bluetooth module. After the connection is successful then we can click the "Pornit" button to turn on the conveyor. This process will continue till the "Oprit" button is clicked. In our app the "Deconecteaza" button is used for providing the disconnection between the app and Bluetooth module. The reception of data is implemented using the Clock1 timer. Once per 1000 microseconds, the client checks to see if data is available, and if it is, reads and displays the data on the app display. Sequence of commands that specifies the action to be performed are shown in figure 7.

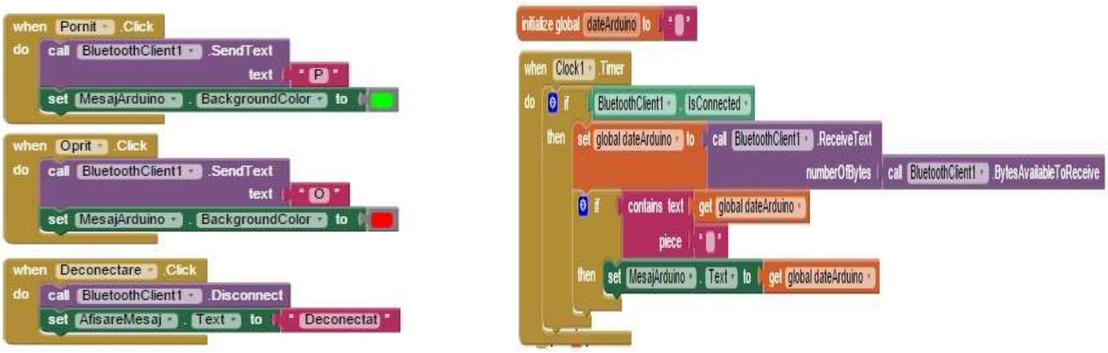

Figure 7. Block code

As shown in figure 4 the step motor rotates the belt. Depending on the process requirements different sensors can be placed on the conveyor belt system to detect motion product. So according to this we need to design a new circuit which will control the conveyor belt. Various commands are also available for the belt conveyor:

- ✓ Forward - the motor will start rotating clockwise and the product on belt will move ahead;
- ✓ Reverse - the motor will start rotating anticlockwise and the product will move back;
- ✓ Speed - this will change the speed of belt as the voltage applied to the pin of motor is varied from 0-5 V.

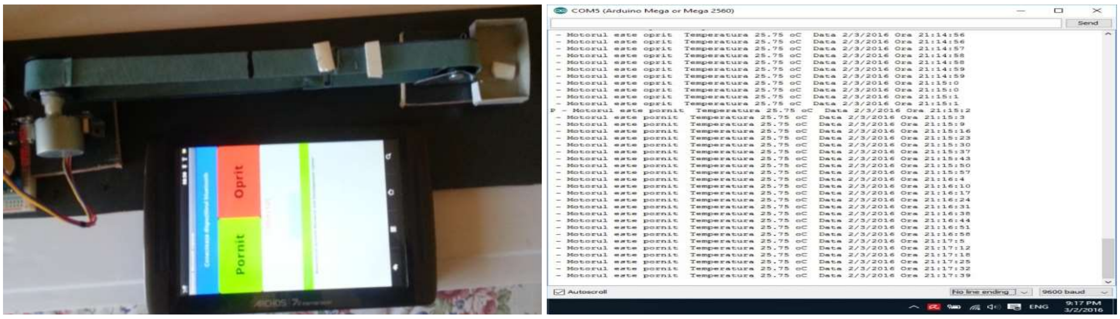

Figure 8. Testing the wirelles system controller

Figure 8 shows two examples of test control. The first, shown in figure 8_left is testing the application on an Archos tablet running Android 2.2.1, and the second, shown in figure 8_right, is displayed on the screen serial data transmitted from the MIT App Inventor app to the Arduino device via Bluetooth capabilities.

Despite the modes of operation and the variety of external sensors supported, the control system remains very simple to configure and use. For example, those options that are not required are not visible if they are not enabled [8]. In this way the controller and its user interface is only as complex as application requires.

4. CONCLUSIONS

Controlling the machines and environment makes human life easier and more comfortable. The outcome of the paper is a simple belt conveyor which is controlled by a smart android device. This research aims to provide simple guidelines for people interested in automatic machine and, also, to familiarize the engineering students with fundamentals of the Arduino and Android to build anything possible in the real world. Results of experimental tests have shown that the proposed wireless control system, ensure optimal working conditions conveyor belt. However, in its current state, this prototype system is already prepared for deployment in real-world test beds, and is an adequate low-cost alternative for much expensive industrial PLC controllers. As a future directive, full implementation of the proposed system must be taken into consideration.

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KEY FACTORS IN REMEDIATION TECHNOLOGIES

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ABSTRACT

Due to the problematic of soil pollution, there is a growing pressure to develop more cost-effective remediation technologies. Various estimates place the global cost of potential liabilities for owners of environmentally contaminated sites in the trillions of dollars. These potential liabilities have arisen as a result of contamination of the world's soil and water with chemicals, metals, and other compounds with effects that can range from an offensive odor to a carcinogenic or lethal outcome. In order to optimize a remediation technology, some key factors should be taken into account. So, before implementing a remediation technology, it is necessary to know factors that can influence the output of the decontamination method. The number of the key factors that have to be considered in selecting a remediation technology can vary. The present paper will analyze the main factors that can influence the optimization and the output of a remediation process.

1. INTRODUCTION

Several billion EUROS are spent in the EU each year on the remediation of land affected by contamination [1, 2]. It is an important goal from all perspectives that this money is spent wisely and appropriately. A risk based decision-making process for remediation is now the norm across most EU member states [1]. The global market for environmental remediation technologies was valued at roughly $59.5 billion in 2013. The total market is expected to expand from nearly $61.7 billion in 2014 to $80.5 billion in 2019, with a compound annual growth rate (CAGR) of 5.5% from 2014 through 2019 [2].

According to the study presented in the PR Newswire, China is expected to more than double their total market share from 4.7% in 2014 to 10.8% in 2019, reflecting a percentage change of 132.3% over the five year period and the Latin America and Caribbean region could see stronger growth than average as it expands its global market share by 5.0%, from 7.4% in 2014 to 7.8% in 2019 [2].

In the last decades the remediation technologies have been applied with success and many contaminated sites in the most developed economies of North America, Western Europe, Japan and Australia, have been cleaned. However, despite the progress that has been made in cleaning contaminated sites in these regions and countries, there remains significant work to be done [1, 2].

The inventories made in the last few years, at European level, have underlined the need of intervention. According to the European Environmental Agency (EEA) a number of 2.5 million potentially contaminated sites in the EEA-39, of which about 45 % have been identified to date. A constant pressure can be observed for reducing the final costs of a remediation technology.

In literature there are different types of classification for the remediation technologies, depending on the processes that take place during the treatment, on the finalization of the treatment (with total or partial contaminant removal), on the application type, that is in situ or ex situ.

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2. METHODOLOGY

The term 'remediation' is used here to encompass all activities leading to reduced exposure to contamination and to improved environmental and/or economic value of a site. It does not, however, necessarily imply recreation of pristine environmental conditions.

The terms "rehabilitation" and "restoration" are often used interchangeably in a similar context, depending on the language and other national peculiarities.

In the present paper the term "remediation" refers to the management of contamination, that is, removal, fixation, monitoring, and so on [3].

According to Reddy and Adams, an ideal remediation technology (and all associated on-site or off-site actions) should aim to [4]:

- minimize the risk to public health and the environment in a cost-effective manner and a reasonable time period;
- eliminate the potential for secondary waste and prevent uncontrolled contaminant mass transfer from one phase to another;
- provide an effective, long-term solution;
- minimize the impacts to land and ecosystem;
- facilitate appropriate and beneficial land use;
- minimize or eliminate energy input. If required, renewable energy sources (e.g., solar, wind, etc.) should be used;
- minimize the emissions of air pollutants and GHGs;
- eliminate fresh water usage while encouraging the use of recycled, reclaimed, and storm water. Further, the remedial action should minimize impact to natural hydraulics water bodies;
- minimize material use while facilitating recycling and/or the use of recycled materials.

A complicating factor in estimating the breakdown of market segments for environmental remediation technologies stems from the nature of the various liability laws in jurisdictions around the world.

One fairly common practice in environmental remediation is for a governmental body to undertake and see to the complete remediation of a key contaminated site; and, while remediation is underway or once it has been completed, this governmental body will seek payment for the costs of remediation from the responsible party (if this party is still in existence—many times they are not). In instances where such a process has been used successfully, the value of the remediation equipment, services, materials and so forth are applied to that specific industry application.

Of particular importance is the overall effectiveness of a project within the given legal and institutional framework, under the prevailing socio-economic boundary conditions, and balancing technology performance and risk reduction with the fixed or limited budgetary resources, not simply the result of the technical remediation operation itself (Figure 1).

Public perceptions of the remediation process and its results can be of overruling importance. Cost–benefit assessments and constraints on the availability of resources could also have a decisive influence.

Underlying rationales and incentives for remediation, which may be of economic nature, such as envisaged future land use, or of more ethical quality, need to be included [3].

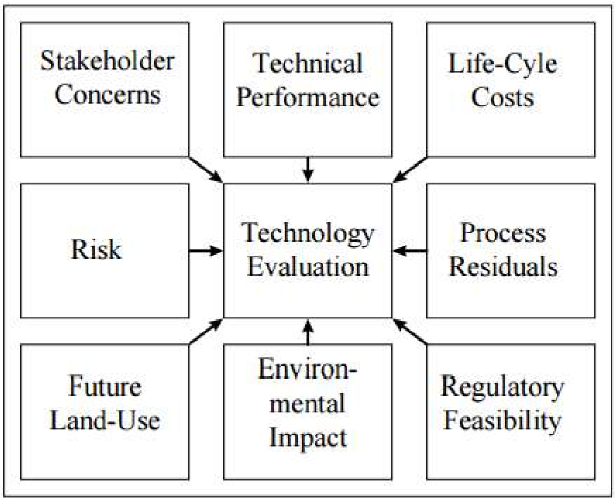

Figure 1: Technology evaluation framework [3]

There is a number of factors that need to be considered in selecting an effective remediation solution. These include considerations of core objectives such as risk management, technical practicability, feasibility, cost/benefit ratio and wider environmental, social and economic impacts. In addition, it is also important to consider the manner in which a decision is reached. This should be a balanced and systematic process founded on the principles of transparency and inclusive decision-making. Decisions about which risk management option(s) are most appropriate for a particular site need to be considered in a holistic manner.

According to Inaki, key factors in decision making include [1]:

- driving forces to remediate and goals for the remediation objectives;
- risk management;
- sustainable development;
- stakeholders' views;
- cost effectiveness;
- technical feasibility.

The **driving forces to remediate and goals for the remediation objective**, refers to the initial motive of the initialization of a treatment. This initial motive can be [1]:

a) to minimize the human health risk and the environmental risk;
b) to enable redevelopment;
c) to reduce the pollutants concentrations from the area;
d) to limit potential liabilities.

The fundamental purpose of a remediation technology is to reduce risks to human health and the environment. However, the relative degree of risk reduction offered by one remediation technology versus another is very difficult to determine because quantitative estimates of health and environmental risks at contaminated sites are highly uncertain [5].

Regarding the **risk management**, the assessment and management of land contamination risks involves three main components [1]:

1) the source of contamination (e.g. metal polluted soils, a leaking oil drum);
2) the receptor (i.e. the entity that could be adversely affected by the contamination e.g. humans, groundwater, ecosystems etc.);
3) the pathway (the route by which a receptor could come into contact with the contaminating substances).

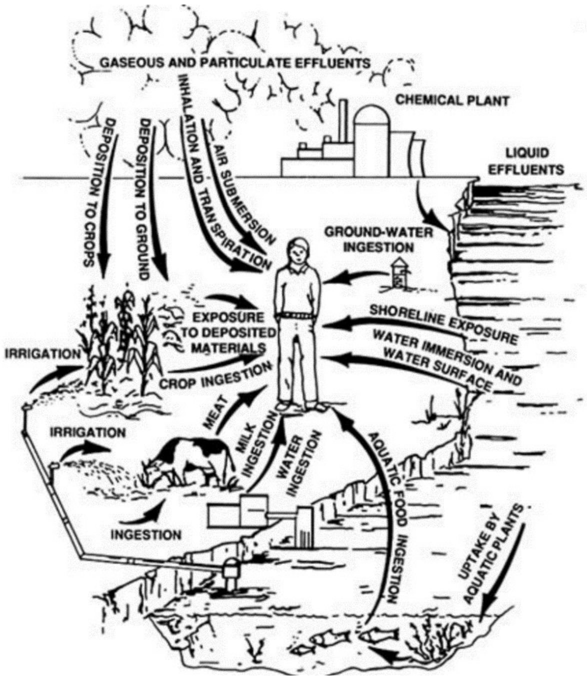

Figure 2. Pathways of human exposure to hazardous wastes [5]

The following four criteria should be used in describing a technology's ability to reduce risks posed by the contamination [5]:

1. Reduction in contaminant mass;
2. Reduction in contaminant concentration;
3. Reduction in contaminant mobility;
4. Reduction in contaminant toxicity.

The third key factor refers to the **sustainable development**. The definition of this concept is given in the Brundtland report from 1987 where it is mentioned that the sustainable development is a "*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". Usually when it is spoken about the sustainable development it's referred to the three different fields: economy, environment and social. So, each remediation technology has an economic, environmental and social impact. It is important that the impact should not be higher than the benefit of the remediation technology application (Figure 3). Although approaches to assessing the wider impacts of individual elements of sustainability (e.g. wider environmental effects) are under development in several countries, a truly integrated approach has yet to be found [1].

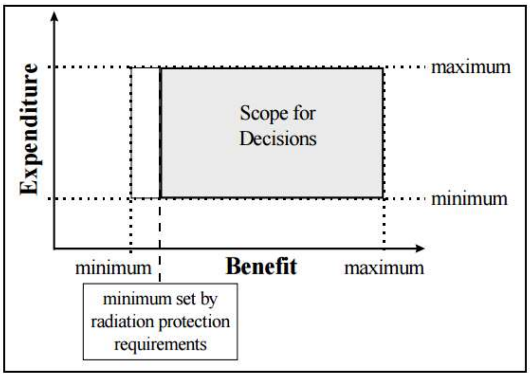

Figure 3. The scope for decision making [3]

Stakeholders will have their own perspective, priorities, concerns and ambitions regarding a site. Expectations about how a technology should perform can vary widely among the key stakeholder groups: the public, regulators, technology users or consumers, investors in innovative technology, insurance companies, and individuals working at the site [5]. The most appropriate remedial actions will offer a balance between meeting as many of their needs as possible, in particular risk management and achieving sustainable development, without unfairly disadvantaging any individual stakeholder [1]. Seeking consensus between the different stakeholders of a decision is important in helping to achieve sustainable development.

Costs of remediation depend on many factors and may be broken down into mobilisation, operation (per unit volume or area treated), demobilisation, monitoring and verification of performance. Although data can only be tentative, comparisons of indicative equivalent costs may be a useful exercise in the early stages of consideration of different remediation options. However, based on the site-specific conditions, the overall cost can mainly depend on [6, 7]:

- soil properties (e.g. moisture, texture);
- depth of contamination; the cost of chemical enhancement (including the cost of conditioning fluids, if necessary, and the cost for the treatment of the process fluid, if necessary);
- the cost of system implementation;
- clean-up time;
- cost of labor;
- energy expenses cost.

A possible distribution of the overall remediation expenses can be the following [7]: 40% for electrode construction; 10-15% for electricity; 17% for labor; 17% for materials; up to 16% for the licenses and other fixed costs.

A **suitable technology** is one that meets the technical and environmental criteria for dealing with a particular remediation problem. However, it is also possible that a proposed solution may appear suitable, but is still not considered feasible, because of concerns about [1]:

- ✓ Previous performance of the technology in dealing with a particular risk management problem (in the countries);
- ✓ Ability to offer validated performance information from previous projects;
- ✓ Expertise of the purveyor;
- ✓ Ability to verify the effectiveness of the solution when it is applied;
- ✓ Confidence of stakeholders in the solution;
- ✓ Cost;
- ✓ Acceptability of the solution to stakeholders who may have expressed preferences for a favored solution or have different perceptions and expertise.

3. CONCLUSIONS

The problematic of contaminated sites has become a quite huge one during the last decades starting with the inventories that were done in the European Countries (and not only there). There is great interest and urgency among environmental professionals to incorporate the beneficial aspects of sustainability into the remediation system selection and implementation. The overlapping interests and divergent expectations of stakeholders in contaminated site remediation form a complex web of shared concerns. Usually there are two parts, the affected public wants to "fix the problem irrespective of cost," whereas technology users wish to "fix the problem at the lowest possible cost".

So, the main key factors that can influence the output of a remediation technology can also be completed with others (with a smaller but important influence) depending on the specific sites. To all that is presented in this paper, the legal aspects can be added.

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EQUILIBRIUM MOISTURE CONTENT OF PUMPKIN FLOUR

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ABSTRACT

The equilibrium moisture content of pumpkin flour has been studied and the corresponding sorption-desorption curves have been obtained at temperature 20°C. The strain measurement method has been used to establish the sorption curves. Analytical dependences describing the sorption and desorption curves have also been derived. Values of equilibrium moisture contents for temperatures higher than 20°C have been obtained by the Pass method. The results are presented in graphical and table form.

1. INTRODUCTION

Prolonged contact between a product and the wet gas at constant external conditions leads to the establishment of thermal and diffusive equilibrium, which was maintained throughout the period of storage. The temperature of the product becomes equal to the ambient temperature, as well as the partial vapor pressure of the liquid is equal in the material and the environment. At this point the moisture of the material is constant and it is called equilibrium moisture content.

The equilibrium moisture content of a product W_P can be measured for series of values of the relative humidity of the air at a constant temperature. The functional dependence of $W_P = f(\varphi)$ at *t=const* has been plotted according the data obtained in the coordinate system φ, W_P, and it represents an isotherm of sorption or desorption, depending upon whether it is obtained, by moistening or drying a wet material to an equilibrium state [1, 2].

The equilibrium dependencies are a valuable source of information about the type and the format of the connection of the water with the material, for determining the acceptable level of saturation of the drying agent at the exit of the drying chamber etc.

Aim of the work

The aim of this study is to determine experimentally the equilibrium moisture content of pumpkin flour and to obtain dependences describing the sorption-desorption isotherms at different temperatures. They will be used in determining the conditions for storage and sizing of drying plants.

2. MATERIALS AND METHODS

The object of this study was a pumpkin flour obtained from pumpkin variety cucurbita maxima. The equilibrium moisture content of pumpkin flour, used as an additive to produce gluten-free products [4] has been experimentally determined by the strain measurement method. This method is long and labor-consuming but it provides high accuracy measurements.

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The method comprises the following: a certain amount of material has been placed in an exicator at a constant temperature (20°C) and relative humidity. The sample has been periodically weighed. Upon reaching a constant weight the equilibrium moisture content of the material has been determined. An analytical balance with accuracy of 0,0001 g has been used for determining the mass of the material. The equilibrium moisture content of the product has been determined by the weight method by drying the sample to constant mass in an atmospheric oven at 100 ± 2 °C.

The constant humidity of the air into each sealed vessel (exicator) has been maintained by means of saturated aqueous solutions of some salts, which have the ability to maintain a constant pressure of water vapor in the atmosphere above them. The relative humidity and the salts used in the experiment at a temperature of 20°C are shown in Table 1.

Table 1. Salts used in the experiment and the corresponding relative humidity maintained at 20°C.

Salts	NaOH	LiCI	CH_3COOK	$MgCl_2$	K_2CO_3	NaBr	NaCl	Na_2SO_4
φ, %	6,98	11,14	23,1	32,1	43,9	58,7	75,4	86,9

Dependences of the $W_P = f(\varphi)$ type ((equation (1)) have been obtained from the experimental results, taken at 20°. A standard statistical program Table Curve 2D v.5.01 has been used for determining the abovementioned dependences. Values of the equilibrium moisture content of pumpkin flour for accurate values of relative humidity have been calculated from the resulting equations for sorption and desorption.

However, for dimensioning of the drying processes and systems, it is necessary to have a sorption (desorption respectively) isotherms for a sufficiently wide temperature range. For determination of the equilibrium moisture content at other temperatures (40, 60 and 80°C) the Pass and Slepchenko's methods have been used [1]. These methods give good results for cereals and wood in the temperature range (-20 ÷ 100°C). On the basis of the data received, analytical dependences have been deduced. The equilibrium moisture content of the product has been calculated using these equations for the same values of relative humidity.

3. RESULTS AND DISCUSSION

The results for the equilibrium moisture content of pumpkin flour are presented in Table 2 and Table 3. The values at 20°C have been obtained experimentally, and those at 40, 60 and 80°C have been defined theoretically by the Pass and Slepchenko's methods.

Table 2. Equilibrium moisture content of pumpkin flour W_P,%, determined by sorption at different temperatures

φ, %	Temperature, °C			
	20	40	60	80
10	3,679	2,965	2,585	2,368
20	6,265	5,265	4,613	4,173
30	8,196	7,006	6,119	5,448
40	9,947	8,626	7,527	6,620
50	12,11	10,66	9,355	8,210
60	15,33	13,69	12,18	10,80
70	20,31	18,37	16,61	15,01
80	27,80	25,36	23,30	21,49
90	38,85	35,83	32,96	30,95

Table 3. Equilibrium moisture content of pumpkin flour W_P ,%, determined by desorption at different temperatures

φ, %	Temperature, °C			
	20	40	60	80
10	5,436	4,411	3,843	3,490
20	9,105	7,739	6,821	6,165
30	11,55	10,04	8,889	7,984
40	13,46	11,92	10,59	9,478
50	15,68	14,10	12,63	11,31
60	19,18	17,42	15,76	14,23
70	25,00	22,80	20,83	19,04
80	34,24	31,18	28,70	26,58
90	49,94	44,66	40,40	37,81

Except in tabular form, analytical consideration of sorption and desorption isotherms is also interesting. Due to the large number of factors that affect the sorption process, the describing of the equilibrium isotherm with a single equation is not possible. Many empirical and semi-empirical equations valid in a certain range of relative humidity for specified products have been derived in practice. The equations of the BET (Brunauer, Emmett and Teller) or GAB (Guggenheim, Anderson and de Boer) type are the most commonly used [3]. These equations have a common disadvantage that except their theoretical basis, they contain constants which must be experimentally determined.

The resulting analytical relationships describing the sorption-desorption curves have the following form:

$$W_P = a + b\varphi + c\varphi^{2,5} + d\varphi^3 + fe^{\varphi} \qquad (1)$$

where: φ - relative humidity of the air, %;

W_P - equilibrium moisture of pumpkin flour, %;

a, b, c, d and f are coefficients whose values are given in Table 4 and Table 5.

Correlation coefficients - r^2 and the average statistical error are presented in the same tables. The resulting equations are valid in the range $0 < \varphi < 0,9$.

Table 4. Coefficients for the equation of sorption

Coefficients	Temperature			
	20	40	60	80
a	0,19387	-0,12012	-0,19117	-0,1945
b	0,38550	0,34120	0,30877	0,28779
c	$-1,77565.10^{-3}$	$-1,57720.10^{-3}$	$-1,51199.10^{-3}$	$-1,52828.10^{-3}$
d	$1,92214.10^{-4}$	$1,727917.10^{-4}$	$1,66689.10^{-4}$	$1,68252.10^{-4}$
f	$2,322057.10^{-40}$	$3,921345.10^{-40}$	$2,675735.10^{-41}$	$2,247479.10^{-41}$
r^2	0,99982	0,99984	0,99924	0,99842
Fitt Std Err	0,20975	0,19996	0,43775	0,62994

Table 5. Coefficients for the equation of desorption

Coefficients	Temperature			
	20	40	60	80
a	0,23993	-0,21306	-0,30531	-0,29836
b	0,58018	0,51412	0,46174	0,42363
c	$-2,8447.10^{-3}$	$-2,43556.10^{-3}$	$-2,21891.10^{-3}$	$-2,12315.10^{-3}$

d	$2{,}93795.10^{-4}$	$2{,}53280.10^{-4}$	$2{,}32595.10^{-4}$	$2{,}23686.10^{-4}$
f	$1{,}56111.10^{-39}$	$9{,}15685.10^{-40}$	$7{,}85466.10^{-41}$	$5{,}12726.10^{-41}$
r^2	0,99979	0,99961	0,99863	0,99744
Fitt Std Err	0,28359	0,39132	0,73252	1,00010

The data from Table. 2 and Table. 3 are presented graphically in Fig. 1 and Fig. 2. As can be seen the increase in temperature leads to a shift of the equilibrium isotherms to the left in the entire temperature range. There is also a pronounced sorption hysteresis.

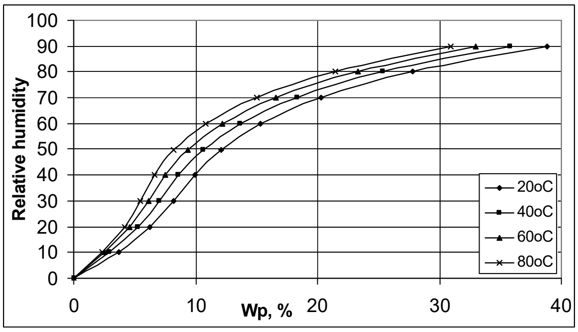

Figure.1 Sorption isotherms of pumpkin flour at different temperatures

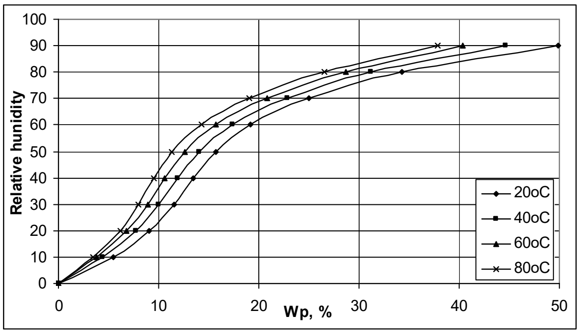

Figure.2 Desorption isotherms of pumpkin flour at different temperatures

The isotherms have clearly depicted S - shaped character, which indicates the existence of three types of connection of moisture to the material - monomolecular adsorption, polymolecular adsorption and capillary condensation. The analysis of the character of the sorption and desorption curves shows that the adsorption bound moisture in the material is a minor portion (up to Wp = S,% at 20°C) and decreases with increasing the temperature, which is testified by convex section of the curve in the direction of the X-axis. This convex section decreases at high temperatures, which means that the major part of the moisture is related to the capillary and polymolecular adsorption.

4. CONCLUSION

1. Experiments for determination of the equilibrium moisture content pumpkin flour at a temperature of 20°C have been conducted. The values of the equilibrium moisture content at higher temperatures - 40, 60 and 80°C have been recalculated by Pass and Slepchenko's methods. The results are presented in tabular form - Table 2 and Table 3.
2. An analytical relationship (equation 1) for calculating the equilibrium humidity of pumpkin flour for a range of relative humidity $0 < \varphi < 0{,}9$ and range of temperatures t = 20 ÷ 80 ° C has been obtained.
3. Sorption and desorption isotherms of pumpkin flour at various temperatures have been presented in graphic form.
4. The results may be useful in determining the storage conditions and design of drying equipment and installations for the production of pumpkin flour.

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REDUCING POLLUTANT EMISSIONS IN GASIFICATION BOILERS

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ABSTRACT

An exigence of our times is represented by development and use of green and economic technologies for production of clean energy in a sufficient amount. The term *clean* refers specifically to the minimal impact that the energy production technology should have on the environment.

This material presents some solutions to mitigate the polluting emissions in wood biomass gasification boilers by maintaining optimum temperature at the smoke flue and also by controlling the gasification process and obtaining biochar that, by sequestering the carbon pollutants into the ground, positively influences agricultural production and reduces the pace of climate change.

1. INTRODUCTION

The fossil fuels energy conversion into useful energy is always accompanied by the change of matter state, with the release of harmful components having a negative effect on the environment. The study on the effect of pollutants on the environment has been initiated very late, after 1980. Unfortunately, some of these pollutants acted on the soil, water and forests. Pollution size depends on the fuel used to generate electricity on the one hand, as well as the means of fuel combustion, on the other hand.

By "emissions", according to the Environmental Protection Law, it is understood "pollutants discharged into the environment as well as noise, vibration, electromagnetic radiation, which is manifested and measured at the starting point of the source". Urban pollution is given by the rersultant of some sources and the particular conditions of pollutants travel, by concentrating them under a blockage altitude, which interposes as a barrier to their spread [3].

Renewable energy sources are widely recognized in the EU as environmentally friendly alternatives to conventional forms of energy, leading to reductions in CO_2 emissions, reduced dependency on imports, development of new industries and creating new jobs [1].

Biomass energy conversion methods are:

- direct burning and using thermal energy for heating premises and cooking;
- burning of biomass and biomass derived products to produce heat and/or electricity;
- biochemical and thermochemical conversion of biomass for obtaining the biogas and liquid fuel that can be used as fuel for transport or for heating premises, cooking, electricity generation.

All life on earth is based on green plants, which convert the carbon dioxide and water of the environment into organic matter and oxygen, using energy provided by the sun. This process is called photosynthesis. Solar energy is accumulated through photosynthesis in the chemical bonds of the structural components of biomass. When biomass is burned, oxygen in the atmosphere combines with carbon and hydrogen from plants to produce carbon dioxide and water. The process is a cyclic one, because the carbon dioxide that reaches the air is again absorbed by the plants. [2]

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A comparison of energy carriers from biomass can be achieved on the basis of their ability to produce heat, electricity and fuel for engines. A useful way for comparison of biomass and the fossil fuels is based on their reports O:C and H:C, known as Van Krevlen diagram, Fig.1. The lower the reports are, the higher the energy content of the material in question is [4].

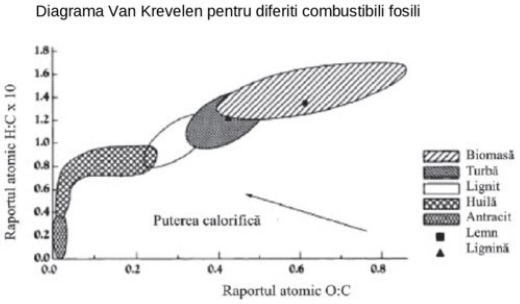


Figure 1: The Van Krevlen diagram for fossil fuels

Burning is the oldest and most widely used method for conversion of combustible materials into energy. Conversion effectiveness into electricity is 20- 25%. Biomass can be burned directly (as the wood is burned for heating or the wastes are incinerated) or burned together with coal (co-combustion). Modern boilers are designed to use co-combustion to reduce CO emissions. When designing the combustion system there are taken into account the characteristics of the fuel to be used, the environmental laws, the cost and performance of the available equipment. During combustion, a biomass particle goes through several phases, more or less distinct.

2. THE DIAGRAM OF A HEATING PLANT ON BIOMASS

Bellow we have the diagram of a wood boiler with co-burning, where the wood is introduced in the upper chamber of the boiler and the flames direct toward the lower chamber. On this type of boiler we can control the amount of wood that is burned and the power of the boiler that is generated by the use of an automated process control.

The air that is used for the process of burning is split into two components, one that is introduced inside the boiler through the nozzle, also called the primary air, and another that is introduced through the upper chamber, secondary air. Both components are preheated for an optimal burn of the wood and the achievement of gasification.

According to several estimates, global energy demand will increase by about 1.8% / year during the period 2000-2030. This leads to the need to increase the power production in direct proportion to demand. If we correlate this estimate with the one according to which the nuclear energy, hydropower, biomass and other clean energy will remain at a percentage of at most 25% of the energy production, there will result two directions:

1. increasing the conventional fuel consumption, which in the conditions in which we do not take action in researching and developing clean fossil fuel technologies, will mean a considerable increase in the emission of CO_2 into the atmosphere.

2. research, development and ultimately the use of equipments with high efficiency for producing electrical and thermal energy using as primary source of energy conventional fuels; increased efficiency translates into reduced fuel consumption for the same amount of energy produced. In this direction we must take into account the rising cost of natural gas and liquid fuels, proportional to the resource depletion, which surely will guide us to the use mainly of biomass and solid fossil fuels (coal).

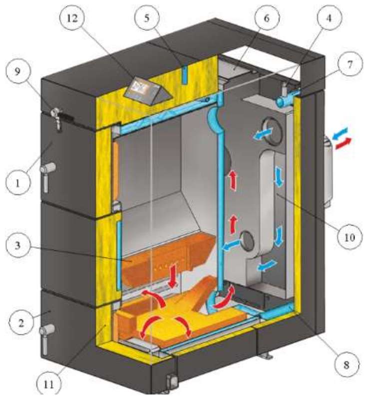


Figure 2

1. Supply upper door
2. Lower door for mashes
3. Heat resistant piece - Nozzle
4. Draft regulator
5. Cooling serpentine
6. Cleaning hole cover
7. The flow pipe
8. The return pipe
9. Rood for actuating flue gas damper
10. Preheating chamber for primary/secondary air
11. Boiler insulation
12. Boiler automation block

Air intake
Smoke evacuation
Primary agent circuit

In the gasification process there are used as raw material wood, vegetal mass, manganese, wastes and other materials within the biomass category, and the gas generator product is used for the production of heat and / or electricity. A gasification installation consists essentially of a gasification unit, a purification system and energy converters, boiler or engine. Gasification is essentially a thermochemical process of biomass conversion into the so-called gas from the gas generator that contains carbon monoxide, hydrogen, methane and some inert gases, mainly nitrogen. The gas from the gas generator can be used, with some minor modifications, also in engines that function on gasoline or diesel fuel.

Gasification process steps happen concurrently in different regions of the reactor. These steps are drying, pyrolysis, oxidation and reduction.

Drying is necessary because the biomass moisture is variable between 5 and 55%. At temperatures above 100°C, water is removed and converted into steam. During drying, the biomass is not subjected to any kind of decomposition.

Pyrolysis takes place in the temperature range from 150 to 700 °C and consists in thermal decomposition of the biomass in the absence of oxygen.

Oxidation takes place by means of air introduced into the oxidation zone. This contains, along with oxygen, also water vapor, inert gas, nitrogen, and argon which do not react with the components of the biomass. The oxidation occurs at 700 - 2000 °C.

Reduction takes place in the reduction zone of the reactor, and there are some chemical reactions at a temperature of 800 - 1000 ° C in the absence of oxygen.

The gas for the generator is a mixture of combustible and non-combustible gases. Combustible gases are: carbon oxide (15-30%), hydrogen (10-20%), methane (2-4%). Noncombustible gases are: nitrogen (45-60%), water vapor (6-8%), carbon dioxide (5-15%).

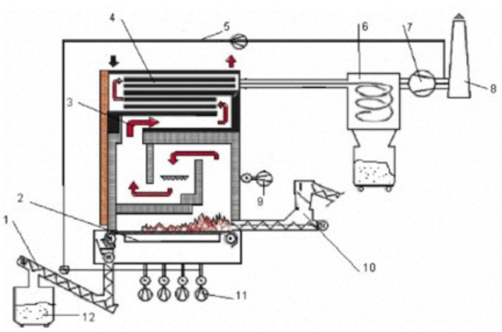


Figure 3

Biomass gasification technologies are of great diversity. Theoretically, any biomass with a moisture content ranging from 5% to 30% can be gasified. However not from all biomass there can be obtained high quality gas generator product. Most research works were conducted with usual fuels such as coal, charcoal and wood.

Research has shown that, compared to gas generators powered by wood or agricultural waste, the gasifiers based on charcoal present fewer problems in operation and are they recommended for use in rural areas. Gasification microsystems with a power ranging from 1kW to 10kW, can be used to provide the energy needed for irrigation of small or medium sized farms. The equipment must be small, inexpensive, simple and transportable (Fig3).

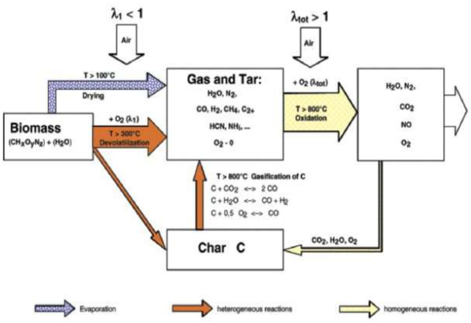
The fuel is extracted from the silo with an auger and is dosed into the dispenser *10*. Another conveyor auger will feed the combustion chamber *3*. The necessary air will be taken in through two types of pipes, the primary one *11* and the secondary one *9* (primary air for the combustion of wood, and the secondary for combustion of gases, both of which are heated). The warm air will heat the water in the boiler tubes *4*. Only part of the flue gases will be discharged through the chimney *8*, a large proportion being used to heat the air needed for combustion. Before the evacuation, the gas will be separated from the solids in the separator *6*. The particles of ash from the grate *2* will be evacuated by conveyor auger *2* in the storage box *12*.

Biomass combustion technologies present some problems. The most significant are related to cogging and corrosion of heat exchange surfaces:

- slugging and cogging reduce the heat exchange of the surface and cause corrosion;
- corrosion and erosion shorten the equipment lifetime;
- deposits or surface cogging is caused by inorganic material present in the biomass that is burning;
- Sodium, Na and potassium, K lower the melting temperature of ashes and therefore deposition of ash in the boiler pipes increases;
- Ca and Mg cause an increase in the melting temperature of ash;
- Silicon can be combined with K producing the silicate with low melting temperature in volatile particles. This process is important on the one hand in preventing the synthesis / agglomeration and melting of the ash on the burning grate or in the fluidized bed of the combustion installations, and on the other hand in preventing slugging of the ash on the surface of heat exchangers.

3. COMBUSTION IMPACT ON THE ENVIROMENT

Biomass burning furnaces produce relatively high emissions of NOx and suspensions in the air, compared to burning furnaces with natural gas or oil. For combustion of wood, a recent lifecycle assessment indicates that the impact of a burning furnace is **38.6% NOx 36.5% suspensions in the air and only 2% CO_2, the remaining 22.9% being due to other pollutants**. Life cycle assessment for wood, oil and gas shows that the wood impact on the environment is higher than the one of natural gas, in terms of the greenhouse effect. This leads to the improvements to wood burning installations.



Main reactions during two-stage combustion of biomass with primary air and secondary air

Figure 4

For ordinary biomass, the combustion reaction can be described by the following equations, neglecting components as N, K, Cl etc.:

$$CH_{1.44}O_{0.06} + \lambda\ 1.03\ (O_2 + 3.76N_2)$$
$$\rightarrow \text{Intermediates } (C, CO, H_2, CO_2, C_mH_n \text{ etc.})$$
$$\rightarrow CO_2 + 0.72\ H_2O + (\lambda\text{-}1)\ O_2 + \lambda 3.87\ N_2 - 439\ \text{kJ/kmol}$$

The main parameter of combustion is the coefficient of excess air (λ) which describes the ratio of stoichiometric quantities of combustion air and the actual amount used.

Following the combustion process a series of pollutants result, which can be classified as follows (fig. 4):

1. Unburned pollutants, such as CO, CxHy, polyaromatic hydrocarbons, tar, soot, unburned carbon, H2, HCN, NH_3 and N_2O;
2. Complete combustion pollutants, such as NO_x (NO and NO_2), CO_2 and H_2O
3. Ash and contaminants, such as ash particles (KCl, etc.), SO_2, HCl

4. REDUCING OF POLLUTING EMISSIONS

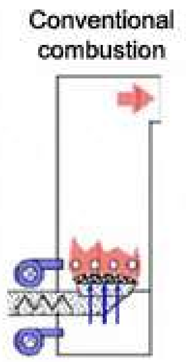


Figure 5

Combustion in stages - in which the excess of air varies in different sections of the furnace

4.1. Two-stage combustion – It consists of introducing primary air into the fuel layer, followed by the introduction of secondary air in the upper part of the combustion chamber.(fig.5)

This allows for a better mixing of the combustion air with the combustible gases formed by volatilization and gasification in the fuel layer.

If there is produced a good mixture, the concentration of unburned pollutants can be reduced close to zero (CO<50 mg/Nm^3 and C_xH_z< 5 mg/Nm^3 at 11 vol. % O_2)

In practice ensuring the optimal excess of the air is done through carefully controlling the process.

4.2. Combustion with air injection on two levels

Compared to the conventional two-stage combustion, the primary air requirement must be below the stoichiometric value (λ<1). Furthermore is it required a time for reaction (and therefore a reductive area in the oven) between the fuel and secondary air insertion.

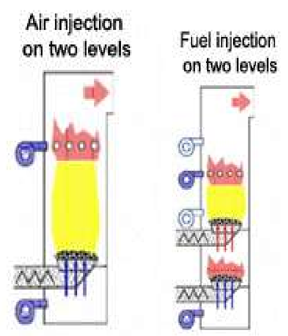


Figure 6

4.3. Combustion with fuel injection on two levels (fig.6)

Primary fuel is burned with excess air ratio of >1. A consecutive reduction zone is achieved by feeding the secondary fuel at a higher level and late inlet of combustion air for the secondary fuel. The last two processes have been developed as primary measures for the in situ reduction of NO_2 resulted from biomass combustion.

We can talk about *thinking on long term* when it is attempted to harness the energy potential of biomass, knowing that they have low costs of raw materials (biomass wastes). *Clean technologies* are technologies that allow recycling of substances, wastes or recovery of pollutants as secondary raw materials. By applying clean technologies, it is intended to reduce the negative environmental impact. To achieve this goal it is necessary that environmental issues to be incorporated in the design and procedure of obtaining these products.

At thermal plants that use gasification technology, the wood in the upper compartment of the boiler, in contact with the embers produced on the grate, cause the "wood gas". In combination with the primary air it travels through the nozzle of refractory brick and self-ignites at over 560°C in a mixture with secondary air inserted through the side holes of the nozzle. In the lower area of the furnace there is formed the so-called "overturned flame". Recovery of heat occurs in primary steel-made exchanger where the heating agent and the flue gas tubes can be found. Gasification technology allows almost complete burning of the wood. This leads to a reduction of costs and extra comfort by reducing the amounts of ash.

There are many techniques that improve combustion conditions and reduce emissions, which give different results in terms of emissions. With a modern wood-fired boiler with a water recovery tank, which is the best technique available, emissions are reduced to more than

90% compared to the old boilers which don't have such a tank. A modern boiler has three different zones: a fireplace for the gasification of wood, a gas combustion chamber lined with ceramic or other materials, which reaches temperatures near 1000°C, and a convection zone. The latter one, in which the water absorbs heat from the flue gases, should be long enough and effective to decrease the gas temperature from 1000°C to 250°C at least. There are other techniques for re-fitting the old boilers, especially the installation of cooling recovery tanks, with ceramic lining or pellet burners (coal agglomerates).

By optimizing the combustion speed we decrease the emissions of carbon monoxide, total hydrocarbons and polycyclic aromatic hydrocarbons. On the other hand, the limits set (by regulatory approvals by each type) for emissions of carbon monoxide and total hydrocarbons also influence the HAP emissions. When the CO emissions and total hydrocarbons are low, also the HAP emissions are low.

5. CONCLUSIONS

It is required more and more clearly to adopt legal and organizational measures to reduce pollution, emission of greenhouse gases and dependence on crude oil imports, which are getting increasingly more expensive and uncertain, oil being on its way to depletion.

It is possible to reduce the emissions of installations that work with biomass, through the following measures [3]:

- By controlling the temperature in the gasification process, the occurrence of nitrogen oxides is much more limited, leading to a reduction of them up to 20 times compared to conventional burning.
- By gasification the problems caused by deposition of melted ash on the heat exchanging surfaces are overcome, phenomenon that leads to clogging of boilers.
- Regarding the un-reacted carbon existing in the ashes discharged from the gasification process, the gasification process can be reorganized so that the carbon could be converted up to more than 95-98%.

Acknowledgement

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INFORMATION ON CURRENT ENERGY CONSUMPTION IN AN INSTITUTION ”POLITEHNICA UNIVERSITY OF BUCHAREST”

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ABSTRACT

The forecast can be defined like approximately of the unknown events from the future; this thing is necessary because of the existence of some unknown events, but this events play an important role in taking some decisions. It is obvious that the uncertainty's elimination is not possible, so the forecast is a tool who tries to minimalize this uncertainties. The forecast's importance in the electrical energy management is very important. The forecast of the energy's request presumes the estimation of this request's characteristics: zise, time evolution, the request's structure, and so on. The forecast of the electrical charge is a tool of a modern EMS.

Keywords: Forecast, electrical energy, mathematical model, consumption.

1. INTRODUCTION

The importance of the forecast in management is very important. The initiatory of the private process of the electricity distribution, the generalization of the dealing on the market, the substantion of a new mechanisms and instruments for the market risk management and the bigger decentralization of the dealing with electric energy are some of the most important aspects in which the forecast studies on short term, are very important.[1]

In this context, the paper shows a lots of aspects conected with the forecast on short term of the electric energy consumption. As part of this paper, the main purpose is to present the elaboration methodology of some forecasts in the energy consumptions area, using few mathematical models.

The forecast for the electrical energy consumption and power also is the scientific activity with the main purpose: the forecast for the energy consumption and power based on calculations analysis and based on the interpretation of a different dates, so we will obtain a more precise concordance between the estimated consumptions and the one effectively realised.We can see that a batch of parameters (reasons) with aleathory character leads to the energy consumtion: climatical factors, demographical factors, economical factors and another factors.[2]

The methodology of elaboration of a forecast study for the energy consumption has few main steps:collecting, selection and analyse the initial dates; establishing the mathematical model for the consumption; the analyse for the variance which has been obtained for the forecast and establishing the final decision.

2. METHODOLOGY

Consumption curve, represints the energy fluctuation in time (or taking into consideration another parameter) and it can be split in more components. The forecast experience of the energy consumption shows four main components which determine the consumption curve *(W)* (See example Figure 1):

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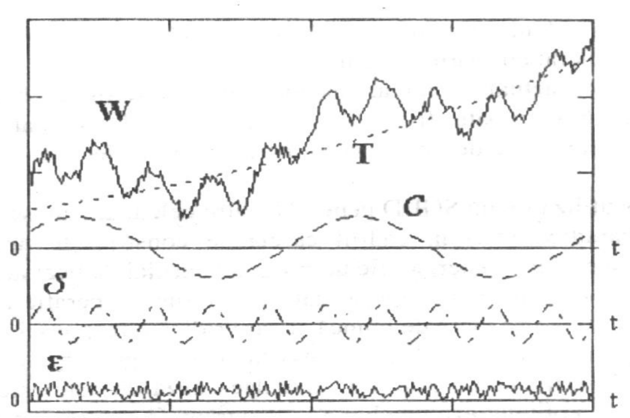

Figure 1: The components for the mathematical model of the energy consumption curve

1.The trend (T) represents the consumptions main compound, establishing the modification essential form of energy consumption.

2.The cyclic component (C) it's due it existence to some fluctuant causes with slowly effect like the request-supply correlation with a period over a year.

3.The seasonal component (S) it is caused by certain parameters which presents seasonal fluctuations (especially climatic elements). This component has a few months variation period and a similar shape for all years. [3]

4.The aleatory component (ε) it dues to perchance causes, that has been previously specified.

As a conclusion, the energy consumption results, totaling the elements that have been specified above:

$$W(t)= T(t)+C(t)+S(t)+\varepsilon(t) \qquad (1)$$

The direct forecast methods are supposing the assumption that the causes, the factors and the trends which established the energy consumption in the past are also maintaining in the future, without appearing any dramatic and sudden changes during the forecast which to affect the consumption evolution.

This assumption justifies the energy consumptions evolution trend extrapolation from the past for the future period and brings the forecast problem to the analysis of the energy consumption variation law from the past to the future. [4]

It is considered a value set y_t observed, of a chronological serie. Mathematical shaping can be made using an additive model: $y_t= T(t)+C(t)+S(t)+\varepsilon(t)$ **a)The trend T_t** is determined by using liniar model:

$y_t=b_0+b_1*t+\varepsilon_t$,where finding the parameters b_0, b_1 is made with matrix method.

Are noted the following matrixs : $X = \begin{pmatrix} 1 & x_1 \\ 1 & x_2 \\ \dots & \dots \\ 1 & x_n \end{pmatrix}$, $Y = \begin{pmatrix} y_1 \\ y_2 \\ \dots \\ y_n \end{pmatrix}$ $B = \begin{pmatrix} \hat{b}_0 \\ \hat{b}_1 \end{pmatrix}$ => $B= (X'X)^{-1}(X'Y)$

=> $\hat{b}_0$ and $\hat{b}_1$ parameters which determine the regressive right line : $y_t=\hat{b}_0 + \hat{b}_1 \cdot x_t$. (2)

The advantaje for this method is that it can be applied successfully in case of multiple regressive and non right line regressive.

b) **The cyclical component C_t** is aquired using the additive model;

c) **The seasonal component S_t**

The seasonal parameter is used to compare with periodical fluctuations on short term between seasons (in our paper: months). The method showed below is applied for the additive model and assuming that doesn't exists a cyclic effect.
d) The forecast can be obtained by smoothing.[5]

3.CASE STUDY

It is considered a data base (60 dates) which represints the electrical energy consumption from University Politehnica of Bucharest, during January and February 2016. The registrations from the data base represints a real data base concerning the energy consumptions which allows to locate, with a certain trust level, the consumptions on intervals obtained by proportional division principle. The safety of the forecasts is directly proportional with the number of the available registrations and with their precision, and the dates are renewed daily.

The dates estimation and the forecast in a time series is made using the modeling methods which have been discussed earlier. We have elaborate using Matlab, the mathematical model for the forecast of the electrical energy consumption.

Realising a forecast for the energy consumption on short term is made with Matlab, reaching the following steps:

a) It is realised a data base;

b) We will make the calculations for the geometrical trend and we will see that concordant with the graphical method;

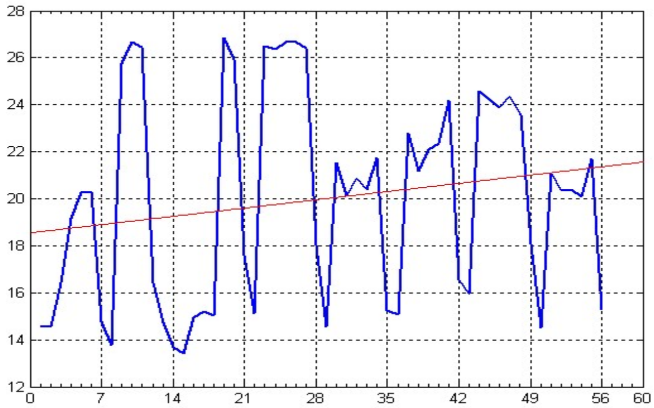

Figure 2: The evolution in time of the energy consumption

c) We've made the calculations for determing the cyclical component and this is shown like below;

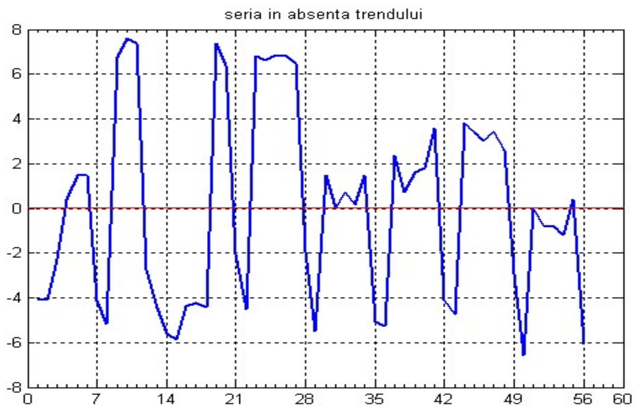

Figure 3: The estimative result 100 * y/y for determine the cyclical effect.

d) We've made the calculations for the seasonal effect and we have obtained the graphic:

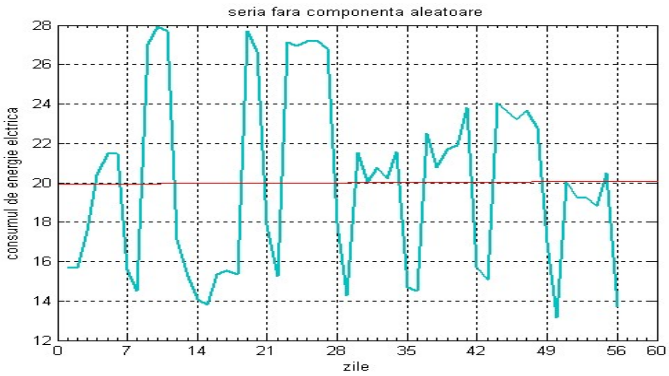

Figure 4: The produced energy evolution in time, after the dismission of the seasonal effect.

e) It is realised the forecast for the next year using the exponential straightening and we will obtain the graphic.

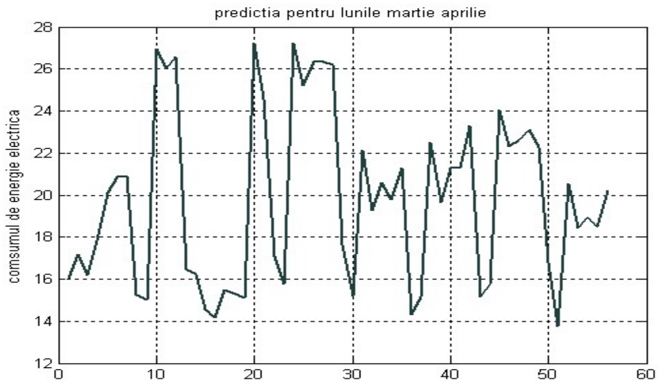

Figure 5: Estimative forecast of the energy comsuption for March and April 2016

4. CONCLUSIONS

The forecasts for consumption represents the main elements for analysis in the elaboration/ modification of some decisions in different stages of the supply electric energy service management. In this case, is need to make some consume forecasts on short and medium term, very precise, in this way we want to obtain the contract on the competitive market of a eighth quantities and implicit the cost reduction connected to the electrical energy acquisition. Using a proceedure of recursive approximation gave us some good results, and so in the conditions of large variations, to develop a model which takes into considerations the previous dates in reduced number. In conformity with the graphics, the forecast shows that the energy consumption in March and April 2016, at University Politehnica of Bucharest is almost the same with the one realised in January and February 2016.

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DECONTAMINATION TECHNOLOGIES FOR POLLUTED SITES

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ABSTRACT

In the context of European requirements on polluted sites decontamination from industrial activities, we must develop new strategies with the main target to neutralize the harmful effects on the ecosystem. To implement decontamination technologies, we must considered a first plan that aims improving soil structure by agro-technical works and a second plan that seeks to establish technologies for crop plants that have the capacity to decontaminate and greening the soil. They can cultivate herbal plants, wild plants, legumes that improve the soil through atmospheric nitrogen fixation, trees and shrubs. Growing energy plants brings substantial benefits, by making forestry curtains that prevents soil erosion. The resulted wood can have many uses: in pellets and briquettes manufacture, in furniture industry, etc.

1. INTRODUCTION

The new national strategy for managing contaminated sites from Romania came into force on 31.08.2015 and provides that, in the absence of a legal framework to prevent pollution and protect the soil and subsoil, Romania has inventoried 1,393 contaminated / potentially contaminated sites, entered into the database which includes national inventory. This action started in 2007 and recorded the sites number is expected to increase by imposing a strict and mandatory declaration schemes.

[6]

Map of contaminated and potentially contaminated sites in Romania

Table 1 shows the estimated cost for potentially contaminated sites that require investigation and risk assessments, based on them to determine whether or not they require recovery works.

Table1

Number of potentially contaminated sites	Investigation action			Remedial action			Total costs (Euro)
	Impact and risk assessment	Medium price (Euro)	Subtotal costs (Euro)	Number of potentially contaminated sites	Medium price (Euro)	Subtotal costs (Euro)	
1.183 sites	1.183	40.000	47.320.000	1.183	6.000.000	7.098.000.000	7.145.320.000

Estimated costs for potentially contaminated sites

NOTE: These numbers are estimates and have as a source, the average cost in U.E. member countries for risk assessment and remediation of contaminated sites.

Table 2 shows the estimated cost for areas that require risk assessment updating, and based on them to establish remediation works.

Table 2.

Number of contaminated sites	Investigation action			Remedial action			Total costs (Euro)
	Updating impact and risk assessment	Medium price (Euro)	Subtotal costs (Euro)	Number of contaminated sites	Medium price (Euro)	Subtotal costs (Euro)	
210 sites	210	20.000	4.200.000	210	6.000.000	1.260.000.000	1.264.200.000

Estimated costs for contaminated sites

NOTE: These estimated numbers have as a source average cost of U.E. member countries for risk assessment and for contaminated sites remediation.


[7]

Tailing deposits from Moldova Noua

In the two tables above, it appears that total estimated cost of the transactions was 8.4 billion euro. Estimation presumes that Romanian Government will apply an administration based on risk assessment analysis. This means that the sites remediation will be undertaken by achieving an acceptable level of risk for their use.

Environmental contamination has a bad effect on health and life quality, negatively influencing living organisms and the environment in which they develop. Most often, polluting substances are coming from human activities and less from natural causes such as volcanic eruptions.

Living organisms depend on a balanced environment for growth, development and reproduction. If the environment becomes polluted, all these functions that organisms must meet, become difficult to achieve.

Pollutants can be grouped into biodegradable and non-biodegradable:

- Biodegradable pollutants come from wood waste, paper, textile material, organic matter, manure, food waste, animal waste etc., all these can be used in agriculture for soil enrichment in nutritional elements in compost form. A major role in materials decomposing has it the microorganisms. Household water can be decomposed quickly using natural processes.

- Non-biodegradable pollutants do not decompose, or decompose very slowly, requiring a long time. These non-biodegradable compounds, such as dichloro-diphenyl-trichloroethane (DDT), dioxin, polychlorinated biphenyls (PCB), heavy metals, metal and plastic products, pesticides, radioactive material, etc. may negatively affect the trophic chain. The molecules of these toxic compounds can settle on some aquatic plants without influence their development and small organisms that feed on these plants take over in their bodies these molecules. Furthermore, organisms that feed on those already infected, take over these toxic substances sending them further through the trophic chain. This process is called 'bioaccumulation'.

In the years of forced industrialization, in urban areas air has been contaminated with a mixture of carbon monoxide and organic compounds derived from incomplete combustion of fossil fuels such as charcoals and sulfur dioxide from fuel impurities. This mixture is known as the "smog". Sulfur oxides and nitrogen in the atmosphere are converted into acids and under the influence of rain, snow or fog; these compounds are deposited on plants surface and become toxic.

One of the biggest problem caused by air pollution is global warming, an earth temperature rise caused by the accumulation of atmospheric gases such as carbon dioxide. With fossil fuels intensive use in the twentieth century, the carbon dioxide concentration in the atmosphere has increased dramatically. Carbon dioxide and other gases, known as greenhouse gases, reduce the heat dissipated from Earth but does not block the sun radiation. Due to the greenhouse effect is expected that global temperature increase with 1.4 ° C to 5.8 ° C by 2100. This trend seems to be a major change, the increase would make the earth to be warmer than it was in the past 125,000 years, perhaps changing climate patterns, affecting agricultural production, changing the animals and plants distribution and rising sea levels. [3]

Air pollution can affect the superior atmosphere called the stratosphere. Excessive production of chlorine containing compounds such as chloro-fluoro-carbonates (CFC) (until recently compounds used in refrigerators, air conditioners and manufacture products based on polystyrene) reduced stratospheric ozone layer, creating a hole over the Antarctic lasting several weeks each year. As a result, direct exposure to sun rays has affected the aquatic and land life threatening and human health from the planet southern areas. [3]

According to OMS (2009), about 2 million people die annually from air pollution, mostly in Asia. [3]

2. METHODOLOGY

To implement decontamination technologies, we must consider a first plan that aims to improve soil structure by agro-technical works and a second plan that seeks to establish technologies for crop plants that have the capacity to decontaminate and greening the soil. They can cultivate herbal plants, wild plants, legumes that improve the soil through atmospheric nitrogen fixation, trees and shrubs.

Almost all polluted land cases; they exhibit deficiencies in nutrients elements, which mean to pay particular attention to improve soil conditions:

- Soil fertilizing by adding complex NPK organic fertilizers.
- Covering with a layer of fertile soil with a 30 cm thickness.
- Adding of sludge from water treatment plants or irrigation canals.
- Fighting soil acidity by amending with lime or limestone.

Among nitrogen fixing species, White Sea buckthorn *(Hippophaë rhamnoides* L.) is a plant that is suitable to be grown on the polluted land, having an important role in soil improvement.

Spread. White Sea buckthorn or river sea buckthorn is a very branched shrub, which grows thick and thorny in the sandy areas of the seashore, meadow, plains, till the hill and mountain regions, forming copses spread across large areas. In areas with slops, the sea buckthorn fixes very well in the ground by a strong root separation. It shows excellent resistance to climatic conditions, supporting both drought and frost. It's a loving light and heat plant, growing well in places exposed to direct sunlight.

Fertilization. It is recommended that at a culture establishing, to manage manure or organic fertilizers based on soil analysis result.

Soil works begins in the fall, it is recommended a 30 cm plowing or 50-60 cm(deep plowing. Simultaneously with plowing is recommended incorporation of organic manure in the soil in quantity of 30-40t / ha.

Multiplication. Sea buckthorn multiplies vegetative, by cuttings root (root separation) but can multiply by seed, producing seedlings in the nursery**.**

Vegetative multipliction. Cuttings are planted in autumn or early spring at a distance of 3x1,5 - 2m, in report of eight female plants and two male plants, without which you do not obtain fruits.

Seedlings multiplication. The seeds (after it removes the pulp) was seeded on fall or spring in the nursery (2-3g seed in m linear, resulting in about 30 plants / m). Sea buckthorn seedlings is able to be planted in 1-2 years, must have minimum size of the base of 7mm (I-quality), 5mm (II-quality) and 3mm (III-quality). Are planted nearly 10 thousand plants / ha, in holes done manually or mechanically, ensuring watering if necessary, for gripping. [5]

White sea buckthorn (*Hippophaë rhamnoides* L.) [4]

The care works consist in making cultivation whenever necessary, mechanized between rows and manually between plants on the row**.**

Fruit harvesting can be done from August (when they have orange color) until the first frost (that causes sharp decrease in vitamin C content). Fruits are separated from the branches with scissors (is cut bunches that bears the fruits) or by "beating" the bushes (productive method, but fruit quality decreases, being mixed with impurities and in part of the are crushed) [5]

3. CONCLUSIONS

For the best possible management of polluted sites from Romania, must achieve and implement a new national strategy, more efficient than the one in effect. The techniques and methodologies that we have today are satisfying and can help reduce the negative effects that these sites have created over time. Plants that can be grown on these soils are multiple and their roles are varied. For example, nitrogen fixing plant growing on these lands bring more fertile soil; energy plants can serve as forestry curtains, thus alleviating soil erosion, and having an energetic role in Wood processing and afforestation of these areas can mitigate the effect of desertification redressing the natural ecosystem.

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CONSIDERATIONS REGARDING THE CONSTRUCTION AND OPERATION OF THE COUPLING SYSTEMS USED TO TOW AGRICULTURAL MACHINERY

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ABSTRACT

The paper presents some considerations regarding construction and operation of coupling systems used for tractors to aggregation, for achieve agricultural works.

1. INTRODUCTION

Tractors, trailers and connecting these elements (devices traction / coupling) must meet certain requirements and mechanical strength in terms of traffic safety on public roads in Romania and their acceptance into circulation.

The technical conditions in order to develop new systems of engagement for tractors, trailers and agricultural machines are harmonized European standards in order to increase the degree of interchangeability and safety in circulation, one of the main reasons why it is necessary to study these devices is due to the multitude of accidents caused in operation and circulating through the use of coupling systems are inadequate (tractors or trailers, or between tractors şimaşini farm), which are made in accordance with certain specifications related to the safety and security of traffic [1, 3].

Referring specifically to the case of coupling systems of tractors, trailers and machines designed to work in agriculture or forestry, provided that they are made and meet the same rules lies, on the one hand the need to be able coupling between them all equipment of the same type on the Romanian and European market and on the other hand, the fact that these coupling systems (link) are elements of safety in operation but especially on the road.

Although organizational measures and improving road traffic safety level in road traffic in particular is still far from being satisfactory, still recorded a high number of traffic accidents causing major damages and losses human life. An important role in these accidents transport has represented agricultural and forestry systems tractor - trailer or agricultural machine, although their participation is occasional public traffic [2].

Most of these accidents occur due to inadequate general technical condition or malfunctions safety components, including systems coupling of agricultural machinery and forestry involved. An important source that can provoke incidents and accidents, is the fact that some tractors and are not fitted with the appropriate coupling.

In Romania as well as in other European countries, road traffic, in particular, recorded variations from year to year and from country to country according to the index rise of motorization, the state road network, the country's economic development in general, and especially those of road transport.

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2. METHODOLOGY

Based on studies on traffic, applicable zonal, town and the entire network of roads and localities systematization studies in our country every year road traffic recorded substantial improvements. Despite these measures supported the organization and improving traffic, safety, road traffic in particular is still far from being satisfactory, still recorded a high number of traffic accidents involving significant damage and loss of life.

An important role in this statistic junk transport has represented agricultural and forestry systems tractor - trailer or agricultural machine, although their participation is occasional public traffic. Most of these accidents occurred on the grounds of inadequate general technical malfunctions or safety components, including systems coupling of agricultural machinery and forestry involved.

An important source that can provoke incidents and accidents, is the fact that some tractors and are not fitted with the appropriate coupling. Coupling systems are vehicle-mounted devices gunman and used for coupling and towing trailers and various agricultural and forestry machines fitted with towing eyelets or coupling forks.

3. RESULTS

Tests of resistance of the coupling system between the tractor and trailer, by testing its endurance test on an apparatus under simulated accelerated Hidropuls type (fig. 1 and 2) was studied by [4], together with a numerical simulation of carried out on the mathematical models used the finite element method, the theoretical results coincided finally the physical tests, showing that theoretical modeling of these devices, even basic, it is useful not only in the design of these devices, but even for testing virtual them, with the prospect of replacing physical tests with the numbers, at least partially. Of particular importance is the number of cycles that calculation must take account of fatigue that has grown in recent years from 20,000 to 2,000,000 in order to increase operational safety.

Figure 1. The coupling system tractor - trailer [4]

Figure 2. The coupling system in the testing device on the stand [4]

Static analysis of structural linkage lower link on the tractor using the finite element method was studied in [5], by analyzing the linkage of agricultural tractors using finite element method. The research conducted in this paper presents a new methodology for structural analysis of the lower link of the linkage of the tractor U 650M, using the finite element method is analyzed rod upper link, based on the distribution of displacement of all nodes model stress distribution equivalent von Mises criterion under study and optimization allowing lower link using this easy method.

In [6] the author has studied the influence of linkage on the dynamics of the tractor wheel, the primary objective of the study is the development of theoretical and experimental research on the influence of linkage on system dynamics tractor - machine worn for different types are maşinişi the movement working in various conditions (level ground and uphill).

Suspension mechanisms in the three points used to connect the tractor engine wear, providing a link hinged at three points, both the tractor and the agricultural machine by means of three rods known as tie rods, is placed behind the tractor and, in the latter time and in front of the tractor (front suspension mechanisms). The points of articulation rods (hitch) linkage coupling triangle of the frame of agricultural machinery must ensure the optimum system tractor - machine work and achievement indicators corresponding machine: work quality, productivity and efficiency technological process.

The study of suspensions on a spit in semi farm in aggregate with tractor (Fig. 3) was analyzed in [7], by making a thorough research of the phenomena occurring in aggregate tractor trailer, the effects of introducing the suspension to spit on dynamic behavior assembly and finding ways to optimize the suspension, with application in design.

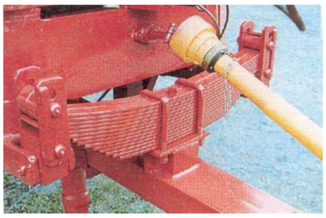

Figure 3. Drawbar with suspension mounted transversely in front of the trailer [7]

In [8] the authors present the ways in which the machinery and equipment in agriculture should be tested in terms of operational performance, determining quality indicators and work safety which protection systems and coupling them provides the operator during operation, protection that provides an environment and life, before being placed on the market to determine compliance. Testing coupling systems (Fig. 4) is performed in laboratories specialized equipment and using metrologically devices checked or calibrated properly.

Figure 4. Drawbar / frame load cell mounted between tractor and towed machine [8]

Research on determining the mechanical strength of a drawbar of a tractor of 20 HP were achieved [9] Also performing endurance tests to determine resistance to breakage thereof, under accelerated the amplitudes and frequencies experimentally established checking whether this type of bar provides the necessary degree of mobility being easy, there were tears, residual deformations or visible external damage.

Also [10] studied the behavior endurance of a bar hauling a 200 HP tractor, when tested accelerated in order to determine the mechanical strength of the bar to see if when tested accelerated after a number of cycles, appeared cracks and deformations can seriously jeopardize the safety on public roads. To establish conditions existing technical perspective and regulated in pursuit of new systems of engagement for tractors, trailers and machinery for agriculture / forestry, harmonized European rules, namely the increasing interchangeability and safety in circulation [11] the authors present the research conducted for this purpose.

The couplings between tractor and trailer must meet the requirements of European standards, namely the rotation horizontally lengthwise and crosswise in [12] authors creating a kinematic analysis and dynamic coupling ball as coupling element between tractor and semitrailer the ball head coupling system that meets these conditions cinematics.

Research on simulation behavior to fatigue bar traction was achieved [13], the authors studied the behavior of the drawbar of a tractor Zimbru 185 HP, fatigue bench (fig. 5) to see if after a minimum of 2,000,000 cycles cracks and deformities that can seriously endanger road safety. In parallel with a program of analysis using finite element method to analyze the fatigue behavior of the bar being simulated calculatorşideterminate points most requested or high risk areas will appear fissures (fig. 6, 7).

Figure 5. Fatigue testing of drawbar on HIDROPULS installation [13]

The results of static finite element analysis enabled us to highlight the stress and strain and the establishment of critical areas:

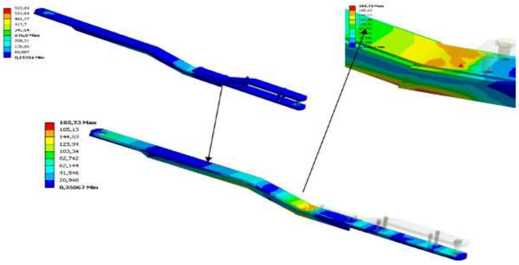

Figure 6. von Mises equivalent stress [13]

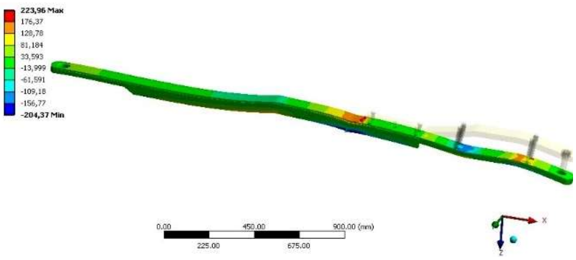

Figure 7. Normal stress,σ_x [13]

To determine and analyze the effects of introducing a system of suspension on drawbar semi-trailers were carried out theoretical and experimental research for three types are proţapuri suspension with resilient leaf spring and one without suspension, in [14], the authors studied the dynamic behavior system tractor - trailer equipped with spring sheets agricultural roasted. Research on the coupling devices have been made over time in the INMA Bucharest [15], [16], [17], [18], as follows:

- Fatigue and endurance testing a "*towing eyelet*" produced by Autonova S.A., part of the whole spit, used to tow agricultural dump trailer RAB 4 (fig. 8) [15].

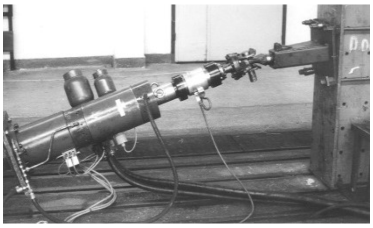

Figure 8. Towing eyelet tested on the stan type HIDROPULS [15]

- Testing "*traction devices for family tractors between 45 and 77 HP*" [16] produced by UTB Brasov for equipping tractors for work in aggregate with various machines. Research on the traction devices in the montages that were performed included several traction devices connected in series, three types of test were carried out:

a) attempt mechanical assembly fork coupling (Fig. 9) aimed at checking the mechanical strength thereof and the mounting configuration - "crankcase rear axle" "housing PTO", "assembly universal support" and "mounting coupling top / bottom ";

b) test the mechanical mounting device with bolt (fig. 10) aimed at checking the mechanical strength thereof and the mounting configuration - "crankcase rear axle", "housing PTO", "assembly universal support" and "device with I bolt assembly".

All three tests have verified the components of towing devices chains component, rear axle housing and housing PTO serving as intermediate elements for catching those chains on the testing stand (Hidropuls type).

Figure 9. The mechanical testing of traction device type mounted on the stand [16]

Figure 10. The mechanical testing of device mounting with bolt on the stand [16]

- Testing "*drawbar*" which uses the tractor towing farm machinery by CEAHLĂU 4601 "(fig. 11) [17].
- Testing "*support the coupling device*" used as intermediate fastening element on the coupling device GEDA tractor fork produced by UTB Brasov. Both assemblies were installed and tested simultaneously test platform installation Hidropuls (fig. 12) [18].

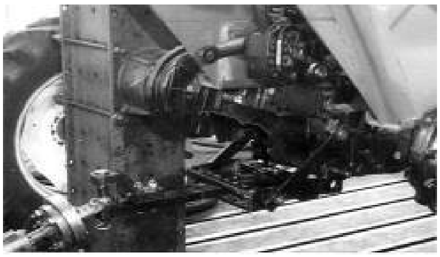

Figure 11. The mechanical testing of drawbar on the HIDROPULS stand [17]

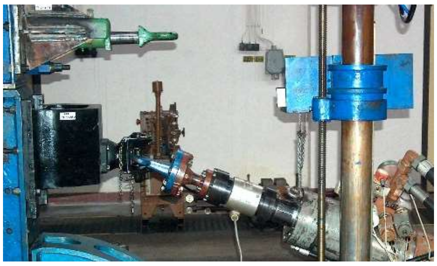

Figure 12. The mechanical testing of coupling device support on the stand [18]

On the world researchers and manufacturers seek to find solutions for optimizing the coupling devices to increase safety and security in transport.

In [19] authors present a method which simulates comportamantul cornering when the tractor (machine agricultural) more towing equipment (fig. 13 and 14). Because the current trend is to use agriculture with large working widths and weights handling these influence by limiting beam steering. The method helps to design steering systems and components coupling system using SolidWorks software packages and CosmosMotion.

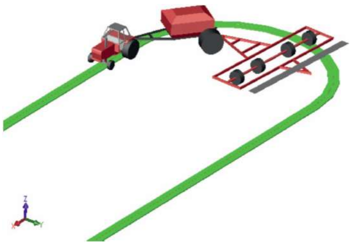

Figure 13. Three-dimensional view of of the bend U-turn of a tractor towing a cultivator and drill [19]

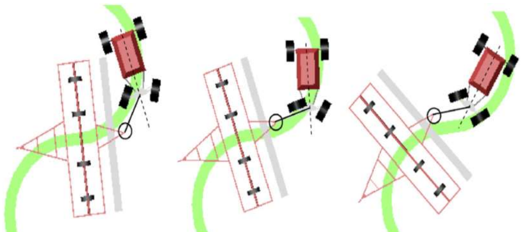

Figure 1. Plan view of a tractor towing a drill while running S-shaped bends (Note: point grip (circled) [19]

In [20] a method for the operational test of a trailer, farm to determine the operational load thereof (Figure 15). Experiments were done in static and dynamic sensors being placed on towing eyelets, components and chassis axle trailer. Experimental results were interpreted using the finite element method.

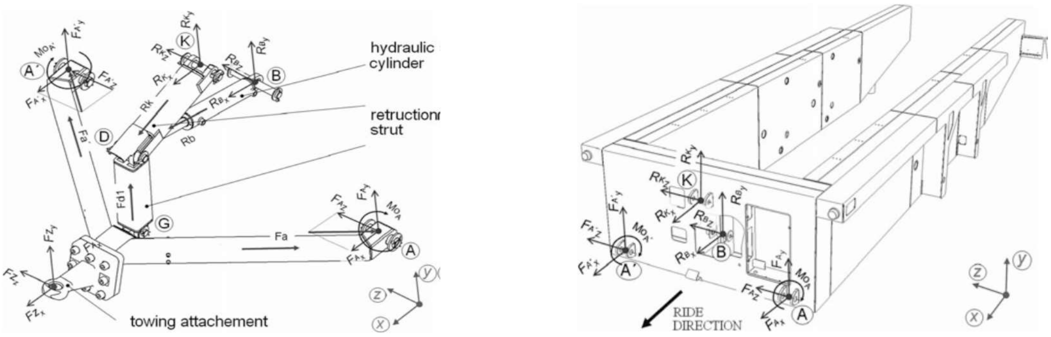

Figure 15. The forces acting on the trailer when towing [20]

A method of measuring the deformation of a towing hook (fig. 19) using finite element analysis has been studied in [21], in order to perform load measuring forces and designed a test. Load monitor the forces acting on the hook was performed using the software package Easy Catman, static deformation is measured by Tritop industrial photogrammetry system. 3D virtual model of the tow to be processed by finite element method was created by reverse engineering using a 3D scanner Atos III Triple Scan. The paper presents the results of FEA, when compared with the photogrammetric measurements on an experimental stand.

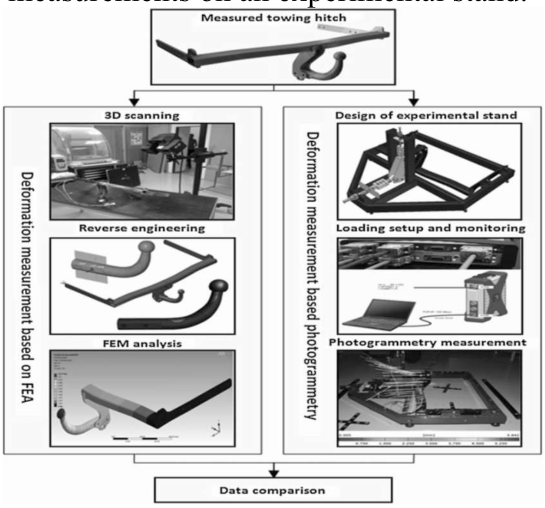

Figure 16. Approaches to analyze the deformation of the hook towing [21]

In order to achieve deculare easier coupling and the tractor trailers, [22] patented a tow hook at the coupling and uncoupling trailers to be done automatically by actuating levers. In [23] the author has patented a solution for a removable towing hook (fig. 17), the invention seeking to provide an alternative form of tow hook which by its design decreases the risk of injury to operators wishing to attach equipment towed and improves the efficiency of the process. An original solution for a tow hook Truck (fig. 18) patented [24], tow truck being movable between a use position where the towing eye extending to the rear of the car in the longitudinal direction of the machine and storage position, in a plane transverse to the longitudinal direction of the machine.

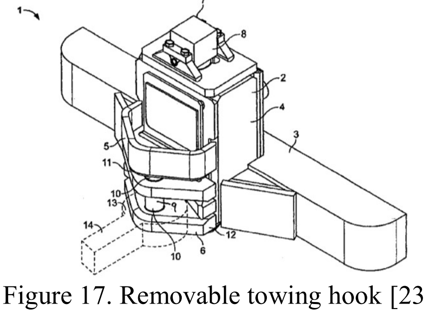
Figure 17. Removable towing hook [23]

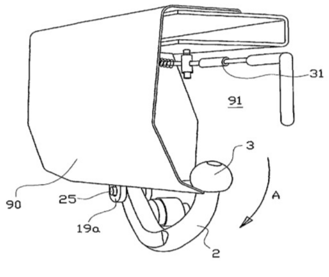
Figure 18. Retractable towing hook [24]

4. CONCLUSIONS

The links between vehicles towing and towed vehicles are mechanical linking of particular importance for traffic safety on public roads, which designed and operated improperly can become generators of traffic accidents due to fracture, in which the towed vehicle remains without control of direction can collide with other vehicles in traffic or other obstacles encountered in their way.

The couplings are mounted on the vehicle gunner and used for coupling and towing various agricultural machinery and trailers equipped with towing eyelets or fork coupling generally kinematic couplings.

Coupling systems of tractors, trailers and equipment intended to work in agriculture, require them to be carried out and meet the same standards on the one hand it should be possible coupling between them of all equipment of the same type on the market and on Furthermore, the fact that these coupling systems (link) are elements of operational safety and especially on the road. Coupling systems, combine to affect the safe operation and movement imposes strict conditions by national and international rules on the construction, operation parameters, installation conditions, etc. which must be strictly observed.

ACKNOWLEDGMENT

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PHYSICAL PRETREATMENTS OF ORGANIC SUBSTRATE FOR ANAEROBIC DIGESTION IMPROVEMENT

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ABSTRACT

Considering the concept of renewable energy that is implemented nowadays very often in correlation to modern society, we focused our attention on the mechanical pretreatment of organic substrate for anaerobic digestion improvement. This process is used to obtain biogas from different types of substrate like organic fraction of municipal solid waste, aquatic biomass, crop residues, animal manure and energy crops suitable for this process. In this context, the paper reviews the mechanical methods that have been studied for pre-treatment of biomass for conversion to biogas through anaerobic digestion process.

1. INTRODUCTION

Anaerobic digestion is a complex process by which different types of microorganisms transforms organic matter under oxygen-free conditions into biogas and digestate. Raw biogas typically consists of methane (max. 60%), carbon dioxide (max. 40%), water vapor and trace amounts of hydrogen sulphide [1].

In order to improve biogas production from lignocellulosic biomass, such as agricultural residues and energy crops, a pretreatment process is necessary, due to the complexity and variability of biomass chemical structures [2].

Lignocellulosic biomass consists of three types of polymers, namely: cellulose, hemicellulose and lignin, these components making resistant to biodegradation. In order to improve the degradation of organic matter and the biogas production from lignocellulosic biomass, physical, biological or chemical pretreatments need to be used [3, 4].

In figure 1 can be seen the effect of the pretreatment methods on the rate of anaerobic digestion process and increase the methane yield.

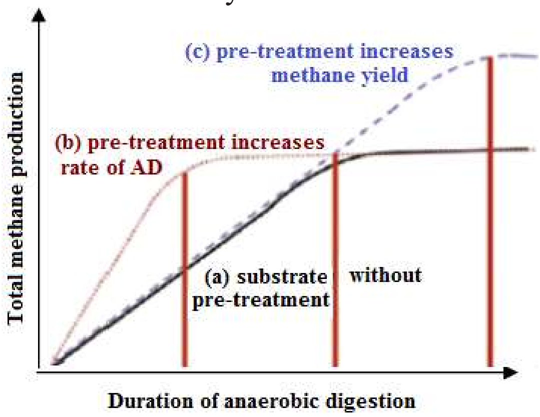

Figure 1: Effect of the pretreatment on anaerobic digestion rate and methane yield (Adapted from [5])

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Liew et al. concluded that the biodegradability of lignocellulosic biomass increased with decreasing lignin content, and if the lignin content is found in a high concentration, the biogas production will decrease [6].

Mechanical pretreatment is used in order to reduce the particle size and the crystallinity of lignocellulosic materials, in order to increase the specific surface area and to reduce the degree of polymerization. This effect can be obtained by a combination of chipping, grinding or milling, depending on the final particle size of the tested material [7].

This paper presents a literature review regarding the mechanical pretreatment of organic substrate for anaerobic digestion improvement.

2. METHODOLOGY

Physical pretreatment includes methods that do not use chemicals or microorganisms during the pretreatment processes. Physical pretreatment includes [8, 10]:

- mechanical pretreatment - comminution (e.g. milling and grinding);
- thermal pretreatment;
- extrusion;
- irradiation (ultrasound and microwave).

Mechanical pretreatment is defined as the crushing of the used feedstock and due to this there is an increase in the surface area which will be responsible for providing better contact between substrate and inoculum [9, 10].

Comminution of biomass is utilized to reduce particle size in order to improve feedstock degradation in anaerobic digestion process for biogas production [11]. Particle size reduction not only increases the rate of enzymatic degradation, it can also reduce viscosity in digesters and can reduce the problems of floating layers [5].

Dumas et al., [12] investigated the effects of grinding processes on anaerobic digestion of wheat straw. They found that the biogas production rate increased from 183.4 to 252.8 mL/gOM/h (+37%) for the particles classes of 759–88 µm. In figure 2 can be seen that the biogas production was not significantly improved by reduction of particle size.

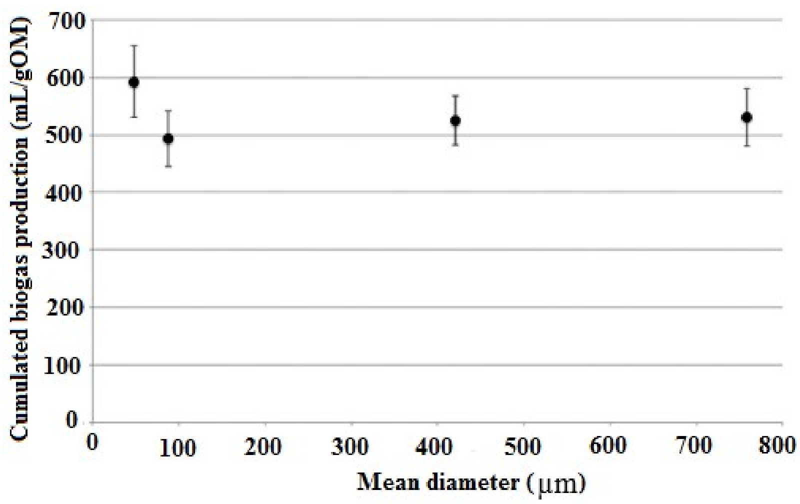

Figure 2: Cumulated biogas production depending on particle size [12]

Hajji and Rhachi [13] studied the influence of particle size on the performance of anaerobic digestion of municipal solid waste, in order to improve the biogas production. Their results showed a high correlation between particle size and the production of biogas, with optimum production recorded for small particle sizes.

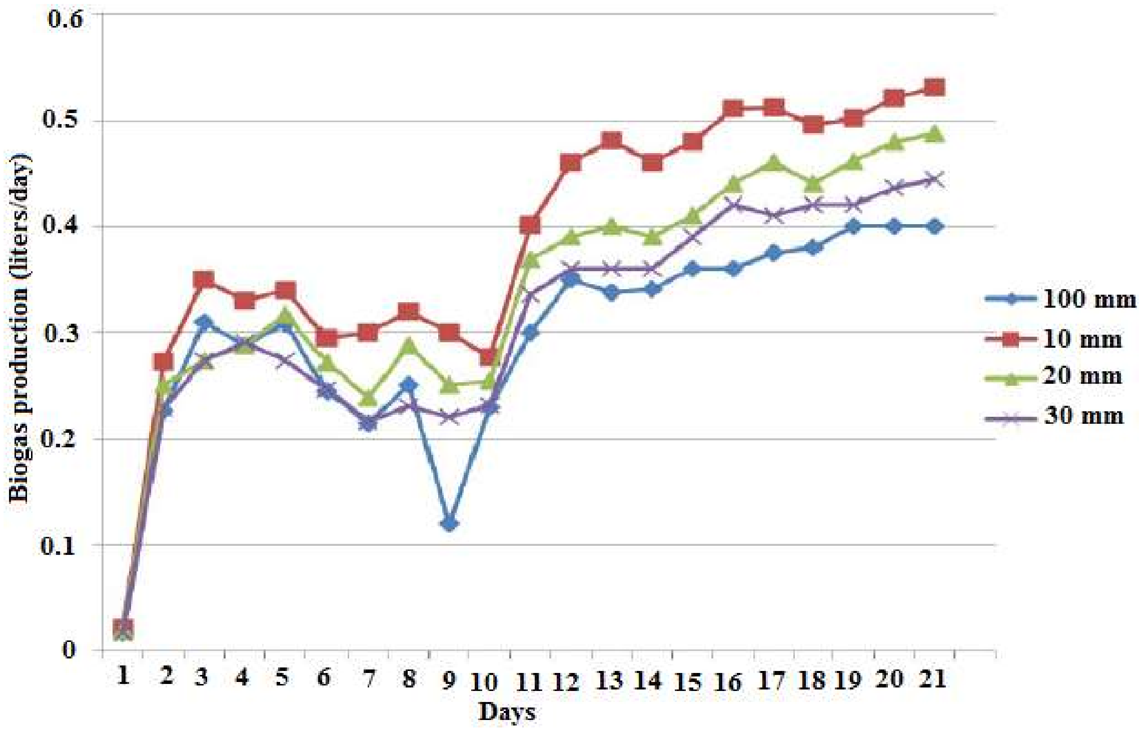

Figure 3: Biogas production as a function of particle size [13]

Considering the high energy requirement of comminution and the rise of energy prices, comminution is currently not economically feasible [14].

Hydrothermal pretreatment by hot water has been applied for the pretreatment of lignocellulosic biomass in the last period.

Steam-explosion is considered to be one of the most effective pretreatment for biomass used in anaerobic digestion for biogas production [15]. In this method, biomass particles are heated with high-pressure saturated steam for a short period of time [8].

This method has been used to treat various types of biomass for enhancement of methane concentration, including corn stalks [16] and Miscanthus (the best result is obtained for pretreatment at 220 °C for 10 min) [17].

Steam-explosion was proved to be effective for increasing methane yield from wheat straw by 20-30%, compared to untreated wheat straw. In table 1 are presented the values of biogas and methane production of untreated and whole steam-explosed wheat straw.

Table 1: Biogas and methane production of untreated and whole steam-explosed wheat straw [18]

	Biogas (l_N kg^{-1} VS)	**CH_4 (l_N kg^{-1} VS)**
Untreated	484.1	275.6
160°C, 10 min.	545.9	314.0
180°C, 10 min.	557.2	310.8
180°C, 15 min.	592.5	330.9
180°C, 20 min.	497.2	295.5
200°C, 10 min.	523.0	305.2

Cotana F. et al. [19] proposed a scheme for a steam explosion reactor coupled with an anaerobic digester for biogas obtaining.

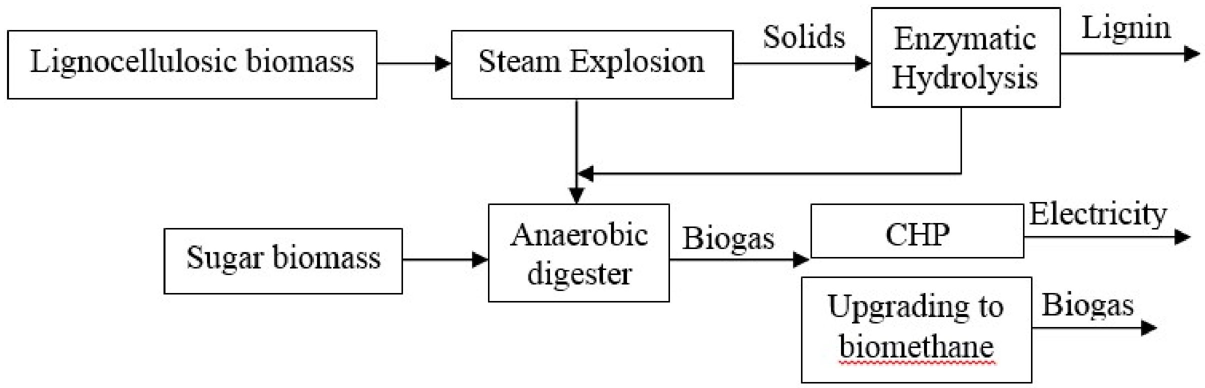

Figure 3: Biogas plant process flow [19]

Panepinto and Genon [20] tested the effect of extrusion pretreatment for the anaerobic digestion process. They observed an improvement that can correspond to values from 0 to 15% from the point of view of the methane production. Also, they concluded that the principal parameter influencing the production of biogas and methane concentration is the quality of the substrate and the suspension that is introduced in the anaerobic digester.

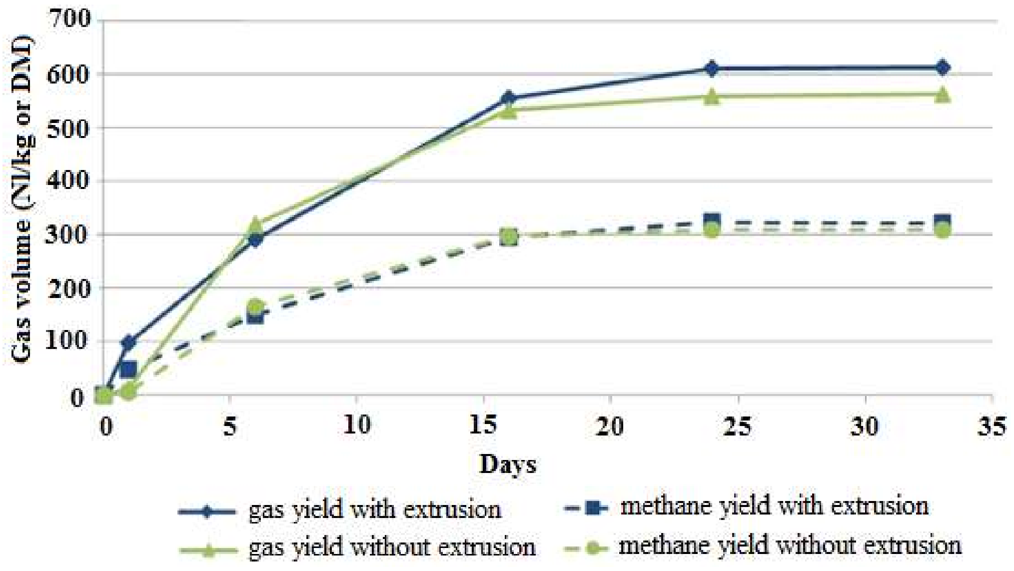

Figure 2: The extrusion influence on gas and methane yield from maize silage [20]

Microwaves are short waves of electromagnetic energy varying in a frequency from 0.3 to 300 GHz, industrial and domestic microwaves ovens operate at 2.45 GHz. Under microwave irradiation, lipids are hydrolysed to palmitic acid, stearic acid, and oleic acid; proteins are hydrolysed into saturated and unsaturated acids, ammonia, and carbon dioxide [21, 22].

Yeneneh A.M et al. [23] compared the effect of microwave pretreatment to combined microwave-ultrasonic pretreatment on anaerobic biodegradability of mixed sludge. They concluded that the cumulative methane production for mixed sludge pretreated by microwave-ultrasonic, was enhanced by 18% compared to microwave pretreated sludge after a retention time of 22 days.

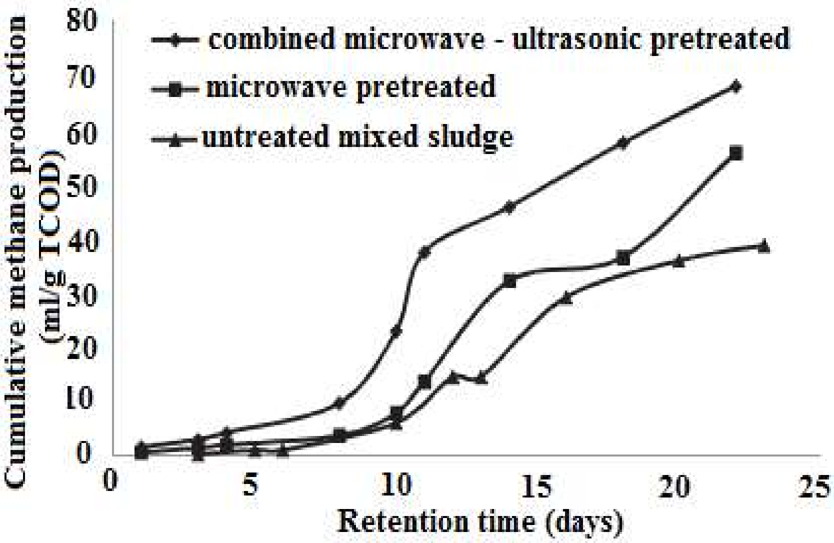

Figure 3: The effect of microwave pretreatment on cumulative methane production [23]

3. CONCLUSIONS

Anaerobic fermentation is an effective biological process used for treating different types of feedstocks for low cost production of biogas.

Individual pretreatment techniques such as ultrasonic, microwave, chemical, thermal, mechanical and biological pretreatment can be applied to increase digester performance. The used pretreatment can decrease crystallinity of cellulose, increase accessible surface area and reduce lignin content.

The pretreatment of feedstock by the reduction of the particles size led to an increase in the production of biogas, but considering the high energy requirement of comminution and the rise of energy prices, this method is currently not economically feasible. Steam-explosion is considered to be one of the most effective pretreatment for biomass used in anaerobic digestion for biogas production.

Concluding, physical pretreatments tend to enhance the biodegradability of most substrates, this aspect increasing the biogas production and the methane yield.

ACKNOWLEDGMENT

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KINETOSTATIC ANALYSIS OF SIEVES ACTUATING MECHANISM AT A CORN MILL TYPE MP42

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ABSTRACT

In the paper is made kinetostatic analysis of sieves actuating mechanism from a corn mill, type MP42, with grinding rollers and two sifting sieves. For a corresponding dimensioning of sieves actuating mechanism elements, it is necessary to know the forces and moments acting on them. For kinetostatic analysis of mechanism shall be reduced inertia and applied forces in the elements centres of gravity, after which it calls the appropriate functions to each structural group in part. Finally, is obtained the motor moment which should be applied in couple *A*, for setting in motion the mechanism. For the correctness of calculation, is determined the actuating moment by virtual powers too.

1. INTRODUCTION

After structural and kinematic analysis of the mechanism, is proceeding to its kinetostatic analysis, i.e at determining the forces and moments acting on the kinematic elements, [1,2,5,7].

Kinetostatic analysis of mechanism comprises several stages, namely, [3,4,6]:

a) kinetostatic study on each modulation group in part,[10];

b) drawing up the calculation program for determining the reactions from kinematic couplings of the mechanism, as well as equilibration moment (motor moment) in the active couple *A*;

c) plotting reaction hodographs corresponding to couplers *A*, *D*, *E*, *G*, *J* and *K*;

d) tabular presentation of reactions from couple *A* for 36 equidistant position of element **1**, as well as the equilibration moment calculated by the kinetostatic method and by virtual powers method, [8,9].

2. METHODOLOGY

In figure 1 it shows the kinematic scheme of sifting system with two sieves from the corn mill MP42. On item 4 of mechanism is mounted the first sieve, and on item 8 is mounted the second sieve.

A. Kinetostatic analysis of mechanism

Kinetostatic analysis of the mechanism starts from the extreme position, ie at position in which the crank and connecting rod of quadrilateral mechanism 4R(1,2,3) lies in the extension, [9,10].

For kinetostatic analysis of mechanism shall be reduced the inertia and applied forces in gravity centres of elements, after which it calls the

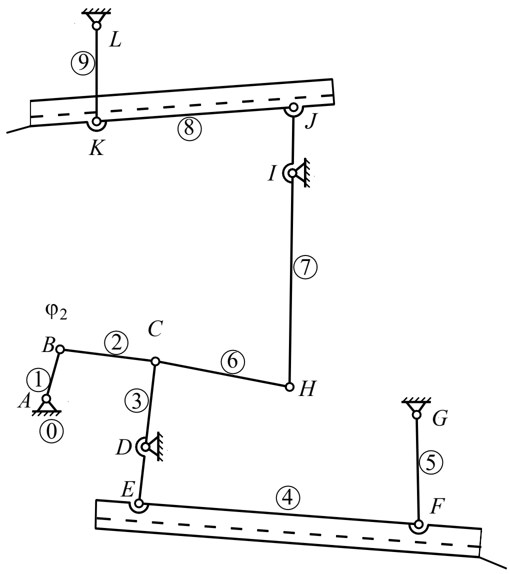

Figure 1. Kinematic scheme of sifting system, with highlighting sieves

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appropriate functions to each structural group in part. It is noted that the kinetostatic analysis sis in reverse with kinematic analysis, ie starting from the last structural group analysed kinematic (dyad *RRR*(8, 9)) and ending with the first group (motor group *R*(1)).

***Dyad RRR*(8, 9)**

On the dyad elements act (Fig. 2.*a*):

- forces of weight: $\overline{G}_8 = -m_8\overline{g}$ and $\overline{G}_9 = -m_9\overline{g}$;
- the resulting inertia forces: $\overline{F}_{i8} = -m_8\overline{a}_{G8}$ and $\overline{F}_{i9} = -m_9\overline{a}_{G9}$;
- the resultant moments of inertia forces: $\overline{M}_{i8} = -IG_8 \cdot \overline{\varepsilon}_8$ and $\overline{M}_{i9} = -IG_9 \cdot \overline{\varepsilon}_9$.

In figure 2,*b* is presented kinetostatic scheme of dyad *RRR*(8,9). Reduction points of forces system it is considered in gravity centres *G*8 and *G*9, of elements **8** and **9**. Kinematic parameters of these points is calculated by using the function **A1R.m**.

Acceleration of reduction points G_8 and G_9, of forces systems, are known through components on the coordinate axis, namely:

$\overline{a}_{G8} = a_{G8X}\,\overline{i} + a_{G8Y}\,\overline{j}$, $\overline{a}_{G9} = a_{G9X}\,\overline{i} + a_{G9Y}\,\overline{j}$; or: $\overline{a}_{G8} = \ddot{X}G8 \cdot \overline{i} + \ddot{Y}G8 \cdot \overline{j}$, $\overline{a}_{G9} = \ddot{X}G9 \cdot \overline{i} + \ddot{Y}G9 \cdot \overline{j}$.

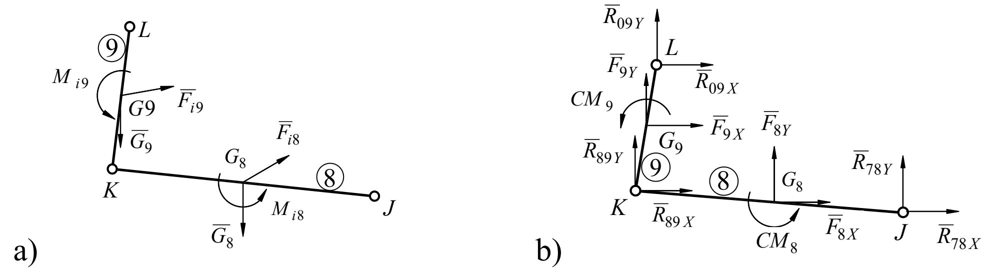

Figure 2. Dyad *RRR*(8, 9); *a)* highlighting the forces and moments acting on the elements of dyad *RRR*(8,9); *b*) kinetostatic scheme of dyad *RRR*(8,9)

Since the acceleration of reduction points are known through the projections on the coordinate axis, results that the inertial forces have the form:

$$\overline{F}_{i8} = F_{i8X}\,\overline{i} + F_{i8Y}\,\overline{j}\ ,\ \overline{F}_{i9} = F_{i9X}\,\overline{i} + F_{i9Y}\,\overline{j}\ .$$

Resultants of the applied forces, of inertia and weight, are of the form:

$\overline{F}_{R8} = \overline{F}_{8X} + \overline{F}_{8Y}$, $\overline{F}_{R9} = \overline{F}_{9X} + \overline{F}_{9Y}$, or: $\overline{F}_{R8} = F_{8X}\,\overline{i} + F_{8Y}\,\overline{j}$, $\overline{F}_{R9} = F_{9X}\,\overline{i} + F_{9Y}\,\overline{j}$.

The projections on the axes of the applied, inertia and weight forces resultants are:

$$F_{8X} = -m_8 \cdot a_{G8X};\ F_{8Y} = -m_8 \cdot (a_{G8Y} + g);\ F_{9X} = -m_9 \cdot a_{G9X};\ F_{9Y} = -m_9 \cdot (a_{G9Y} + g)\ .$$

In report with reduction points, resultants moments are: $CM_8 = -IG_8 \cdot \ddot{\varphi}_8$, $CM_9 = -IG_9 \cdot \ddot{\varphi}_9$

The reactions from kinematic couplings *J*, *K* and *L* are forming the output data of the function **D1RC.m**.

***Dyad RRR*(6, 7)**

On the dyad elements act (Fig. 3,*a*):

- forces of weight: $\overline{G}_6 = -m_6\overline{g}$ and $\overline{G}_7 = -m_7\overline{g}$;
- the resulting inertia forces: $\overline{F}_{i6} = -m_6\overline{a}_{G6}$ and $\overline{F}_{i7} = -m_7\overline{a}_{G7}$;
- the resultant moments of inertia forces: $\overline{M}_{i6} = -IG_6 \cdot \overline{\varepsilon}_6$ and $\overline{M}_{i7} = -IG_7 \cdot \overline{\varepsilon}_7$;
- reaction of element **8** of dyad *RRR*(8,9) on the element **7** of dyad *RRR*(6,7), namely: $\overline{R}_{87X} = -\overline{R}_{78X}$, $\overline{R}_{87Y} = -\overline{R}_{78Y}$.

In figure 3,*b* is presented kinetostatic scheme of dyad *RRR*(6,7). Reduction points of forces systems it is considered in the gravity centres, G_6 and G_7, of elements **6** and **7**. Kinematic parameters of this points is calculated using function **A1R.m.**

Acceleration of reduction points G_6 and G_7, of forces systems, are known through the projections on the coordinate axis, namely:

$$\bar{a}_{G6} = a_{G6X}\,\bar{i} + a_{G6Y}\,\bar{j}\,,\quad \bar{a}_{G7} = a_{G7X}\,\bar{i} + a_{G7Y}\,\bar{j}\,; \quad \text{or:} \quad \bar{a}_{G6} = \ddot{XG6}\cdot\bar{i} + \ddot{YG6}\cdot\bar{j}\,,\quad \bar{a}_{G7} = \ddot{XG7}\cdot\bar{i} + \ddot{YG7}\cdot\bar{j}\,.$$

Since the acceleration of reduction points are known through the projections on the coordinate axis, results that the inertial forces have the form:

$$\bar{F}_{i6} = F_{i6X}\,\bar{i} + F_{i6Y}\,\bar{j}\,,\quad \bar{F}_{i7} = F_{i7X}\,\bar{i} + F_{i7Y}\,\bar{j}\,.$$

Resultants of the applied forces, of inertia and weight, are of the form:

$$\bar{F}_{R6} = \bar{F}_{6X} + \bar{F}_{6Y}\,,\quad \bar{F}_{R7} = \bar{F}_{7X} + \bar{F}_{7Y}\,, \quad \text{or:} \quad \bar{F}_{R6} = F_{6X}\,\bar{i} + F_{6Y}\,\bar{j}\,,\quad \bar{F}_{R7} = F_{7X}\,\bar{i} + F_{7Y}\,\bar{j}$$

The projections on the axes of the applied, inertia and weight forces resultants are:

$$F_{6X} = -m_6 \cdot a_{G6X}\,;\quad F_{6Y} = -m_6 \cdot (a_{G6Y} + g)\,;\quad F_{7X} = -m_7 \cdot a_{G7X}\,;\quad F_{7Y} = -m_7 \cdot (a_{G7Y} + g)\,.$$

In report with reduction points, resultants moments are:

$$CM_6 = -IG_6 \cdot \ddot{\varphi}_6\,,\quad CM_7 = -IG_7 \cdot \ddot{\varphi}_7 - R_{78X} \cdot (YJ - YG7) + R_{78Y} \cdot (XJ - XG7)\,.$$

The reactions from kinematic couplings C_{23}, H and I, are forming the output data of the function **D1RC.m**.

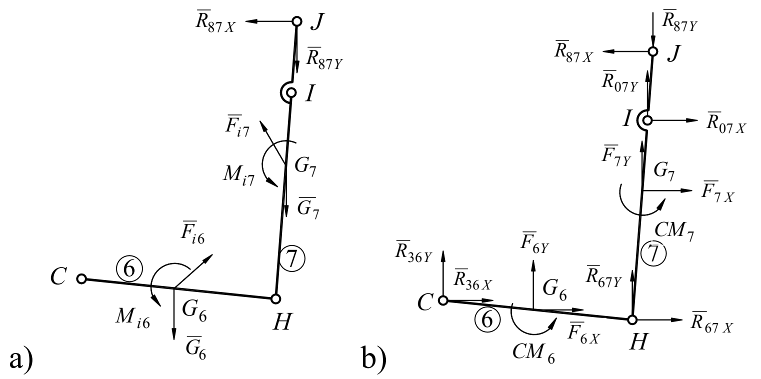

Figure 3. Dyad *RRR*(6, 7); *a*) highlighting the forces and moments acting on the elements of dyad *RRR*(6,7); *b*) kinetostatic scheme of dyad *RRR*(6,7)

***Dyad RRR*(4, 5)**

On the dyad elements act (Fig. 4*a*):

- forces of weight: $\bar{G}_4 = -m_4\bar{g}$ and $\bar{G}_5 = -m_5\bar{g}$;
- the resulting inertia forces: $\bar{F}_{i4} = -m_4\bar{a}_{G4}$ and $\bar{F}_{i5} = -m_5\bar{a}_{G5}$;
- the resultant moments of inertia forces: $\bar{M}_{i4} = -IG_4 \cdot \bar{\varepsilon}_4$ and $\bar{M}_{i5} = -IG_5 \cdot \bar{\varepsilon}_5$.

In figure 4.*b* is presented kinetostatic scheme of dyad *RRR*(4,5). Reduction points of forces systems it is considered in the gravity centres G_4 and G_5 of elements **4** and **5**. Kinematic parameters of this points is calculated using function **A1R.m**.

Acceleration of reduction points G_4 and G_5, being known by components on the coordinate axis, inertia forces have the form: $\bar{F}_{i4} = F_{i4X}\,\bar{i} + F_{i4Y}\,\bar{j}\,,\ \bar{F}_{i5} = F_{i5X}\,\bar{i} + F_{i5Y}\,\bar{j}\,.$

Resultants of the applied forces, of inertia and weight, are of the form:

$$\bar{F}_{R4} = \bar{F}_{4X} + \bar{F}_{4Y}\,,\quad \bar{F}_{R5} = \bar{F}_{5X} + \bar{F}_{5Y}\,, \quad \text{or:} \quad \bar{F}_{R4} = F_{4X}\,\bar{i} + F_{4Y}\,\bar{j}\,,\quad \bar{F}_{R5} = F_{5X}\,\bar{i} + F_{5Y}\,\bar{j}\,.$$

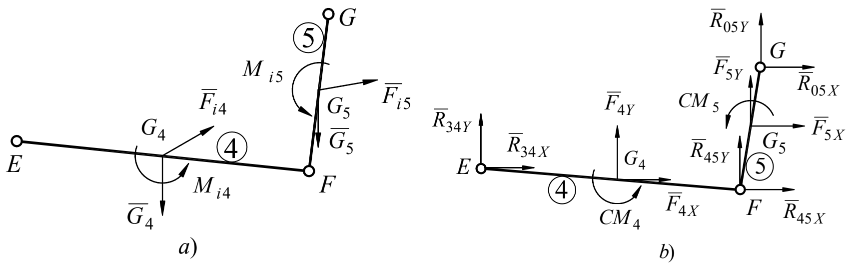

Figure 4. Dyad *RRR*(4, 5); *a*) highlighting the forces and moments acting on the elements of dyad; *b*) kinetostatic scheme of dyad

The projections on the axes of the applied, inertia and weight forces resultants are:

$F_{4X} = -m_4 \cdot a_{G4X}$; $F_{4Y} = -m_4 \cdot (a_{G4Y} + g)$; $F_{5X} = -m_5 \cdot a_{G5X}$; $F_{5Y} = -m_5 \cdot (a_{G5Y} + g)$.

In report with reduction points, resultants moments are: $CM_4 = -IG_4 \cdot \ddot{\varphi}_4$, $CM_5 = -IG_5 \cdot \ddot{\varphi}_5$

The reactions from kinematic couplings *E*, *F* and *G* are forming the output data of the function **D1RC.m**.

***<u>Dyad RRR</u>*<u>(2, 3)</u>**

On the dyad elements act (see Fig. 5.*a*):

- forces of weight: $\overline{G}_2 = -m_2 \overline{g}$ and $\overline{G}_3 = -m_3 \overline{g}$;
- the resulting inertia forces: $\overline{F}_{i2} = -m_2 \overline{a}_{G2}$ and $\overline{F}_{i3} = -m_3 \overline{a}_{G3}$;
- the resultant moments of inertia forces: $\overline{M}_{i2} = -IG_2 \cdot \overline{\varepsilon}_2$ şi $\overline{M}_{i3} = -IG_3 \cdot \overline{\varepsilon}_3$;
- reactions of elements **4** of dyad *RRR*(4,5) on the element **3** of dyad *RRR*(2,3): $\overline{R}_{43X} = -\overline{R}_{34X}$, $\overline{R}_{43Y} = -\overline{R}_{34Y}$;
- reaction of element **6** of dyad *RRR*(6,7) on the element **2** of dyad *RRR*(2,3): $\overline{R}_{62X} = -\overline{R}_{26X}$, $\overline{R}_{62Y} = -\overline{R}_{26Y}$.

Reduction points of forces systems are considered in the gravity centres G_2 and G_3, of elements **2** and **3**. Kinematic parameters of this points is calculated using function **A1R.m**.

Acceleration of reduction points G_2 and G_3, being known by components on the coordinate axis, results that the inertia forces have the form:

$$\overline{F}_{i2} = F_{i2X}\,\overline{i} + F_{i2Y}\,\overline{j}\ ,\ \overline{F}_{i3} = F_{i3X}\,\overline{i} + F_{i3Y}\,\overline{j}\,.$$

Resultants of the applied forces, of inertia and weight, are of the form:

$$\overline{F}_{R2} = \overline{F}_{2X} + \overline{F}_{2Y}\ ,\ \overline{F}_{R3} = \overline{F}_{3X} + \overline{F}_{3Y}\,,\quad \text{or:}\quad \overline{F}_{R2} = F_{2X}\,\overline{i} + F_{2Y}\,\overline{j}\,,\ \overline{F}_{R3} = F_{3X}\,\overline{i} + F_{3Y}\,\overline{j}\,.$$

The projections on the axes of the applied, inertia and weight forces resultants are:

$$F_{2X} = -m_2 \cdot a_{G2X} - R_{26X};\ F_{2Y} = -m_2 \cdot (a_{G2Y} + g) - R_{26Y};\ F_{3X} = -m_3 \cdot a_{G3X} - R_{34X};$$
$$F_{3Y} = -m_3 \cdot (a_{G3Y} + g) - R_{34Y}\,.$$

In report with reduction points, resultants moments are:

$$CM_2 = -IG_2 \cdot \ddot{\varphi}_2 - R_{26X} \cdot (YC - YG2) + -R_{26Y} \cdot (XC - XG2);$$
$$CM_3 = -IG_3 \cdot \ddot{\varphi}_3 - R_{34X} \cdot (YE - YG3) + R_{34Y} \cdot (XE - XG3) + R_{34X} \cdot (YE - YD) + R_{34Y} \cdot (XD - YE)$$

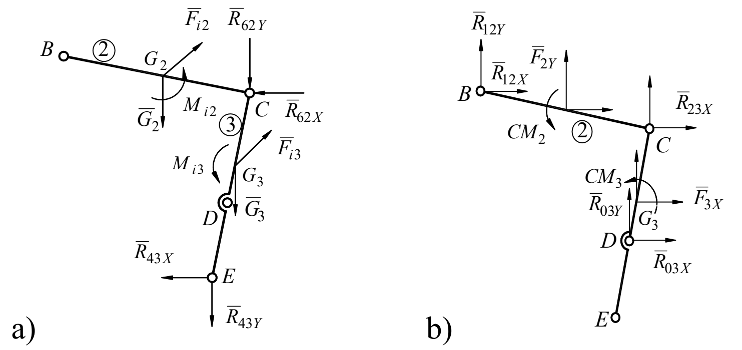

Figure 5. Dyad *RRR*(2, 3); a) highlighting the forces and moments acting on the elements of dyad; *b*) kinetostatic scheme of dyad

The reactions from kinematic couplings *B*, *C* and *D* are forming the output data of the function **D1RC.m**.

***Motor group R*(1)**

On the motor group elements *R*(1) acts (Fig.6.*a*): forces of weight $\overline{G}_1 = -m_1\overline{g}$; the resulting inertia forces: $\overline{F}_{i1} = -m_1\overline{a}_{G1}$; the resultant moments of inertia forces: $\overline{M}_{i1} = \overline{0}$ (was considered $\varepsilon_1 = 0$); reactions of element **2**, of dyad *RRR*(2,3), on the element **1** of motor group *R*(1), namely: $\overline{R}_{21X} = -\overline{R}_{12X}$, $\overline{R}_{21Y} = -\overline{R}_{12Y}$.

Weight and reactions forces resultant is by the form: $\overline{F}_{R1} = \overline{F}_{1X} + \overline{F}_{1Y}$, or: $\overline{F}_{R1} = F_{1X}\,\overline{i} + F_{1Y}\,\overline{j}$

The projections on the axes of the resultant forces are: $F_{1X} = -R_{12X}$; $F_{1Y} = -m_1 \cdot g - R_{12Y}$;

In report with reduction point *A*, resultant moment is: $CM_1 = R_{12X}(YB - YA) - R_{12Y}(XB - XA)$.

Reaction from active couple *A*, as well as equilibration moment *ME* are forming the output data of the procedure **A1RRC.m**.

Equilibration moment (motor moment) in active couple *A* can be calculated, also, with the equation of virtual power, namely:

$$\Sigma\overline{P}\cdot\overline{v} = \overline{M}_{e1}\cdot\overline{\omega}_1 + (\overline{F}_{i1}+\overline{G}_1)\cdot\overline{v}_{G1} + (\overline{F}_{i2}+\overline{G}_2)\cdot\overline{v}_{G2} + (\overline{F}_{i3}+\overline{G}_3)\cdot\overline{v}_{G3} + (\overline{F}_{i4}+\overline{G}_4)\cdot\overline{v}_{G4} +$$
$$+ (\overline{F}_{i5}+\overline{G}_5)\cdot\overline{v}_{G5} + +(\overline{F}_{i6}+\overline{G}_6)\cdot\overline{v}_{G6} + (\overline{F}_{i7}+\overline{G}_7)\cdot\overline{v}_{G7} + (\overline{F}_{i8}+\overline{G}_8)\cdot\overline{v}_{G8} + (\overline{F}_{i9}+\overline{G}_9)\cdot\overline{v}_{G9}\overline{M}_{i1}\cdot\overline{\omega}_1 +$$
$$+ \overline{M}_{i2}\cdot\overline{\omega}_2 + \overline{M}_{i3}\cdot\overline{\omega}_3 + \overline{M}_{i4}\cdot\overline{\omega}_4 + \overline{M}_{i5}\cdot\overline{\omega}_5 + \overline{M}_{i6}\cdot\overline{\omega}_6 + \overline{M}_{i7}\cdot\overline{\omega}_7 + \overline{M}_{i8}\cdot\overline{\omega}_8 + \overline{M}_{i9}\cdot\overline{\omega}_9 = \overline{0}$$

Using the upper relation, results:

$$M_{e1} = (m_1(a_{G1X}\cdot v_{G1X} + (a_{G1Y}+g)\cdot v_{G1Y} + IG_1\cdot\omega_1\cdot\varepsilon_1 + m_2(a_{AG2X}\cdot v_{VG2X} + (a_{AG2Y}+g)\cdot v_{BY} + IG_2\cdot\omega_2\cdot\varepsilon_2 +$$
$$+ m_3(a_{G3X}\cdot v_{G3X} + (a_{G3Y}+g)\cdot v_{G3Y} + IG_3\cdot\omega_2\cdot\varepsilon_2 + m_4(a_{G4X}\cdot v_{G4X} + (a_{G4Y}+g)\cdot v_{G4Y} + IG_4\cdot\omega_4\cdot\varepsilon_4 +$$
$$+ m_5(a_{G5X}\cdot v_{G5X} + (a_{G5Y}+g)\cdot v_{G5Y} + IG_5\cdot\omega_5\cdot\varepsilon_5 + m_6(a_{G6X}\cdot v_{G6X} + (a_{G6Y}+g)\cdot v_{G6Y} + IG_6\cdot\omega_6\cdot\varepsilon_6 +$$
$$+ m_7(a_{G7X}\cdot v_{G7X} + (a_{G7Y}+g)\cdot v_{G7Y} + IG_7\cdot\omega_7\cdot\varepsilon_7)/\omega_1.$$

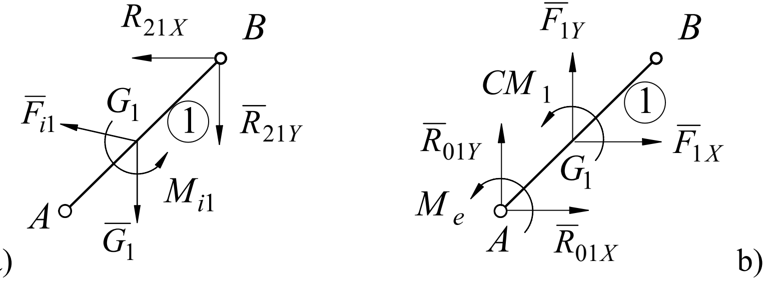

Figure 6. Motor group *R*(1); *a*) highlighting the forces and moments acting on the elements of group; *b*) kinetostatic scheme of dyad

Numerical example

Table 1. The reaction values from the active couple *A*, as well as the equilibration moment values calculated by the two methods, depending on the position of mechanism

pos.	fi1(1)	R01X	R01Y	ME_kinet	ME_vpm
0	0.039861	-1089.953097	-40.919550	0.041149	0.040071
1	0.563459	-875.691121	2.062586	9.380958	9.380955
2	1.087058	-424.790547	6.937770	7.580994	7.580984
3	1.610657	83.751984	-15.470395	-1.660988	-1.660994
4	2.134256	510.221104	-27.355130	-8.329491	-8.329487
5	2.657854	766.180644	-4.900445	-7.031438	-7.031436
6	3.181453	835.459944	41.886030	-0.161392	-0.161392
7	3.705052	751.670770	82.051277	6.650507	6.650506
8	4.228651	526.159970	84.697050	8.532518	8.532515
9	4.752250	126.263988	33.600144	2.549662	2.549667
10	5.275848	-424.610896	-43.395069	-7.648225	-7.648211
11	5.799447	-919.999261	-75.564228	-9.904249	-9.904244
12	6.323046	-1089.944162	-40.919173	0.041150	0.041149

Besides the kinematic scheme, for the kinetostatic analysis of mechanism, is also known: a) Elements sizes and couplings positions adjacent to base, as follow: *AB*=0.020 m, *BC* = 0.200 m, *CD* = 0.16 m, *DE* = 0.11 m, *EF* = 0.620 m, *FG* = 0.340 m, *CH* = 0.450 m, *HI* = 0.800 m, *IJ* = 0.180 m, *JK* = 0.500 m, *KL* = 0.350 m, *XA* = 0.0 m, *YA* = 0.0 m, *XD* = 0.200 m, *YD* = -0.150 m, *XG* = -0.780 m, *YG* = -0.075 m, *XI* = 0.660 m, *YI* = 0.800 m; *XL* = 0.150 m, *YL* = 1.240 m; α = 3.141592 rad ($\alpha = |\angle(\overline{DC},\overline{DE})| = <(\overline{IJ},\overline{IH})$); b) initial position of the mechanism: $\varphi_1 = \varphi_{10} = 0.04$ [rad]; c) angular velocity of element **1**: $\omega_1 = 73.3\,s^{-1}$; d) angular acceleration of element **1**: ε_1=0.0 s^{-2}; e) masses of mechanism elements: m_1 = 0.1 kg, m_2 =0.2 kg, m_3 = 0.5 kg, m_4 =15.0 kg, m_5 =0.1 kg; m_6 =0.5 kg, m_7 = 1.5 kg; m_8 = 10.0 kg, m_9 = 0.1 kg; f) inertia moment of elements, in relation to an axis perpendicular to the plane of movement and passing through the centre of mass: IG_1=0.000003 kgm^2, IG_2=$8\cdot10^{-4}$ kgm^2, IG_3 =$5\cdot10^{-4}$ kg.m^2, IG_4 =2.8 kg.m^2, IG_5 =$9\cdot10^{-4}$ kg.m^2; IG_6 = 0.008 kg.m^2, IG_7 =0.12 kg m^2; IG_8 = 0.8 kg.m^2; IG_9 = 0.001 kg m^2.

Based on the above data it was drawn up a calculation program for determining the reactions from kinematic couplings of mechanism, as well as of actuation moment of it. In the main program were called the calculation procedures mentioned above.

In figures 7, 8, 9, 10, 11 and 12 is presented reactions hodographs corresponding to kinematic couplings *A*, *D*, *E*, *G*, *J* and *K*.

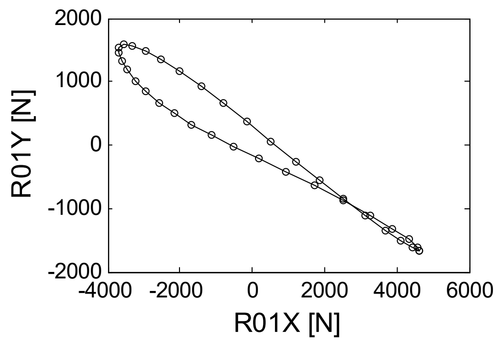

Figure 7. Reactions hodograph from couple *A*

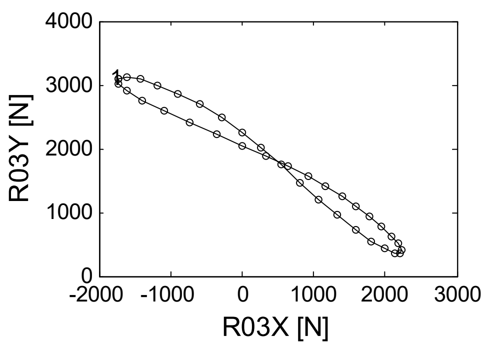

Figure 8. Reactions hodograph from couple *D*

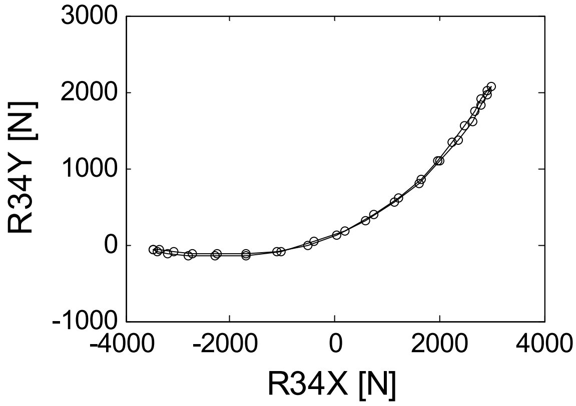

Figure 9. Reactions hodograph from couple *E*

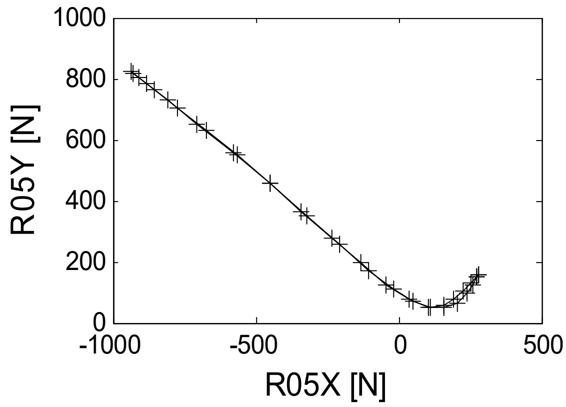

Figure 10. Reactions hodograph from couple *G*

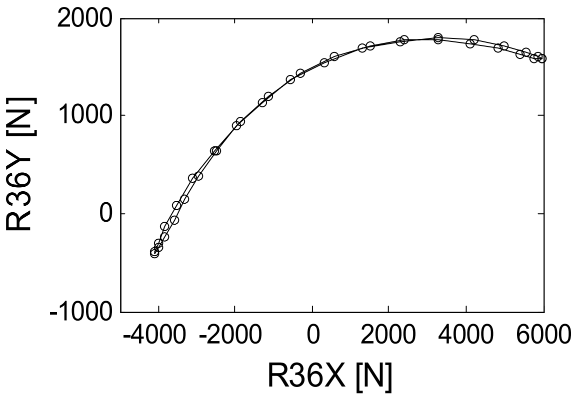

Figure 11. Reactions hodograph from couple *J*

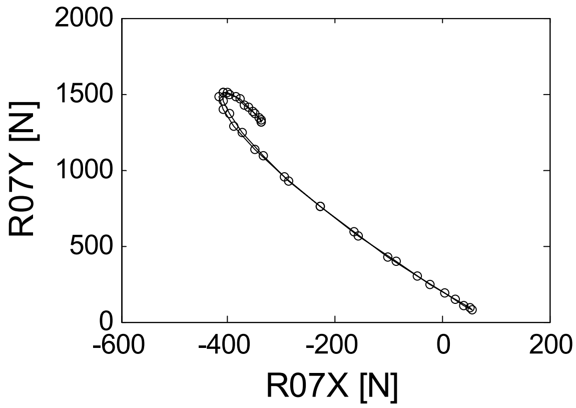

Figure 12 Reactions hodograph from couple *K*

3. CONCLUSIONS

Obtaining values of the reactions from kinematic couplings of mechanism allow passage to the next stage, ie at designing proper kinematic elements. From table 1 it is found that the actuating moment calculated through kinetostatic method and by virtual power method are corresponding to fifth or sixth decimal place, which means that all the calculations were done correctly.

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METHODS FOR DETERMINING THE CHARACTERISTICS OF FLOUR AND DOUGH

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ABSTRACT

Rheological properties of dough from wheat flour are very important both in the kneading and modeling processes, for the production of bread and bakery products. By means of different methods and apparatus may be determined the fundamental principles underlying the mechanical behaviour of the dough, in conjunction with the physical structure of the dough, the molecular structure of the protein continuous phase in the dough and with chemical reactions of functional groups. This paper presents some of the methods currently used in bakery industry for determining the rheological characteristics of the flour and the dough. The Farinograph, the Mixograph and the Chopin are common devices for assessing flour and dough properties during kneading in lab scale.

1. INTRODUCTION

The physical-chemical, biological and technological process of dough affects the operations of kneading and processing, both through the functioning regimes adopted by the machinery on the technological flow and by components of the used recipe (additions of ingredients and additives) [5].

Dough kneading is one of the most important ways to characterize the quality of wheat flour samples. The dough development is a dynamic process where the viscoelastic properties are continuously changing [7].

In milling and baking industry, in order to achieve high quality products, the dough must have an optimum rheology. In terms of rheology, consistency is described by viscosity and elasticity, and the knowledge of these elements has become essential in determining the evolution of quality of food products.

Empirical methods for determining the rheological properties of dough are purely descriptive, the parameters obtained from the sample under analysis are dependent on imposed testing conditions (amount of analyzed flour, the geometry of mixer unit, operating parameters of the device, etc.). However, they are easy to interpret and may represent an important milestone for processors, in assessing the quality of analyzed flour [1].

The farinograph method consists of using a farinograph (Figure 1) representing the film evolution of dough under specific kneading conditions after it was brought to standard consistency of 500 F.U. [11]. The principle of farinograph operation is based on the resistance of dough to the kneader shaft. The resistant moment to the kneader shaft has increasing variation when mixing the components, hydrating of flour particles, dough formation and development, up to a maximum value, close to the value of dough normal consistency. Then, the variation of moment to the shaft, respectively dough consistency remain approximately constant, in the stability phase of the dough which can be maintained for longer or shorter time depending on the characteristics of flour. Graphic recording of the moment (dough consistency) during kneading with the farinograph device is called farinograma [3, 9].

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The mixograph method (Figure 2) measures the kneading characteristics of the dough. In the mixograph, kneading is performed by four vertical bars, attached to a kneading head, rotating the dough into a planetary movement around three fixed straight arms. With the development of gluten is required a gradual increase in the size of kneading force. Maximum capacity for the mixer is 35 g flour.

Figure 1. Brabender farinograph [9]

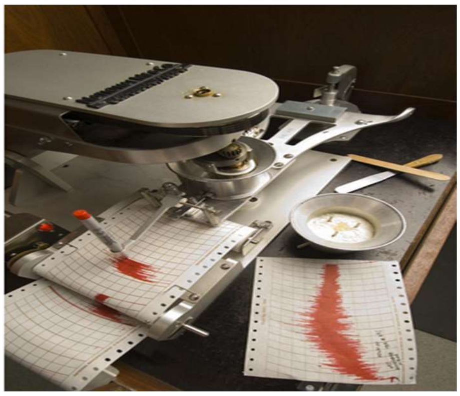

Figure 2. Mixograph [11]

The alveograph method is based on the tensile strength of a dough sheet subjected to air pressure, which inflates under the form of a bubble that grows until it ruptures [1]. The Chopin alveograph (Figure 3) is currently used to determine certain rheological properties such as: tenacity or maximum pressure P, swelling index G, mean abscissa at breaking I and strength energy W [11].

Figure 3. Chopin alveograph [11]

The registration of the alveographic curve may be a hydraulic gauge, or optionally may be used the Alveolink, an accessory performing the recording of alveographic curves and automatic calculation of the values of P, W, L, G, P/L, Ie.

2. METHODOLOGY

2.1. The Brabender farinograph with electronic record has a mixer type Sigma-300 with a capacity of 300 g flour (450-500 g dough) with dual-casing, through which flows hot distilled water at a temperature of 30+1˚C, prepared in an outer recirculation bath. The farinograph is fitted with a special strap used to measure the quantity of water introduced into the kneader, respectively for the hydration capacity of the flour. The mixer has two kneading arms Σ-shaped, which rotate in opposite direction. Resistance opposed by the dough at kneader shaft is transferred to a dynamometer and recorded by computer, which translates this information by displaying a graph. The farinograph curve indicates the rheological characteristics of dough on which is evaluated the quality of flour. The software records measurement data, it evaluates them according to standard methods (AACC, ICC) and prints the farinograph curve with data on the properties of flour and dough [4].

On the farinograph curve (Figure 4) can be read: time of formation or development of the dough, time of stability, the maximum degree of softening of the dough, dough elasticity and flour strength or the farinograph index. On the horizontal axis is the time of kneading from the time of the addition of water, in minutes, such that 10 mm = 1 min [3].

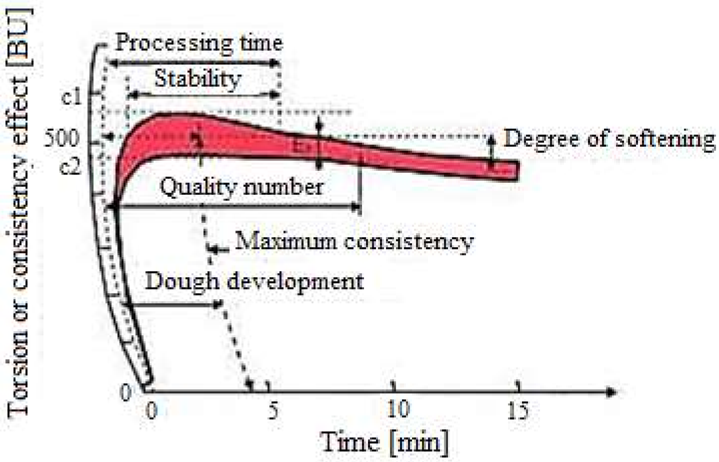

Figure 4. Farinograph curve [1]

Hydration capacity is the amount of water absorbed by the flour to form dough of standard consistency. It is expressed in ml of water absorbed by 100 g flour. Standard consistency is the consistency of 0.5 kgfm or 500 BU (Brabender units). Typical absorption levels for flour used in bread industry are 58-66% [6, 10].

Time of development (formation) of the dough is the time required for the formation of gluten, ie until the consistency of 500 BU.

Dough stability is the time in which the farinograph curve is maintained on a line of normal consistency.

The degree of softening of the dough (the index of tolerance to kneading) is represented by the difference between the consistency of 500 BU and the consistency reached by the curve after 12 minutes from achieving standard consistency.

Volume index of flour (FQN) is an index for measuring the quality of the flour and is measured on the farinograma, on horizontally (in minutes) from the vertical axis of the consistency of the dough to the point where the center line of the curve meets the horizontal line lowered by 30 FU towards the peak of consistency, multiplied by 10 [4].

The rheological characteristics of the dough, made of flour to its absorption capacity, serve to determine the corresponding mixtures of flour, the composition of the manufacturing recipes, as well as setting the parameters of technological regime for the manufacture of bread so as to obtain bread with suitable properties. If the hydration capacity and the characteristics of farinograph curve serve in the formulation of manufacturing recipe, in terms of water dosing and the technological regime, flour strength extremely important in terms of establishing mixtures of flour, so as to ensure for the production a flour of optimal and constant quality.

The criteria for assessing the quality indicators of flour after rheological determinations using the Brabender farinograph are shown in Table 1.

Table 1. Criteria for assessing flour quality by rheological determinations using the Brabender farinograph [1]

Quality parameters	Flour			
	Very high	High	Satisfactory	Unsatisfactory
Capacitate de hidratare [%]	> 65	60 - 65	55 - 60	< 55
Dough development [min]	> 3	2 - 3	1,5 - 2	< 1,5
Dough stability [min]	> 8	5 - 8	3 - 5	< 3
Dough softening	< 60	60 - 80	80 - 100	> 100
Nota farinografică	> 65	50 - 65	40 - 50	< 40

a. For determinations by the ***mixograph method***, 10 grams of flour with humidity of 14% are weighed and placed in the bowl of mixograph. Dough is formed by mixing flour and water, and the mixograph records a curve on graph paper. The moment when the dough begins to develop is indicated by the upward of mixing curve. The mixograph curve indicates the strength of gluten, the optimum time of dough development, and other dough characteristics [11].

Depending on the strength of the flour, the curve can have a maximum defined as a peak or a plateau. After the mixing continues, there is observed a decrease of the mixing curve and the decomposition begins. Dough behavior is reflected in the tail of the curve, when the mixing continues beyond the peak of mixing this is commonly referred to as mixing tolerance.

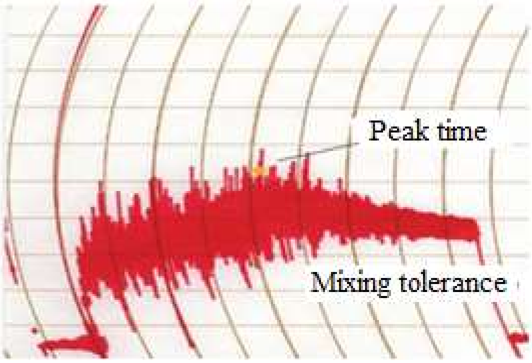

Figure 5. Mixograph curve for flour with low gluten content [11]

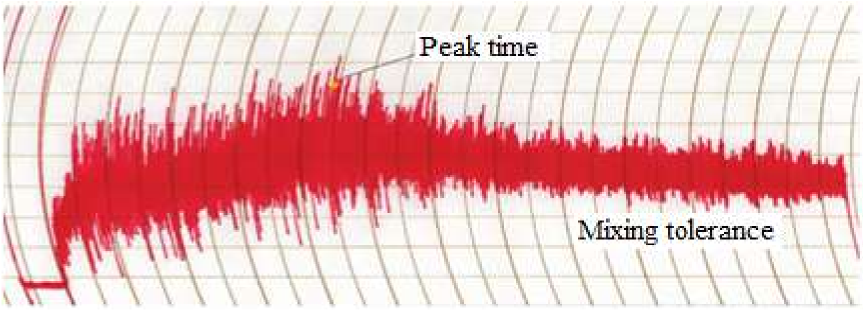

Figure 6. Mixograph curve for flour with high gluten content [11]

Dough with good tolerance will have a broader "window of opportunity" for a baker who will stop dough development until the optimal time. Good tolerance would indicate that the bread dough should be elastic after mixing. The point of optimal development of the dough is maximum in the mixing curve or slightly after the peak. Failure rate shows the stability of dough and its sensitivity to mechanical treatment.

Mixing time is the time required for the optimal development of the dough (the maximum point on the mixing curve or slightly after the peak). By increasing the amount of protein, the mixing time will decrease. Extremely long time for mixing is undesirable because power and time requirements are not economical for a commercial bakery. Mixing for a large period of time it is often associated with hard doughs, which are not developed properly in a mechanized bakery.

Water absorption by flour is assessed visually and depends on the protein content, moisture of flour and the environment. Absorption is used to estimate the time of bread baking..

Type of flour. Wheat quality for good bread is largely associated with the quantity and quality of proteins. A high quality of flour will produce good bread in a fairly wide range of percentages of protein, while a variety of relatively poor quality can produce bread of relatively poor quality even when the protein content is high.

The mixograph is drawn depending on protein content / quality and tolerance. Protein content / quality is divided into three categories: low (less than 10%); medium (10% - 12.9%); high (13% or higher) [11].

b. For determinations by the ***alveograph method***, the following steps are required [2]:

- dough is made from 250 grams of flour mixed with a salt solution;
- five circular balls of dough are formed, with diameter of 4.5 cm, made by mixing and extrusion, followed by conversion into small disks, which are left in standby for 20 minutes in the alveograph, in a compartment with temperature set to 25 ºC;
- each disk made of dough is tested individually. The alveograph blows air into the diskof dough, which extends into a bubble that eventually breaks;
- the pressure inside the bubble is recorded as a curve on graph paper.

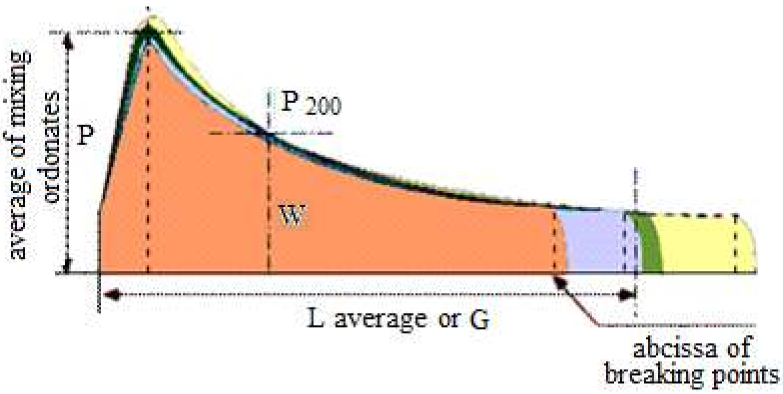

Figure 7. Characteristics of the alveograph [8]

Values of alveograph parameters point to the utility properties of flour. Parameter P gives information on flour elasticity and is related to the consistency, plasticity and water-absorptiveness of a sample. Parameter L is dough extensibility, depending on elasticity of gluten and the ability of dough to hold gases. Parameter G is equal to square root from the air volume necessary to fill in an air bubble. Parameter W characterizes flour strength and is directly proportional to the area of the alveograph. Parameter P/L reflects the shape of the graph and points to utility properties. Parameter I_e is the index of elasticity and it correlates with dough elasticity [8].

3. CONCLUSIONS

Dough strength characteristics are important in assessing the quality of various types of flour and in the selection of raw materials.

Knowing the rheological properties of dough made from bakery flour is useful to specialists in this field, to assess the functional and technological parameters of manufacturing equipment from the technological line.

Dough kneading and shaping plays an important role in making the finished products. Both the farinograph and the mixograph evaluate the behavior of flour during kneading, recording chatacteristics such as: flour hydration capacity, dough development time, dough stability, etc., while the alveograph tests the tensile strength of a sheet of dough subjected to air pressure.

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RESEARCHES ON THE HIGH HARVESTING OF CHAMOMILE INFLORESCENCES

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ABSTRACT

Active principles give a therapeutic value to medicinal plants, and they offer products with beneficial effects on the human or animal metabolism. Many wild species have been taken into culture, thus ensuring increased quantities of drug, necessary for direct valorization or by processing in the profile industries (medicines, cosmetics and perfumes, etc.), but also the possibility to mechanize agricultural works, together with the preservation of biodiversity in the vegetation cover. Thus, mechanized harvesting, applied to these crops, constitutes a guarantee for obtaining a quality plant material as well as profitable yields.

The paper is a continuation of experimental researches conducted within INMA concerning the mechanized harvesting of chamomile inflorescences using different sizes for the active organs. Thereby, it shows the assessment of the high harvesting process, by considering several of its quality indices, achieved using multivariable regression functions, obtained from processing experimental data.

The results of studying the process of harvesting chamomile inflorescences represents a solid base in order to design specific equipment that are efficient and adequate for the conditions in Romania, thus sustaining the revival of chamomile cultivation at national level.

1. INTRODUCTION

Chamomile (*Matricaria recutita L.*) is one of the best known and used medicinal plants, both in human and veterinarian therapy, being intensely cultivated worldwide. It its case, valuable bioactive compounds (chamazulene, bislobol, flavones, etc.) and volatile oil (blue) are found primarily in the inflorescences [1, 5, 8]. Their manual harvesting is performed with a high consumption of work force. That is why, its large scale production, as in the case of other medicinal plants, can be achieved only through the mechanization of the harvesting process. The quality of the plant material obtained from medicinal plants depends at a large extent on the harvesting moment, which should coincide with the period when the accumulations of active principles in the plants is maximized. The mechanization of the harvesting process allows fulfilling this condition [2, 4].

This paper represents a continuation of researches performed within INMA, concerning the mechanized harvesting of chamomile inflorescences, achieved with comb type active organs, with straight and curved teeth. For each type of teeth were achieved several comb versions, differentiated by teeth length, teeth width, the width of the gap between two consecutive teeth, radius of the gap, teeth curvature radius. These scraping combs were mounted one by one on the transporter type harvester. The assessment of the degree of harvesting chamomile inflorescences was achieved by processing the experimental data obtained for the working height H=0.45 m (high harvesting), for the representative versions, for which were registered the highest values for this index.

The harvesting of chamomile inflorescences is an important operation in the production chain, because it has a major impact on the quantity and quality of plant material obtained [2].

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2. METHODOLOGY

The degree of harvesting is the main indicator for the assessment of a harvesting process. In this case, it shows, as percentage, the ratio between the inflorescences detached from plants and the initial number of inflorescences situated in the crop on a 1 m^2 surface. As it was previously stated, several types of combs were used for the experiments, out of which the representative versions were chosen, following the analysis of experimental results. The versions for which the most advantageous values of the harvesting degree were obtained are: version V1 (for combs with straight teeth) and version T2 (for combs with curved teeth).
They are characterized by the following dimensions:

- distance between teeth =4mm (both versions);
- teeth width (V1)=10mm; teeth width (T2)=8mm;
- teeth length (V1)=100mm; teeth length (T2)=80mm;
- curvature radius (T2)=80mm.

The variables used in experimental research, are in most of the times simultaneously dependent of several independent values. Therefore, it is necessary to express this conditioning with an expression of the form:

$$y = f(x_i, a_0, a_i, a_{ii}, a_{ij}) \quad (1)$$

This expresses the dependency of function y to the independent values x_i but also to constants a_0, a_i, a_{ii}, a_{ij}. The problem is complex, its solving requiring the completion of several steps:

- Creating and appropriate program for organizing experiments;
- Determining the values of constants;
- Testing the significance of variables;
- Testing the adequacy of the function's form.[6]

The main characteristics of the experimental program, defined in relation to the requirements to determine adequate functions for the research processes are:

- Compatibility defined in relation to the achievement of a unique solution for the coefficients. The experimental program is compatible when the system of linear equations obtained is compatible, so the main determinant of the system is nonzero. This condition is achieved if the number of different experiments n_* is at least equal to the number of coefficients and if the number of levels in a variable is minimum two.

- Orthogonality defined in relation to the achievement of estimations for the uncorrelated coefficients. Any two variables x_k and x_e are uncorrelated, therefore the program is orthogonal, if is fulfilled the condition: $n\sum_{i=1}^{n} x_{ik}x_{ie} = \sum_{i=1}^{n} x_{ik} \sum_{i=1}^{n} x_{ie}$ (2)

- Verisimilitude defined in relation to the achievement of conclusive values for the indicators for testing the significance of coefficients and the adequacy of the function's form. [6, 7]

In order to determine the coefficients of multivariable functions expressing the degree of harvesting, were chosen the independent variables influencing this dependent variable and their interval of variation. Thus, these are:

- Working speed: v_l = 0.5 – 1.22 Km/h;
- Harvesting height: H=0.3 – 0.45 m;
- Peripheral speed of combs: v_p = 0.52 – 1.08 m/s.

The working (harvesting) height represents the distance from ground level to the longitudinal axis of the inferior drum, on which the band of the transporter type gatherer is wrapped.

Because in a harvesting process, the working (harvesting) height is established and maintained constant, for each of its values (in this case H=0.45m), the qualitative working indexes can usually be determined using two variable functions, dependent on the working speed (v_l=x_1) and on peripheral speed of combs (v_p=x_2), having the form:

$$f(x_1, x_2) = a_0 + a_1x_1 + a_2x_2 + a_3x_1^2 + a_4x_1x_2 + a_5x_2^2 \quad (3)$$

In table 1 are presented the experimental values of the degree of harvesting determined at the constant harvesting height H=0.45m, for versions V1 and T2 for the combs, recorded for different working speeds and respectively different peripheral comb speeds.
Using the values in table 1 and Mathcad program, were determined the coefficients for the two variable function of the form (3). [3]

Table 1 - The degree of harvesting obtained at the height H=0.45 m

No.	Working speed v_l [km h^{-1}]	Combs peripheral speed v_p [m s^{-1}]	Degree of harvesting for V1 la H=0.45 m [%]	Degree of harvesting for T2 la H=0.45 m [%]
1	0.5	0.52	46.8	48.4
2	0.5	0.76	46.9	47.4
3	0.5	1.08	47.2	50.1
4	0.76	0.52	44.8	46.8
5	0.76	0.76	44.6	44.6
6	0.76	1.08	45.2	48.2
7	1.04	0.52	42.2	44.3
8	1.04	0.76	41.5	44.8
9	1.04	1.08	43.8	44.2
10	1.22	0.52	41.8	44.1
11	1.22	0.76	41.7	42.7
12	1.22	1.08	41.8	41.8

For version V1 of combs, at the harvesting height H=0.45m, for a coefficient of correlation R=0983, function (3) representing the degree of harvesting has the form:

$$G_r(v_l, v_p) = 55.842 - 13.307v_l - 9.358v_p + 3.221v_l^2 + 0.437v_lv_p + 6.278v_p^2 \quad (4)$$

For version T2 of combs, at the harvesting height H=0.45m, for a coefficient of correlation R=0.963, function (3) representing the degree of harvesting has the form:

$$G_r(v_l, v_p) = 53.528 + 0.62v_l + 13.695v_p - 0.345v_l^2 - 10.124v_lv_p + 14.323v_p^2 \quad (5)$$

In figures 1 and 2 is represented graphically the variation of the degree of harvesting depending on the working speed (v_l=x_1) and on the peripheral speed of combs, at the harvesting height H=0.45m, using the functions given by relations (4) and (5).
On the axes corresponding to these speeds (x_1 and x_2), appears the number of intervals.

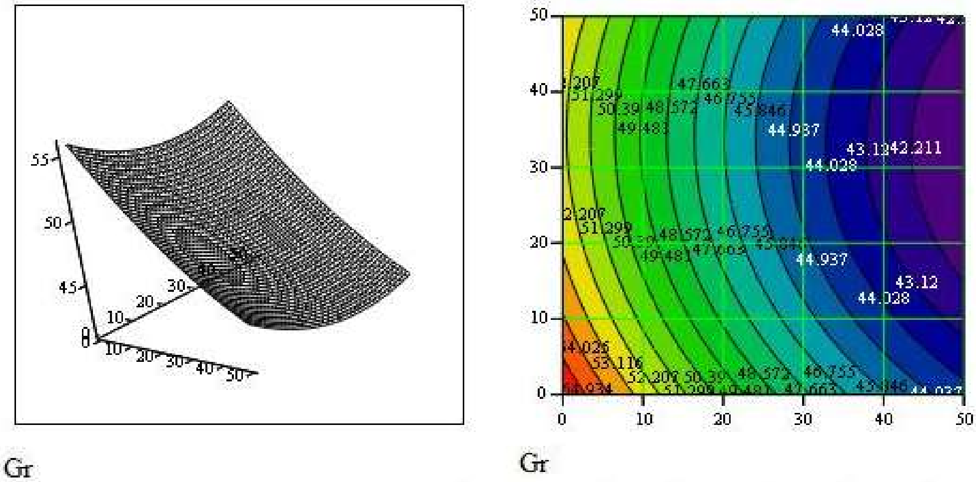

Figure1 Variation of the degree of harvesting (Gr) for V1 depending on v_l and v_p, at H=0.450m

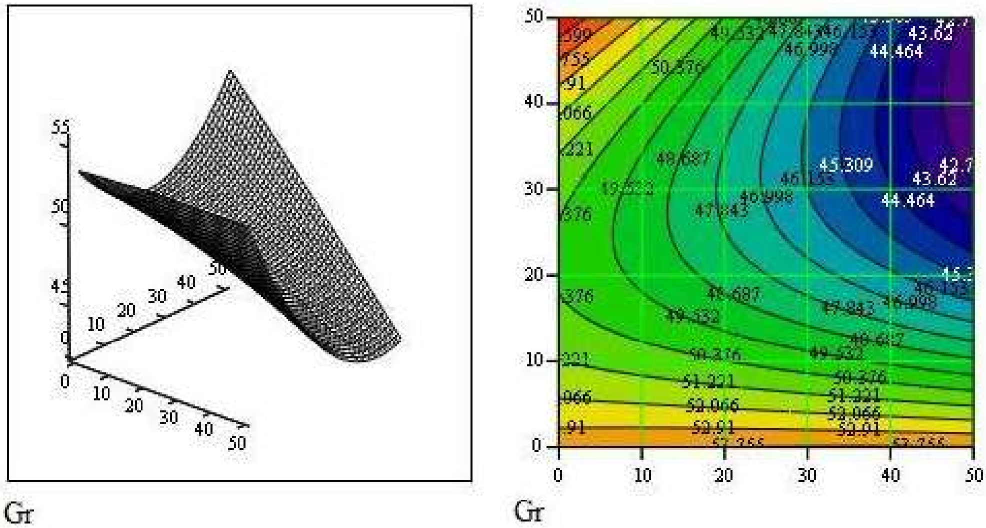

Figure 2: Variation of the degree of harvesting (Gr) for T2 depending on v_l and v_p, at H=0.450m

In figures 3 and 4 was represented graphically the variation of the degree of harvesting for each peripheral speed of combs, (v_{p1}=0.52 ms^{-1}, v_{p2}=0.76 ms^{-1}, v_{p3}=1.08 ms^{-1}), depending on the working speed, v_l, for versions V1 and T2 of combs, at the harvesting height H=0.45m.

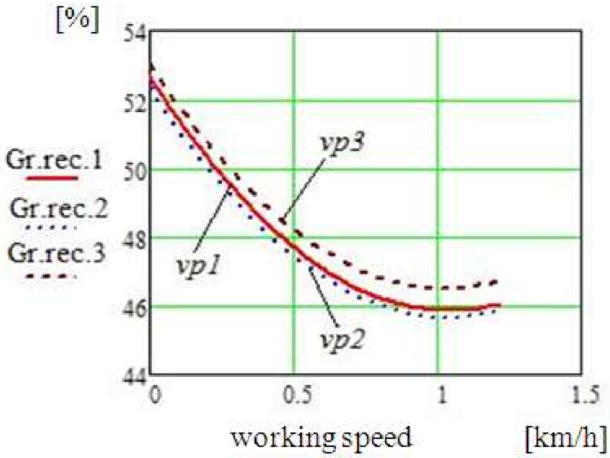

Figure 3: Variation of the degree of harvesting for V1, depending on v_l, at H=0.450m

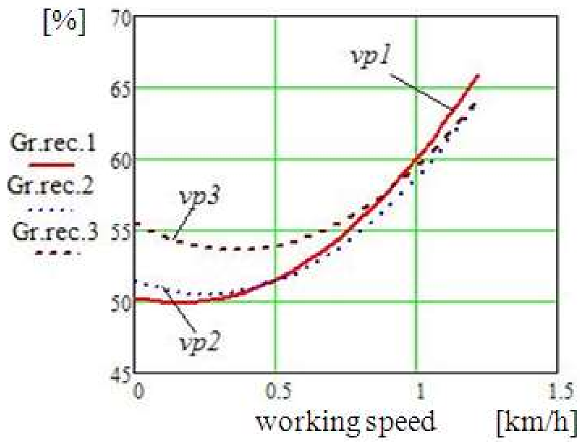

Figure 4: Variation of the degree of harvesting for T2, depending on v_l, at H=0.450m

From figure 3 it is found that the degree of harvesting decreases approximately in the same manner for al peripheral speeds of harvesting combs, depending on the working speed, at the harvesting height H=0.450m. For the peripheral speed $v_{p3}=1.08\ ms^{-1}$, the degree of harvesting has higher values.

From figure 4 it is found that the degree of harvesting increases beginning with the working speed $v_l=0.4kmh^{-1}$, indifferently to the peripheral speed of combs T2, at a harvesting height of H=0.45m. Up to the working speed $v_l=0.9kmh^{-1}$, the degree of harvesting has higher values for $v_{p3}=1.08\ ms^{-1}$.

3. CONCLUSIONS

The analysis of preliminary results from processing the experimental data concerning the degree of harvesting chamomile inflorescences highlights the following aspects:

- The values of the degree of harvesting for version T2 with curved teeth are higher than those registered for the version with straight teeth, indifferently of working conditions (peripheral speed of combs or working speed);
- The values of the degree of harvesting for both constructive versions of active bodies has higher values for their highest peripheral speed, namely $v_p=1.08\ ms^{-1}$;
- For combs with straight teeth, higher values of the degree are obtained at a working speed of approximately 0.5 kmh^{-1}, and for those with curved teeth at working speeds situated between 0.5 and 0.9 kmh^{-1};
- The harvesting of chamomile inflorescences at the height H=0.45m, the so called “high harvesting” is advisable to be performed at the beginning, in the cases where harvesting is performed in two stages. The crop recovers in an interval of 5-17 days, the flowers at la base of plants also reach maturity. Thus, after this period, “low harvesting” can be performed, at a height H=0.3m.

Theoretical results obtained from this analysis constitute an important starting point, in order to achieve efficient equipment for harvesting chamomile inflorescences, adapted to the conditions in Romania.

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OPTIMISATION OF BREAD BAKING PROCESS FOR TUNNEL-OVEN TYPES

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ABSTRACT

Ovens designed for industrial bread-making factories rely on complex scientific processes. The stage of baking bread is extremely important and requires a clear view of the baking parameters, in order to obtain products with the same quality.

This paper presents the results obtained after monitoring the baking process for one type of bread, in the middle of the crumb and inside the baking chamber, using a measuring and data acquisition device for temperature.

The analysis was made on five tunnel-ovens, type Gostol TP1, with the same configuration. Values were registered for the baking process of the same type of bread. It was also registered the gas consumption of each oven, with the purpose of comparing the results and finding the optimal baking diagram. The results of the analysis were introduced in diagrams for baking chamber temperatures, temperatures in the dough piece, gas consumption and product weight loss.

The purpose of this paper is to pinpoint the variations in baking processes, determined by different approaches on the subject and the necessity of a baking process optimisation, from an energetically and economically point of view.

1. INTRODUCTION

Since the baking process constitutes the most energy-intensive operation of bread production, and 30-40% of all bread faults are due to deficiencies during baking, the optimization of the controllable variables merits some consideration. The central object for such considerations is the shaped and proofed dough-piece, and in order to understand what changes the dough-piece undergoes, the baking process must be analysed into the various aspects involved in its technical management [1]. Existing literature tends not to address the link between product and process understanding with the physical engineering principles of an industrial oven [2].

Fresh bread is characterized by a soft and elastic crumb, a brownish crust, a pleasant aroma and a moist mouth feel [3]. During the bread baking process, the dough piece gets transformed into a light, porous and flavourful product under the influence of heat [7]. The quality of the final product mainly depends on the rate and amount of applied heat, the type of baking chamber and the baking time. Some of the physical, chemical and biochemical changes during bread baking include volume expansion, evaporation of water, crust formation, inactivation of yeast and enzymatic activities, protein coagulation and starch gelatinization [8]. The control of the baking parameters like temperature and time combination during baking is an engineering problem that is critical to the successful implementation of commercial flour baking technology [5].

The baking process is the most energy intensive process in the bread manufacturing cycle, consuming an estimated 804 kJ per kg of bread [4], and ultimately determines many of the final physical properties of bread, such as crust colour, crumb texture and taste [7].

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2. METHODOLOGY

The experimental data registered for the analysis of the baking chamber were conducted using a Data Logger type: YC-7, and a dedicated software which transcribed data into diagrams (temp monitor V3), as shown in figure 1.

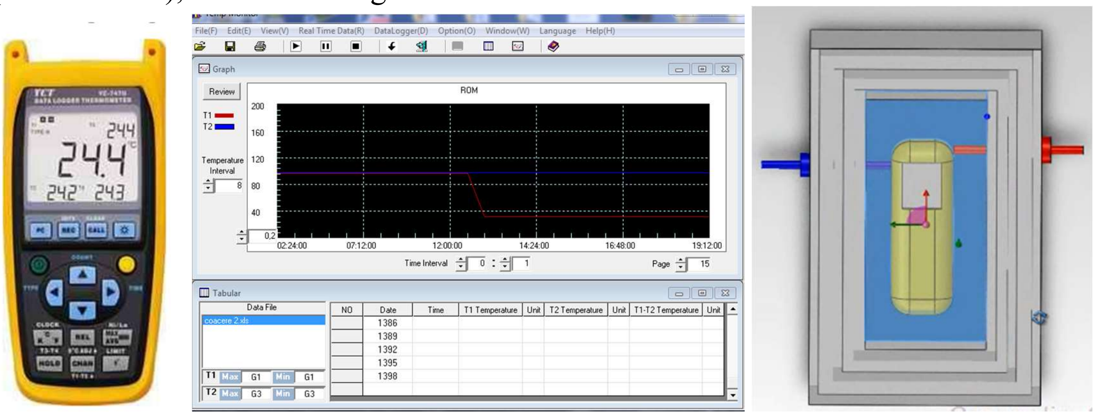

Figure 1. Data logger YC-7 and thermal protection for data acquisition device

The working principle of the measuring method is based on connecting the measuring device to sensors which can measure temperatures up to 1000 Celsius degrees. The device is introduced in a casket with thermal protection up to 400 Celsius degrees (figure 1,b), so as to not be destroyed in the process.

For this paper, five tunnel -oven type Gostol TP1 (figure 2) were analysed and the measurements were taken for the same type of bread. The oven load was 35 pcs/m². The technical characteristics of the analysed oven are presented in Table 1.

Table 1. Technical characteristics for Gostol TP1

Technical characteristics	Area (m2)	Input power (kW)	Total length (mm)	Total width (mm)	Total height (mm)	Thermal input power (kW)
Values	81	19,7	30180	4030	3215	1000

The transport of the products is made with a wire mesh belt (TP). The oven has two burners and heating medium is gas. With the help of sliding flaps and eight regulation areas, the baking diagram can be adjusted manually. The handle of the sliding flap has ten possible positions, with 1-completely closed and 10 -completely open (regulation system for each oven it is shown in Table 2).

Table 2 Setting of sliding flaps for each oven

Oven	**Adjustment sliding flaps**															
	1		2		3		4		5		6		7		8	
	roof	belt	roof	belt	roof	belt	roof	belt	roof	belt	roof	belt	roof	belt	roof	belt
G1	2	6	7	7	7	1	5	8	5	5	7	6	6	6	4	7
G2	2	6	4	5	8	1	6	8	4	6	7	7	6	5	4	3
G3	2	7	3	4	6	3	5	7	6	7	6	5	5	4	4	8
G4	4	9	8	8	9	1	5	7	5	5	6	5	6	6	6	6
G5	4	7	7	7	8	3	6	7	4	6	6	7	5	7	4	7

All the data was registered for white bread of 0.3 kg weight with classic recipe: flour, water (55%), salt and yeast. The physic -chemical characteristics of the flour used for the production of this bread are shown in Table 3.

Table 3. Physic -chemical characteristics for flour type 650

Flour type	Moisture content, [%]	Wet gluten, [%]	Ash, [%] d.s.	Gluten deformation, [mm]	Acidity, [degrees]	Falling number, [sec]	Gluten index
FA–650	13.8	28.4	0.65	3.5	2	323	92

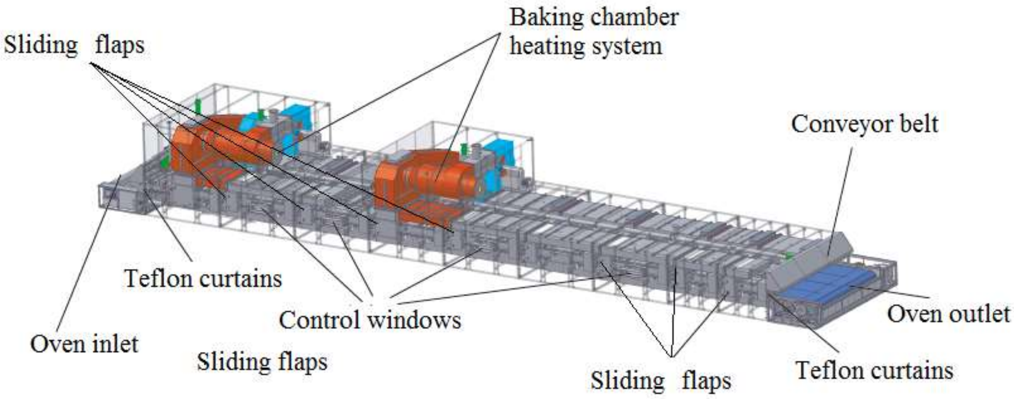

Figure 2. Design of tunnel oven Gostol TP1

All the analysis were done in the same conditions: dough pieces had an average weight of 355 g/pcs, oven load was 35 pcs/m^2, temperature in burner 1 was 300°C and temperature in burner 2 was 280°C and the baking time was set for 18 minutes.

A key parameter of loaf quality that must be monitored is the final core temperature. The definition of 'baked' is an arbitrary one, often determined by the loaf's ability to withstand slicing, but a temperature in the order of 92–95°C at the centre of the loaf at the end of baking is generally accepted as being necessary for the structure to be adequately rigid throughout the loaf, in part because of the loss of water [6]. In most bread and fermented products the foam-to-sponge conversion will have taken place before the product reaches a core temperature of 92–95°C. If the loaf is taken from the oven immediately when this point is reached, it is usually too weak to support its own weight, and so it appears that the continued loss of water contributes to the structural integrity of the product [6].

The end product had to fulfil a few key standard parameters, like: 96°C in the centre of loaf at the end of baking time, crust thickness – 1.5 mm, crust colour – golden brown, on the entire surface, easiness at slicing (when the crumb centre reaches 27°C). Based on what S. Cauvain said in [6], we analysed very closely when the centre of loaf reached 92°C, and based on baking history, it was considered that in order to obtain a loaf of bread with good structure and to fulfil the standard parameters set above, the temperature inside the loaf had to stay above 92°C for more than 25% of the baking time.

In order to evaluate the best energy consumption between the five ovens, a gas meter (figure 3) was mounted at each burner.

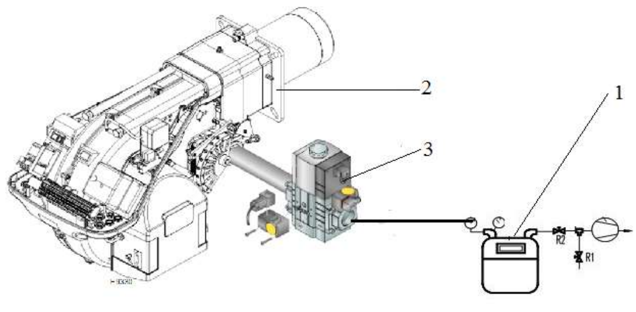

Figure 3. 1. Gas meter, 2.Burner, 3.Gas Regulator.

3. RESULTS AND DISSCUSIONS

The amplitude and temperature dispersion curve in time unit, influence the rise of temperature inside the piece of dough and the speed transfer is different, depending the stage in which the dough-piece is. In Figure 4, it can be seen the oven bread circuit, where *h* is bread height and h_a is dough height at entrance point [9].

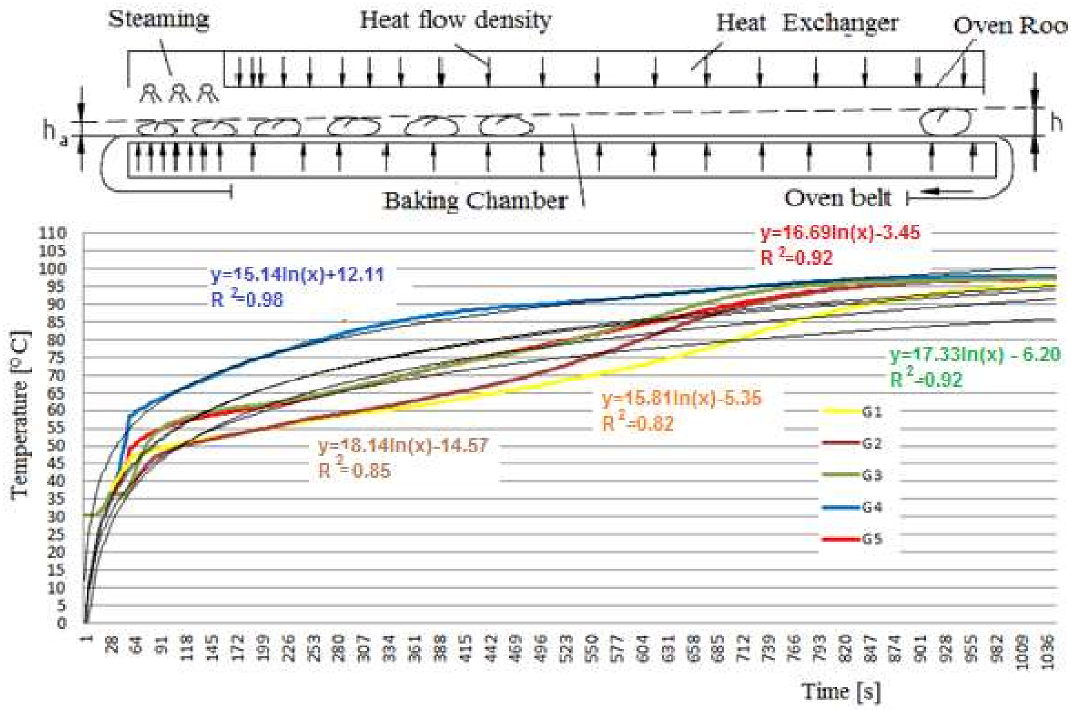

Figure 4. Temperatures diagrams for centre of dough-pieces

In figure 4, it is possible to observe the different amplitude of diagrams described by temperature development in the centre of dough –piece. Even if the temperature inside dough piece is dependant of the temperature in the baking chamber, in the same point, the development of temperature in the piece of dough do not follow in a similar way. It is possible to extract which is the best diagram between those analysed. The temperature in the dough piece for G4 has an ample development and is greater than in the case of the other 4, and this fact is determined by the flow heat, which is bigger in the first part of the baking period.

Regarding the variation of the increase of temperature (T) vs. time t, it is pointed the currency of an empirical, logarithmic equation:

$$T = a \cdot \ln t + b, \qquad (1)$$

Using a logarithmic trend line, we tried to find the optimal development of temperatures inside dough-piece. G4 diagram registered the best development, having an R^2 value of 0.98, which means the values of temperatures for G4 followed very close to the logarithmic trend line.

The values registered for the centre of dough piece were used to calculate the percentage of baking time in which the temperature in the centre of the piece of dough stays above 92°C. The best value was obtained by G4 oven, which had for 43% of baking time, over 92°C in the centre of loaf. The results for all the ovens can be seen in Table 4.

We considered 25% of the baking time, with over 92°C, to be an ideal, set with coefficient 1. The values obtained in the baking processes for the time baking percentage over 92°C were divided to 25%, resulting in the coefficients presented in Table 4.

Table 4. Results on the baking process for each oven

Number Oven	Percentage over 92°C [%]	Weight loss/pc [g]	Gas Consumption [kW/Ton]	Coefficient	Po	Wo	Go
G1	15%	43	350	0.6	25%	71.7	583.3
G2	27%	45	489	1.08	25%	41.7	452.8
G3	33%	49	500	1.32	25%	37.1	378.8
G4	43%	60	550	1.72	25%	34.9	319.8
G5	29%	49	475	1.16	25%	42.2	409.5

The ideal percentage of 25% was generically named Po, the optimal loss weight was named Wo and with Go was named the optimal gas consumption, reported all, to the ideal 25% baking time with temperature in the centre of loaf of over 92°C. In this way, we reported all the values to the same 25%, in order to compare them correctly.

From the analysis of the data in Table 4, it seems that the best results for product weight loss and gas consumption calculated for 25% baking time in which the loaf has over 92°C is registered by oven G4. In figure 7 the values calculated for weight loss and gas consumption can be observed.

In order to test the validity of the analysis above, the oven G4 was used for a baking experiment in which, the same type of product was baked for 16 minutes, respectively 14 minutes. The results are shown in figure 5 and Table 5. The parameters used for the analysis were also kept for this test.

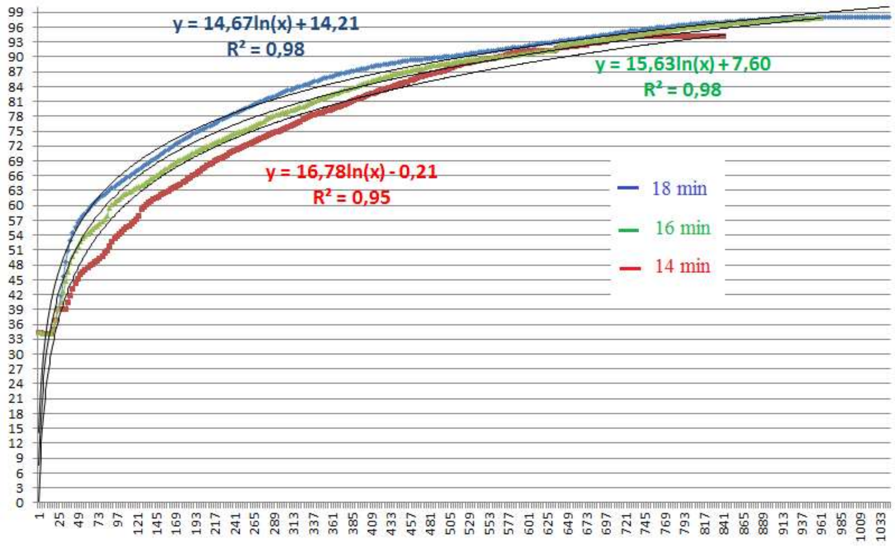

Figure 5. Temperature in the centre of dough piece at 14, 16 and18 minutes baking time

Table 5. Results of different baking time

Baking time [min]	Time exposed [%]	Weight loss [g]	Gas consumption [kW/Ton]	R^2
18	43%	60	550	0.98
16	34%	53	420	0.97
14	27%	40	360	0.95

The third test can be compared to the ideal 25%, due to the 27% of baking time in which the temperature inside loaf was over 92°C. The baking loss weight was 42 g real, and the calculated value for the ideal case was 35g so it results a medium deviation under 5%.

The gas consumption registered for 14 minutes baking, was 360 kW/to and the result calculated was 320, so the medium deviation has remained below 5% in this case too.

Examining the data in table 5, in relation with the experimental points, for each logarithmic equation has resulted $R^2 \geq 0.95$.

4. CONCLUSIONS

Using the same type of oven for the analysis of five baking processes for the same type of bread made in similar technological conditions (the same recipe, similar parameters, the same standard requirements) has shown that, even if the final product meets the standard requirements, there are great differences in the way of getting the wanted results.

The analysis revealed different energy consumption, different weight losses in the final product. This is a consequence of a lack of uniformity in baking parameters, determined by different setting of the sliding flaps and temperature in burner zone.

Acquiring data in the centre of dough piece during the entire baking process made it possible to establish an optimal baking diagram, with a certain trend line. Using a logarithmic trend line, we tried to find the optimal development of temperatures inside dough-piece. G4 diagram registered the best development, having an R^2 value of 0.98, which means the values of temperatures for G4 followed very close to the logarithmic trend line.

In order to find the optimal baking diagram, it was necessary to establish an ideal baking case: for the pieces of bread to be properly baked, it is necessary to keep over 92°C in the centre of the crumb, for more than 25% of baking time. The ideal case was set with coefficient 1 and the measured values were compared with the etalon. A growing temperature in the first baking zone determines a faster reach of set point (92°C); this was possible for G4 oven, in which the heat flow was directed mainly in the first area of baking by opening the sliding flaps to a greater degree (Table 3).

The comparing coefficient between the five ovens, has registered below 5% error (calculus versus measurement) and its accuracy was further tested by changing the baking time from 18 minutes, to 16 and then 14 minutes, for G4 oven, which registered the best baking results. In this case, too, the error was below 5%.

Weight loss and gas consumption can be optimised to 50%, if the baking process is monitored and the baking diagram is correctly set for an optimal exposure to temperature and time.

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CONSIDERATIONS ABOUT SUSTAINABLE POLITICS OF RURAL DEVELOPMENT

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ABSTRACT

As part of the European Community, the rural areas need a clear vision to directing their own efforts and a strategy that highlights the important role to the realization of the potential of absorbtion of European funds. New approaches are needed both to solve the problems of the present and the future. If citizens and the authorities they fail to realize that there is a deep change in the context of the solving of problems at the local level, chances that their reaction to be the right one are very small. The local authorities have the amounts considerably lower than those required, spending money from the budget being restricted by the various requirements. The national authorities are pressed by the major issues faced by Romania at this time. They do not have the time and all the energy to concentrate enough the problems raised by the local communities. A large part of the problems (social problems, environmental and economic development) which were until not long ago sent to the upper levels of the central administration, remain now in the task of local authorities. In this paper we present the sustainable development strategy of a rural location- Mănăstirea Caşin village, which is located near the Natural Reservation „ Bucias".

1. SUSTAINABLE DEVELOPMENT STRATEGY

The Mănăstirea Caşin village is located in the south-west of Bacau county, being crossed the river Casin, the valley between it and the county DJ 115. Perched on the river valley the Casin, Mănăstirea Caşin village, he takes its name from this monastic with the same name, the voivodes of Moldova, Gheorghe Stefan in the year 1653. Common is composed from the villages: Mănăstirea Caşin, Scutaru, Parvulesti, Lupesti (Figure 1) [1].

The development of socio-industrial excessive, carried out after the second world war, did not take into consideration the specific reasons for the protection of the environment and has led to the pollution of the country, of the Bacau county, including the zone of the Mănăstirea Caşin village. It is a truth and the fact that after 1990 the industry has fallen, certain industries even were disbanded.

In any case the effects of pollution week is manifested by drying felling of trees and it has to be said that on the territory of the village there is eroded lands, degradation of having regard as causes soil erosion or landslides field.

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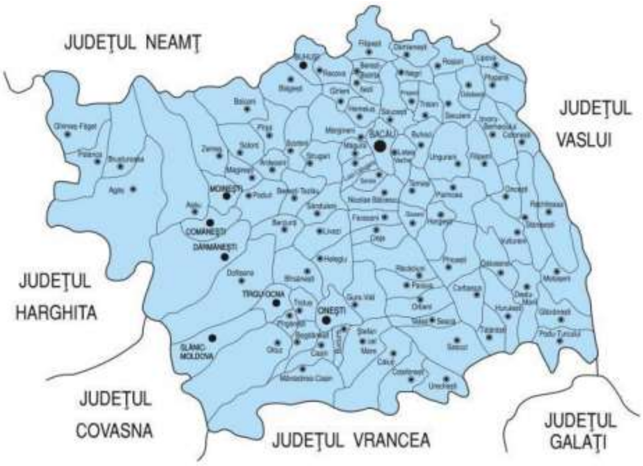

Figure 1: The location of M.Caşin [1]

There are many wonderful places near natural reservation Bucias: the trout Intarcatoarea, which produces annually in about 14 tonnes of fantanel trout, for consumption and approx. 200,000 used saplings indigenous trout intended for populating the waters of the mountain (Figure 2); the Intarcatoare chalet (Figure 3), during the communist period, this chalet was the place for resting, meditation and of restoration for party activists and now this cabin is rented expecially to hunters, where as the Mănăstirea Caşin village has an international renown and field population and many foreigners; the waterfall „Bucias" with a drop of 15 m, located on the creek with the same name (Figure 4).

Figure 2. Trout Intarcatoarea [1]

Figure 3. Intarcatoare chalet [1]

Figure 4. Waterfall Bucias [1]

2. ECONOMIC CONTEXT

The basic component of public policies in the past few years, relaunch of economic growth has become a national priority starting from the importance to both for assuring the conditions for achieving the criteria for accession to the European Union as well as to increase the standard of living [2].

The more so the propagation and continuity at the local level these policies, the involvement of local factors and of the representatives of the civil society have become more and more visible in the process of elaboration and implementation of the programs for development of socio-economic, regardless of whether the financial resources are provided by the governmental funds of funds from internal private or by co-financing and loanes foreign affairs. The profile of the economic is predominantly agriculture, exemplified in fact if not by the weighting of the occupied population in this field, as chosen by the way of life and the specificities of the localities components. This economic profile has been prevailed in the periods of the previous historical, has been altered in the period 1952-1990 because of the occupational dynamics of the population, which has been facing toward the other economic activities which have polarised interests and has attracted the labor force. Orientation toward the industrial activities and economic, other than agriculture, has been diminished gradually after 1992 and denotes a certain orientation of the population by traditional activities.

The restriction of the industrial activities, the effect of economic reform has led to the return in the locality of the work force readily available which was pointing toward the occupations and occupations, services required by the market economy.

Mănăstirea Caşin village has an area of administrative 24.327,43 ha, from which the 2.793,84ha, agricultural land which is divided into the use. Arable land is used for the cultivation of maize and vegetables, in personal households, gardening, fodder plant species. Grassland and highland represents the main support for rearing animals (sheep and cattle, horse). The area of land covered with forests are of 21.533,59 ha. Timber resulting is used for the construction, trade or as fuel, either for export.

3. THE ANALYSIS OF THE LOCAL AGENDA 21 ASPECTS

During the years, on the Manastirea Casin area there economic agents polluters: softwoods. Due to these softwoods can meet illegal deposits of dust located near to heat dangerous sources (Figure 5). Household waste from households, that is not eliminated by burning is deposited in own trash pits. Now, after implementation of the new rules for selective waste collection, the polulation must put the garbage in the special garbage bins. The animal waste is deposited in their own platforms from which to carry on the field.

Figure 5. Illegal deposits of dust

Others sourses of pollution are: the households of the population as the source generating the waste, the emissions from heating systems, the road traffic, dry latrines and wells may affect aquifers, unauthorised storage areas of household waste.

Natural hazards in the territory of the M. Casin are the Casin river floods and the river Saratelul. There are many cases of pollution of the waters river with waste of plastic.The population use the water from natural fountains, but exists the danger of the degradation of the groundwater due to the uncontrolled storage of household trash, because there isn't sewerage system. The interest of the local authorities for the rigorous application of the legislation on the protection of the environment exists, but it is insufficient ecological education and insufficient financing for projects of the environment.

The solutions for successful implementation of the strategic plan for local economy can be identified in Agenda 21 of the village (Figure 6) [3]: the transformation of the strategic plan in the annual operational plans; to grant special attention to the participation of the strategic planning process to every member of the local administration; compliance with ranges of implementation of the strategic plan; diversification of services by attracting investors in the sector of non-farm; increase of the attractiveness of the village for investors by placing at the disposal of land for industrial parks; the creation in partnership courses for the development of business, as well as management and marketing of small-business programs; access the development of information and counselling; the creation in partnership courses of marketing of small-business and entry into distribution networks regional and national of products; the creation of a center of storage and the wholesale trade of agricultural products; the creation or extension of the fair market or the marketing of agricultural products and/or animals; stimulating the associativeness through the organization of meetings of presenting the advantages of association; the creation in the partnership at an office of information and consultation entrepreneurship; The creation of a concept for the promotion of the tourist potential of the area and the development of information campaigns on the objectives of the former Mănăstirea Caşin, The Buciasi, Intarcatoare; arrangement of tourist routes and posting the indicator guidance to tourist attractions of the district; stimulation of local initiatives to create employment; the attraction of the initiatives of social economy, including by accessing the European funds; partnership with non-governmental organizations on the organization of training courses at the local level; the clarification of the legal situations of persons disadvantaged; inform employers about the benefits of the programs for the social economy; information campaigns and health education conducted by medical personnel; more access to information for the citizens of the village; expanding services for the collection of household waste at the level of the village; development of a program of sewerage system at the level of the village; the constuction of a wastewater treatment plant; initiating a program of evaluation of the quality of the water; the creation or extending the network of water from the village. The access of population to need life resources is different: access to drinking water (Figure 7); access to electrical energy (Figure 8); access to medical assistance services (Figure 9); the status of roads (Figure 10) etc.

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Figure 6. Local 21 Agenda

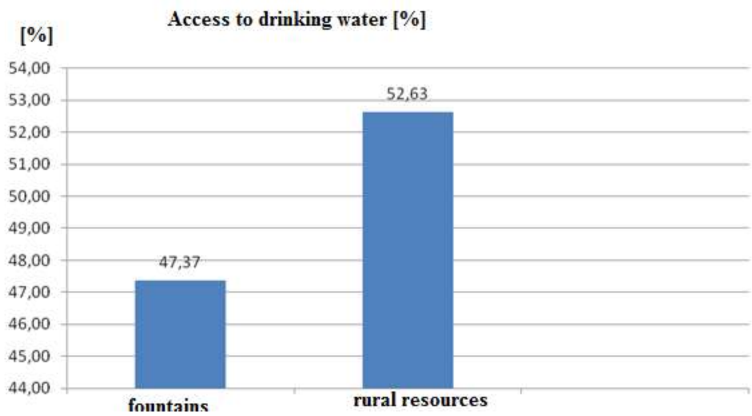

Figure 7. Access to drinking water

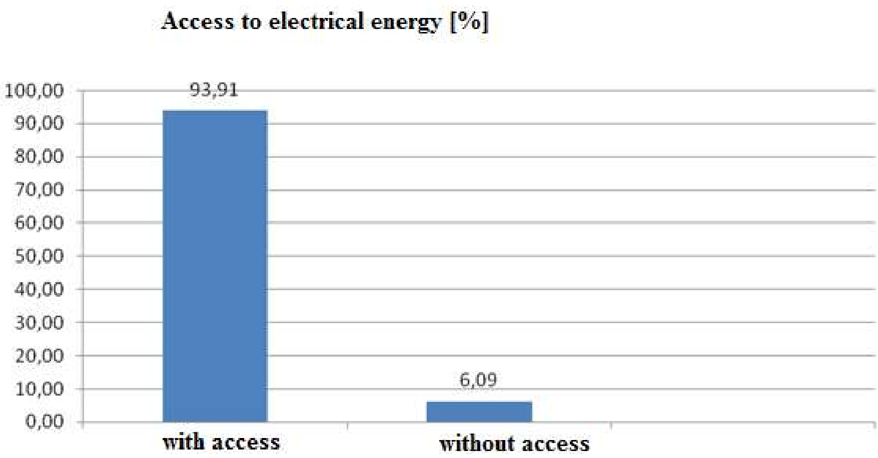

Figure 8. Access to electrical energy

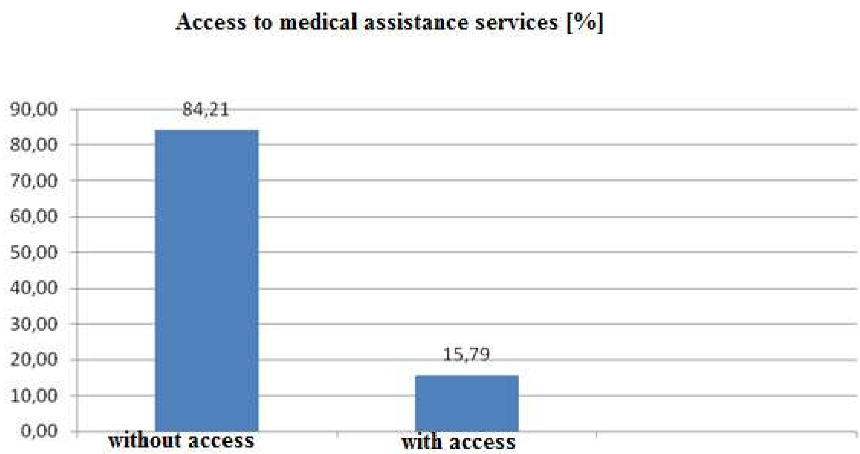

Figure 9. Access to medical assistance services

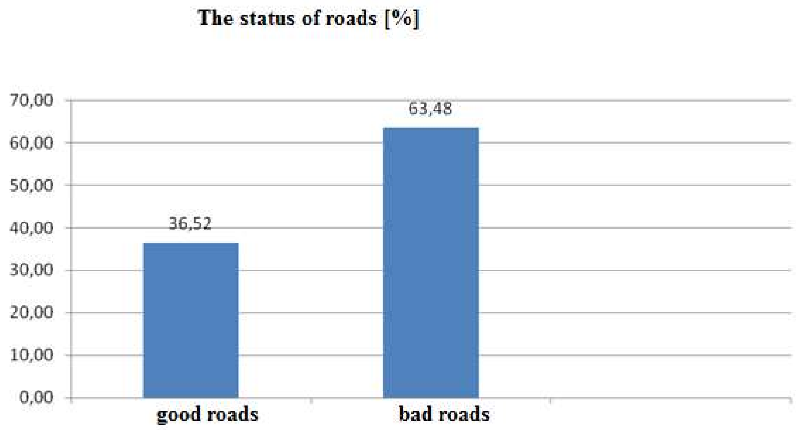

Figure 10. The status of roads

4. CONCLUSIONS

Strategic directions of development will be: lies in raising the welfare and quality of life of citizens of the village Mănăstirea Caşin. In order to achieve this strategic objective have been established six major directions of development: 1) development and modernization of the infrastructure; 2) to create an local economic environment attractive and competitive; 3) creation of employment and social inclusion; 4) an increase of education quality, access to the health sector, the culture sport and information; 5) environmental protection; 6) good governance at the local level. For each direction will be identified specific objectives with indicators for expected results.

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APPLICATIONS OF IMAGE PROCESSING ALGORITHMS IN THE AGRICULTURAL SECTOR

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ABSTRACT

This paper presents general aspects of recognition and processing algorithms of images, depending on the color, shape or position. Work also includes a summary of the main stages of realization and implementation of algorithms for image processing and recognition, both of the acquired in real time, as well as those previously purchased for analysis and later processing.

INTRODUCTION

Image processing has been proved to be effective tool for analysis is in various fields and applications. Agriculture sector where the parameters like canopy, yield, quality of product were the important measures from the farmers' point of view. Many times expert advice may not be affordable, majority times the availability of expert and their services may consume time. Image processing along with availability of communication network can change the situation of getting the expert advice well within time and at affordable cost since image processing was the effective tool for analysis of parameters.. The analysis of the parameters has proved to be accurate and less time consuming as compared to traditional methods. Application of image processing can improve decision making for vegetation measurement, irrigation, fruit sorting, etc. [1]

METHODOLOGY

Image processing represents the process of modifying the properties of images in order to extract relevant information to the user. Evolution of computerized imaging technology allowed the implementation of a large number of fields, including agriculture.

There are known several methods image processing, as follows:

Image restoration aims to eliminate distortions which affect the image distortion due to known physical phenomena, mathematically modeled or estimated.

Image segmentation; realize separation of uniform regions of interest in the image. Uniformity is a general concept; it does not reduce to the consistency of gray levels (the same texture, the same properties, etc.).

In the case of computer graphics, it starts from a description of the image, aiming at the most general case, synthesis of a realistic image. Obtaining the realistic image, is translated by a sequence of algorithms that "close" image synthesized from the real one.

Contour filling algorithms; realize complementary operation to contour extraction, while expansion is complementary to thinning operation.

2D reconstruction restores plane section of the body studied from a set of 1D projections in different directions, of the section. Having available several such sections (parallel or radial), of the studied body, can be achieved 3D reconstruction of the studied body. The reverse is called 2D projection.

Shape recognition, is a commonly used way to extract information from images acquired. It is a broad field that includes handwriting recognition, human face recognition, fingerprint recognition, etc. Shape recognition consist in a classification, and / or a description of the image content. [2]

Further it is presented a system able to differentiate the crops of weeds and buy video frames in real time system mounted on a sprayer in field crops. Figure 1 shows an example of the type of image frames obtained. As can be seen from the figure, the frames captured can vary greatly in illumination, soil background and crop/weed coverage, all of which are uncontrollable outdoor situations to which the image processing should be robust. Moreover, the image processing will have to deal with the issues raised by the displacement of the tractor through an irregular terrain, which can cause blurry images and even sudden displacement of the angle of view.

Figura 1: Example of the type of image frames obtained

Real-time image processing at 25 fps means that each frame has to be processed in 0.04 s. However, due to the difficulty of the task at hand, a simple exploration of the image will not be sufficient to extract the entire crop and weed pixels precisely. Therefore, the proposed image processing method is divided into two different steps. The first step (Robust Crop Row Detection, RCRD) includes all of the operations necessary to detect the crop rows correctly under all circumstances, regardless of the processing time needed. That information is then passed to the second step (Fast Image Processing, FIP), which adapts its results to the current frame.

RCRD detects the crop rows pixels, creating a reference image, Crop Rows, which will then be used by FIP (Fast Image Processing). This reference image is essential not only to guarantee the precision of the results but also to prevent all sorts of errors. Because RCRD is time-independent, several frames will be captured while RCRD is still busy processing previous frames. These frames are stored, waiting for RCRD to be ready for a new processing. Then the first step of RCRD is to combine all of the stored binary frames into a single image with an AND operation. The AND operation yields an image where only the persistent vegetation pixels are kept. Vegetation pixels that persist over a set of consecutive frames, given the movement of the tractor, will mostly be crop rows pixels, except for some weed pixels if a large weed patch is encountered. Figure 2 shows RCRD results on three different input frames.

Figura 2: RCRD results on three different input frames

Finally, once the crop rows are extracted, weed pixels can be determined simply as all other pixels that were part of the vegetation after segmentation and are not considered crop. Figure 3 shows the final result of the whole system on 4 different input images (crops in green, weeds in red) that represent a variety of situations. The proposed methods were implemented in the C++ programming language and compiled as DirectShow filters, to enable their use in Windows platforms directly, using pre-installed applications like GraphEdit. All of the video capture and processing was performed using a mid-range laptop computer (Intel dual core T2400 CPU, 1.83 GHz, 1Gb Ram). [3]

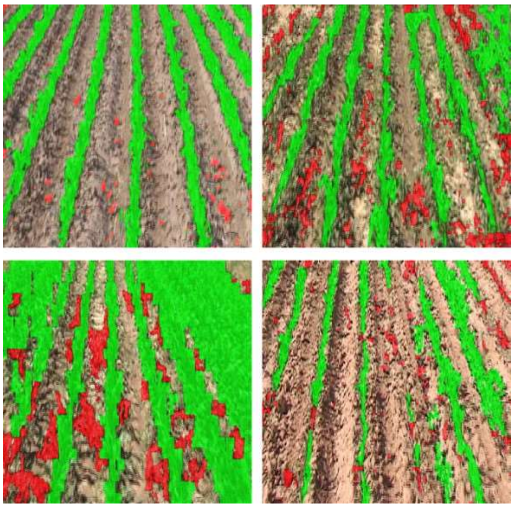


Figura 3: Final weed (red) and crop (green) discrimination over different input frames presenting a variety of situations.

Another application, shows the technical mechanical maintenance equipment in row and between crop plants (fig. 1), assembly EIP-0, is made of a frame (pos. 1) on which are mounted two hoeing sections (pos. 2), two wheels (pos. 3) of displacement and adjusting the working depth, two supports, (pos. 4) for cameras seizing the images and a parking foot (pos. 5).

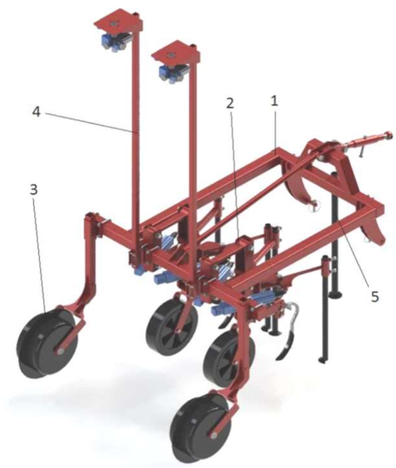


Figure 4**:** Technical multifunctional equipment designed to mechanical maintenance in row and between crop plants

The intelligent control system is a software-hardware system that achieves a differentiation of crop plants from the weeds and the latter destruction. It is based on two intelligent cameras, endowed with internal memory card able to store the software steps and have integrated controller aiming to achieve images processing operations.

Method of recognizing the images proposed consists in performing the following operations:

- sequences of images, in real time, taken directly from the field. This operation will be continuously performed by intelligent camera, with acquisition frequency adjusted by the user, each image being subsequently analyzed by performing the operations below.
- storing images for a subsequent analysis. This operation is optional, allowing to user to estimate the crop weeds level and after that, necessary maintenance works.
- dividing the image in interest areas. The final aim of this operation is that to use a sole intelligent camera for monitoring two rows of crop simultaneously or to perform maintenance works of several crop types with plants of different growing stages.
- identifying the distinct objects from images (soil, stones, plants, etc). This operation will be made by numbering the pixels suitable to each different object, depending on the grey tone intensity of each pixel, taking from reference a scale introduced by the user.
- identifying the space between crop plants.
- PLC gives the command according to existence/non existence of crop plants. In this stage, the digital command will be given within the range of 0-24Vcc to digital input of PLC, in order to drive the arm of mobile knife of multifunctional technical equipment designed to mechanical maintenance in row and between plants of agricultural crops.

RESULTS

Operations described above are performed by making the following steps, (described in software of Vision Builder AI):

Images are taken in sequences, with 640x480 pixels resolution. Images acquired are stored in internal memory of the camera. Images (frames) number with which the acquisition is made may be adjustable, according to exposure time, light and sensor amplifying (figure 5).

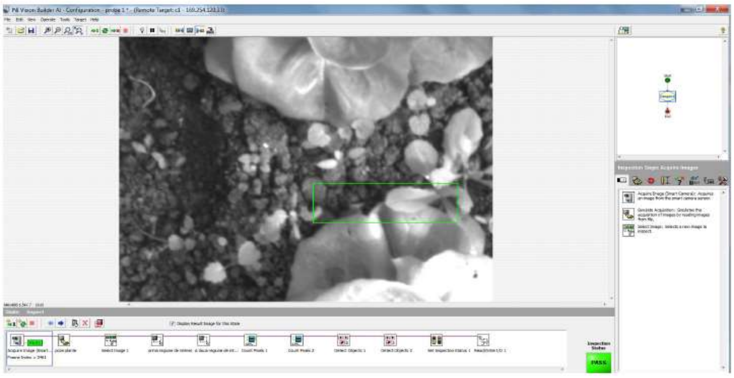
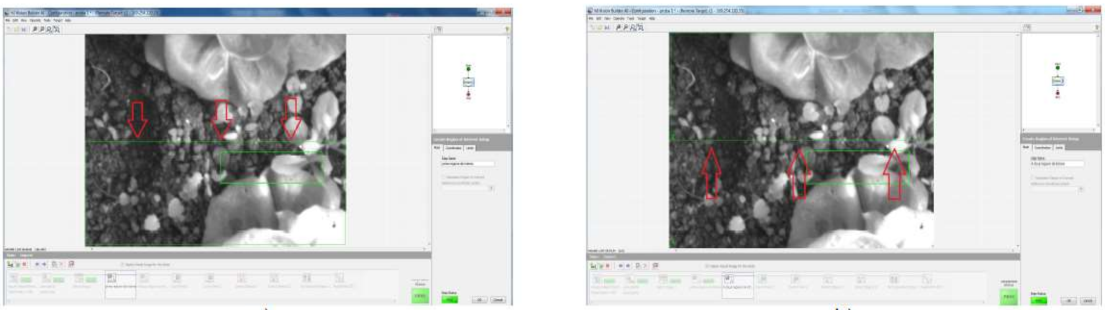


Figure 5: Real-time image acquisition

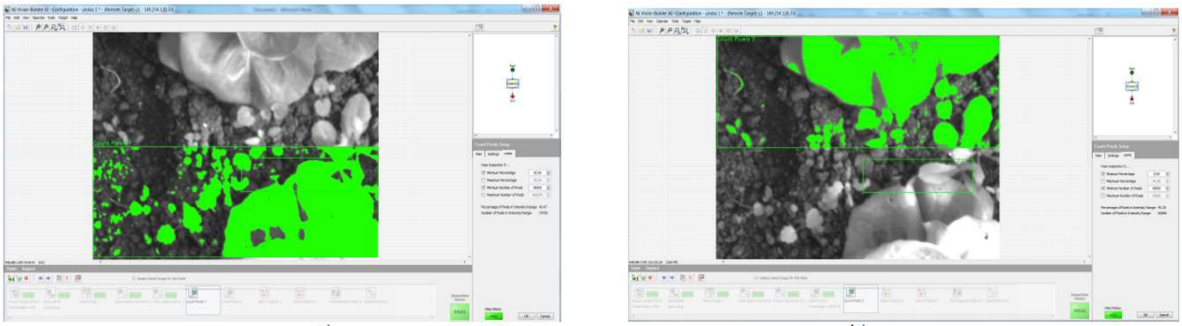
Images can be stored in a previously defined folder to be subsequently analyzed.



a) b)

Figure 6**:** Selecting the interest area
a) Image lower half; b) Image upper half

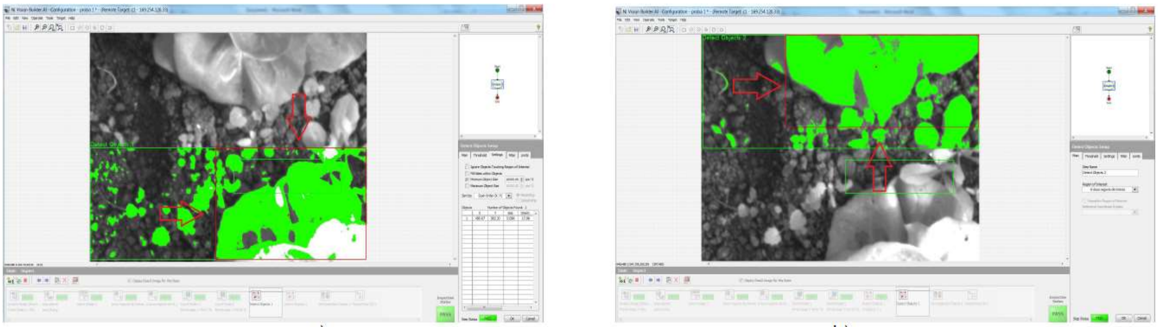
There are identified the interest objects from image lower part, by numbering the pixels of a certain intensity, appropriate to respective object (crop plant, weed, stone, etc).



a) b)

Figure 7: Identification of interest objects (plants and weeds marked in light green)
a) Image lower half; b) Image upper half

In the next step, area of objects surpassing 10000 squared pixels is identified (this number can vary according to crop plant and its average surface at the plant growing level suitable to crop maintenance performing), for image lower part (area framed in red).



a) b)

Figure 8: Identification of interest object (crop plant marked in light green in red frame)
a) Image lower half; b) Image upper half

The area of plants location is framed in red, figure 9, the gap between them representing the field that requires to be worked.

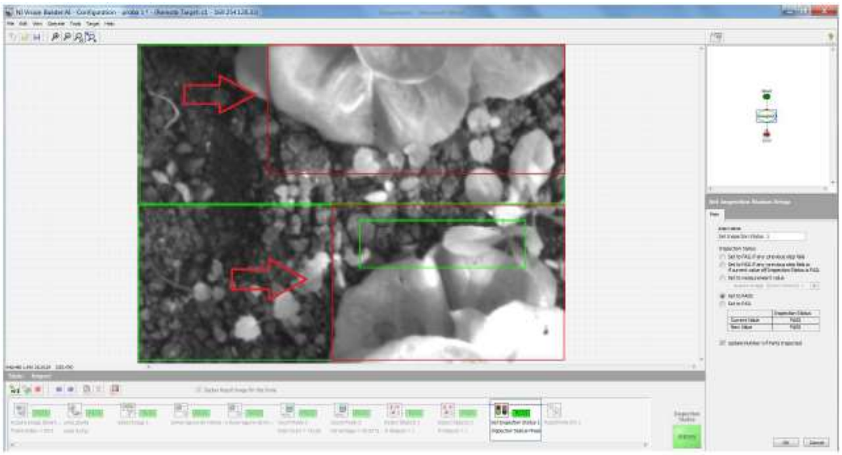


Figure 9: Identification of space between plants

During final step, the output channel by means of which the signal is sent to PLC, is set, as well as the onditions of transmitting it.

CONCLUSIONS

The idea of using algorithms for image processing in the agricultural sector represents a new area not just in our countries and also worldwide, until now, not being introduced in the manufacturing of series equipment destined for agricultural works equipped with intelligent acquisition and processing real-time images. The use of these systems has numerous advantages, such as:

- Increase the accuracy of work;
- Increasing the yield for crops;
- Limit losses by identifying problems in cropsin a timely manner;
- Time saving;
- Monitoring of the entire culture;
- Access to information needed in a timely manner for early intervention.

ACKNOWLEDGMENT

The work has been funded by Ministery of National Education and Research through the National Agency for Scientifical Research, within the project entitled *„Intelligent system for the activ control of works for performing phyo-sanitary treatments in field crops, depending on their degree of infestation with weeds*", PN 16 24 01 05.

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PLANTING ORCHARDS BY DIFFERENT TECHNOLOGIES

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ABSTRACT

The establishment and maintenance of orchards is of great importance, given the strategic role of fruit growing, with final goal in obtaining quantitative and qualitative fruit productions, which do not affect the health of consumers. Therefore, there are concerns in identifying the optimum work technologies in orchards. The planting technologies and related equipment are presented in this article. The other works in technology (soil maintenance, fertilization, irrigation, pruning, plant protection, crop protection against hoar-frost or hail, harvesting and valorization of the fruit) will be developed in another article as a continuation to that.

1. INTRODUCTION

To become more competitive in the market, farmers who want to establish/maintain/operate orchards need to have minimum machinery park. By equipping fruit farm with the appropriate equipment, can be provided an efficient working system, reducing the need for labour and operating costs, increasing productivity and obtaining a competitive qualitative and quantitative fruit production [5].

Improve the overall performance of farms by increasing the competitiveness of agriculture, diversification of agricultural production and high quality manufactured products, is the main objective of the specialists' research from fruit research institutes, and from institutes of agricultural mechanization also. There are known studies regarding analysis of investment budget during planting and maintenance of the apple orchard before fructification [6], research concerning the equipment for planting fruit trees [1], equipment for sorting fruits [4], equipment for orchards maintenance [2,3] etc.

To ensure optimal conditions for growth and fruit trees, the orchard is running a series of specific works: *soil maintenance, fertilization, irrigation, pruning, plant protection, crop protection against hoar-frost or hail, harvesting and valorization of the fruit* etc.

Maintaining soil orchard aims to overcome competition for water and feed that weeds do to trees, ensuring optimal aerohidric regime in soil, necessary to microorganisms, crust destruction and prevent the loss of water through evaporation.

Several methods of soil maintenance are practiced, each having advantages and disadvantages, of which the most used are:

- *worked field* - the method is used generally in young plantations, or associated with intercropping, and mature plantings in areas with less rainfall. Maintaining soil consists of repeated work by plough, disc harrow or cultivator.
- *total grassing or alternative grassing interval between rows*, consisting of sow the aisle with mixtures of herbs and working soil only under the trees crown. It is an increasingly system used in fruit plantations, because it allows access of equipment for performing mechanical treatment plant when the soil is wet, it ensures a better quality of fruit, in the wetlands the grass consume some of the excess water etc. Where fluid gaps appeared, grassing alternative rows are practised.

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- *herbicidation and soil tillage in the interval row of trees*, is practiced mostly in plantations mature and old. Are not recommended herbicides in young plantations because the trees have not well developed their root system and by herbicides washing can damage roots with serious implications for the future growth of trees.
- *total grassing after orchard fructification* is very much practised in Western Europe, by destruction of vegetation that forms and leaving it on the ground.
- În certain situations, în order to save manpower, the soil herbicidation în tree rows is practised by working or grassing the row interval, but only in mature orchards, or the herbicidation of areas with perennail weeds which are difficult to control: couch-grass, pelamide, sesame etc. In young plantations, regardless of how maintenance or soil cultivation on interval between tree rows are, it is appropriate to practise mulching around the trees with plant debris (grass, leaves, straw), which provide a relatively constant moisture in the soil, inhibit weeds growth , thereby ensuring a good growth of the fruit trees.

2. METHODOLOGY

Planting times are early spring, late fall before the ground freezes in winter, when the ground is not covered with snow, or not frozen and temperatures are at least 2-3 ° C

Have been identified two basic methods for planting fruit trees, namely:

- Planting seedlings manually;
- Mechanical planting seedlings.

Mechanized planting is more economical and more productive. The yield depends on the model and type of machine used, the fair use of it and the way is prepared the ground.

Given the high consumption of labour involved by carrying out different works of applied technologies specific to tree plantations throughout the world, they were made a series of machines with highly specialized for specific mechanized work.

Regardless of the planting method (manual or mechanical), some rules must be followed:

- Plant the tree at the same depth that it grew in the nursery.
- Plant the tree in a vertical, upright position to avoid a crooked stem.
- Place the roots in the planting hole in a normal position without twisting or bending.
- Carefully firm the soil around the roots to eliminate air pockets.
- Plant only when soil moisture is adequate to ensure survival.

Different technologies can be made to establish orchards.

Taking into account the aspects presented in the introduction, we decided to analyze the technologies for planting seedlings and establish the appropriate equipment for each technology.

Technology can be achieved by processing land, planted and watered in a single pass or distinct operations to process and plant.

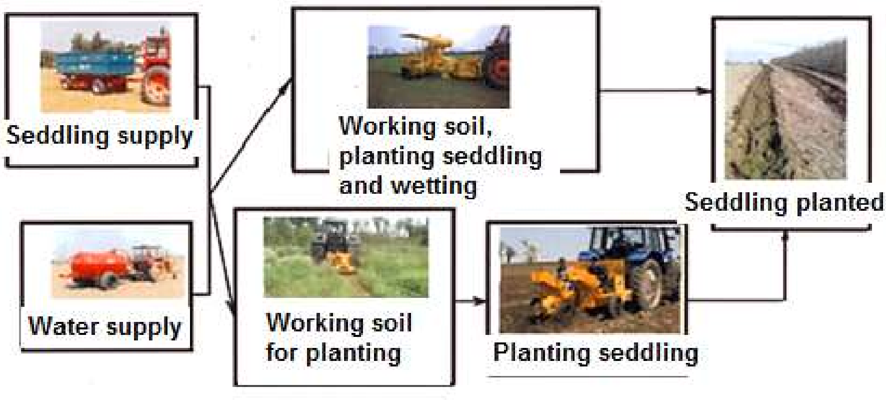

Figure 1: Establishing orchard technology

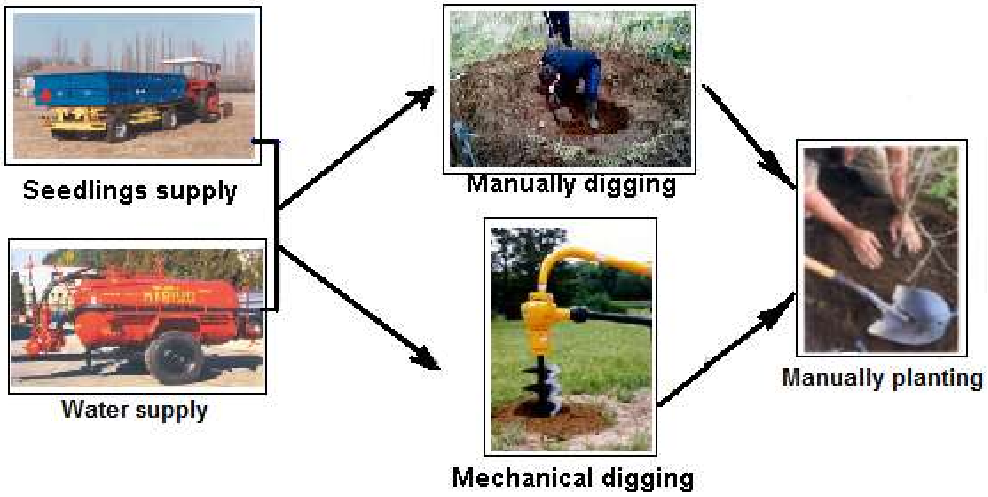

Figure 2: Establishing orchard technology

Establishment of orchards under version 2 consists of:

- *The execution of the holes*;
- *Seedlings planting*.

For planting the following technologies are used:

A) *Digging the holes and planting*. The holes can be manually performed by spade (fig.3) or mechanically performed by drills (fig.4).

Mechanical drilling can be performed by one ore more drills, simultaneous, but this method is not efficiently and recommended, the productivity being small.


Figure 3: Manually digging


Figure 4: Mechanically digging

B) *Working soil in stripes* and *opening a ditch where seedlings are planted mechanically* (fig.5).

This plating technology consists in two distinct operations: first-*open stripes* and *second-planting*, that it means there are necessary two passes of the aggregate (tractor and equipment) on the same surface, resulting the compression of the soil.

When mechanically planting, the equipment ensures a better loosening of soil than when planting manually, because the equipment works the soil along the apple trees row in comparison with a simple hole manually made in order to receive each apple tree. Therefore, the mechanical method of planting allows to work the soil in row direction, namely following the direction of development of roots and then of branches. The interval between rows is cleared in order to allow the equipment to pass. This soil work is very important (useful), as it enables a better taking over comparing to the hole dug by shovel.

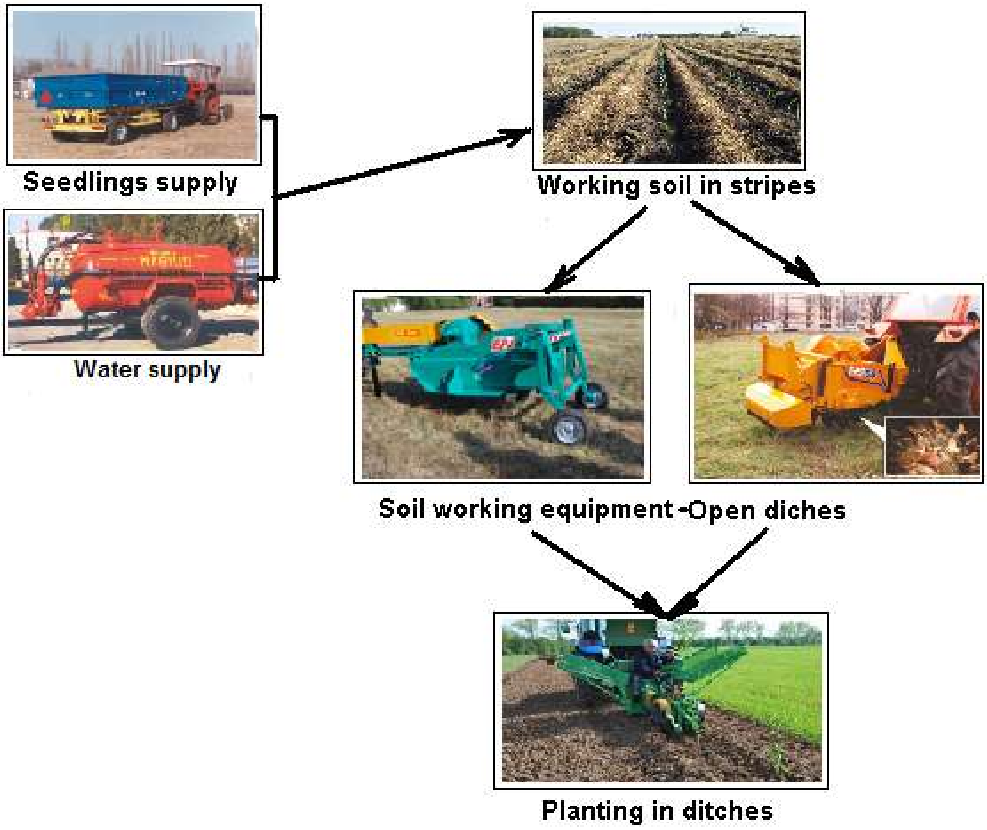

Figure 5: Planting in ditches

The equipment EPF1, by a single working post, realized at INMA Bucharest is worn on three-point linkage of a tractor with installed power of 65-100CP.

The equipment performed planting of seedlings in size between 25-70 cm, to a depth of max.30 cm, in tillage field in strips, of a approx.60 cm with or total processed. Row distance between seedlings can be settled (5 planting schemes): 0.5; 0.75; 1.0; 1.5; 3, planting deep: 0.25-3 m.

Figure 6: Planting equipment by a single row

To reduce the soil compaction, it is necessary to use planting equipment with more working posts. INMA realized such equipment, with 2 or 4 working posts (fig.7).

Figure 7: Planting equipment – 2 working posts

The institute has also designed complex equipment, which comprise: equipment for full processing of the soil; semiautomatic planting of seedlings equipment; seedlings watering equipment after planting. The equipments constituting the multipurpose machinery are modulated system designed, which allows aggregation / their individual use.

Figure 8: Multiporpose machinery: working soil, seedlings planting, seedlings watering

C) *__Extracting the seedlings and replanting__* them (fig.9)

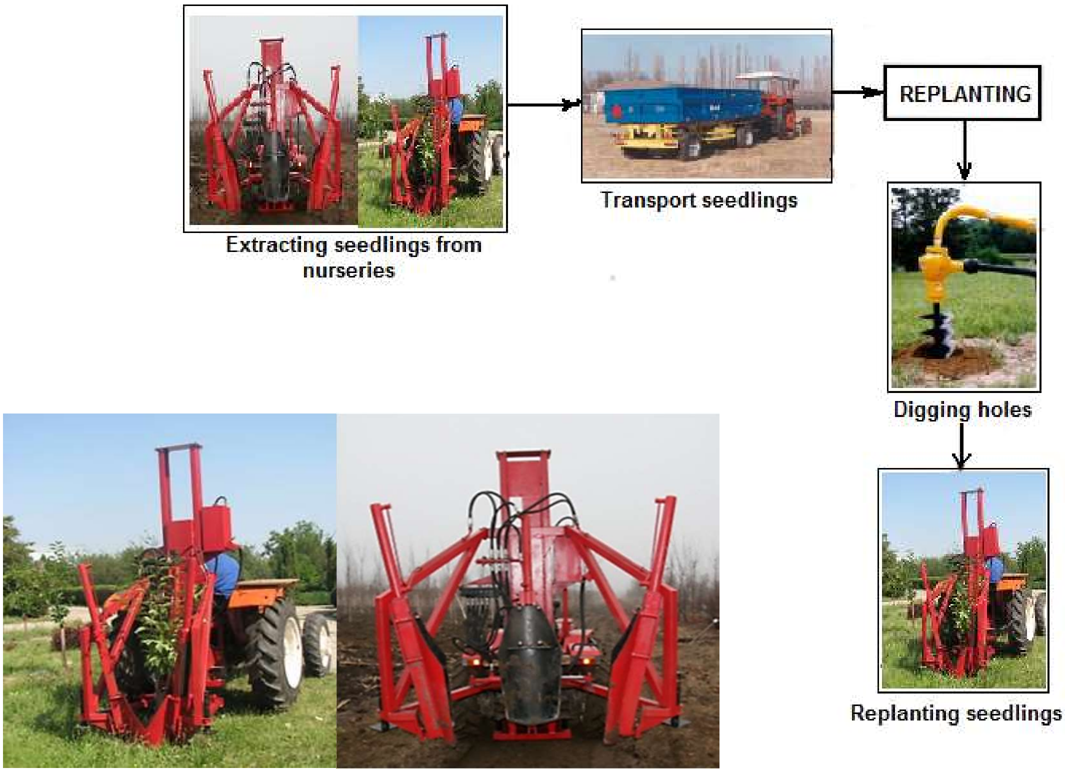

Figure 9: Replanting seedlings.   Equipment EXPLANT 500

This technology can be used in transplanting seedlings come from nurseries or in case it's necessary to extract and replant the trees in another place.

INMA Bucharest has designed the equipment EXPLANT 500. Technical equipment is designed to remove the seedlings dentro-horticultural, ornamental or fruit with earthy root bale in order transplantation in green areas, plantations and/or training fields of nurseries.

Also, the equipment can be used in digging holes where they are anticipated to perform transplantation or planting material extracted with bale earth or bare root material.

Average rates planting manual are 300-500 seedlings/day/person and mechanically planting has an average value of 500-3000 seedlings/hour.

3. CONCLUSIONS

Development of the appropriate technologies and using new equipment for planting and maintenance of intensive and super-intensive orchards will solve one of the real needs of Romanian Horticulture, namely that to increase the qualitative and quantitative fruit production by establishing new orchards and good working in the old orchards.

4. ACKNOWLEDGEMENT

This work was funded by Romanian National Authority for Scientific Research and Innovation (ANCSI), "NUCLEU" Program, the National Program of Romania (*PN 16 24 02 01 Innovative technology for maintenance tree plantations located in rural areas by tillage, cuttings root and precision foliar fertilization*; *PN 16 24 01 02 Technology and innovative technical equipment for organic fertilizer, in orchards, with distribution in strips directly to the rows of trees*), ADER 2020 Program (*ADER 3.3.12. Technical and economic competitiveness increasing in fruit growing through technologies adapted to the climatic conditions of Romania to implement thematic Fruit-growing sub-program, during 2016-2020*).

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CURRENT APPLICATIONS OF OZONE IN FOOD INDUSTRY

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ABSTRACT

The use of ozone in the processing of foods has recently come to the forefront as an anti-microbial agent for food treatment, storage and processing. Ozone is now being used as a safe, powerful disinfectant to control biological growth of unwanted organisms in products and equipment used in the food and beverage industries. In liquid solution, ozone can be used to disinfect equipment, process water, and some food products. In gaseous form, ozone helps sanitize and assist in the preservation of certain food products, and is also used to sanitize food packaging materials.

This paper presents the status of ozone application in food industry as aqueous solution or gaseous phase.

1. INTRODUCTION

Ozone, first discovered in 1840, was utilized as a disinfection agent in the production of potable water in France in the early 1900's. The majority of early development was limited to Europe where it became more widely used in drinking water treatment. The potential utility of ozone to the food industry lies in the fact that ozone is 52 % stronger than chlorine and has been shown to be effective over a much wider spectrum of microorganisms than chlorine and other disinfectants [5].

Ozone is triatomic oxygen, a naturally occurring form of oxygen [11]:

$$3O_2 \leftrightarrow 2O_3 + \text{heat \& light}$$

It is partially soluble in water and, like most gases, increases in solubility as the temperature decreases. It is effective in killing microorganisms through oxidation of their cell membranes [4]. In 1997, an expert panel reviewed the safety and potential for food processing use of ozone and declared ozone to be Generally Recognized As Safe (GRAS) for food contact applications (U.S. FDA1997) [7].

Fruits and vegetables often contain a great diversity of microbial flora and are frequently involved in food-bourne outbreaks. Since fruits and vegetables are mainly consumed uncooked or minimally-processed, microbiological safety becomes a very important issue to minimise consumers'risks (mesophilic microorganisms, coliforms, yeasts and moulds) are microbial populations responsible for both quality deterioration and safety risk. Several studies have demonstrated that ozonated-water treatments promote shelf life extension of food products, and that ozonation is in fact an appropriate method to improve food quality and safety. However, ozone decomposition is rapid in water and, consequently, its antimicrobial action may take place only at food surface [1].

This paper presents the status of ozone application in food industry as aqueous solution or gaseous phase.

2. METHODS OF GENERATING OZONE

Corona Discharge method consists in two electrodes in corona discharge, one of which is the high tension electrode and the other is the low tension electrode. These are separated by a ceramic dielectric medium and narrow discharge gap is provided (fig. 1). When a high voltage alternating current is applied across a discharge gap in the presence of oxygen, it excites oxygen electrons and thus induces splitting of oxygen molecules. Atoms from split oxygen combine

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with other oxygen molecules to form ozone. Ozone production varies depending on voltage, current frequency, dielectric material property and thickness, discharge gap and absolute pressure within the discharge gap. If air is passed through the generator as a feed gas, a 1-4% of ozone can be produced. However, use of pure oxygen allows yields to reach 6 to 14% ozone. Consequently, ozone concentration cannot be increased beyond the point that the rates of formation and destruction are equal. Ozone gas cannot be stored since ozone spontaneously degrades back to oxygen. Dried gas is used to minimize the corrosion of metal surfaces due to nitric acid deposition produced from wet gas inside the generator [5].

Ultra-Violet lamp method is based on conversion of oxygen on ozone molecules by lamp of ultraviolet light (wavelength of 188 nm, fig 2). Nevertheless, the ozone production is of low intensity. At low temperatures, the process of ozone ventilation is made with greater facility. The ozone production takes place generally by the ventilation of electrical discharges of high voltage in the air or pure oxygen.This radiation affects a common oxygen molecule that is found in atmosphere which produces the split of the molecule and separation of free oxygen atom. These atoms collide with other oxygen molecules, forming therefore ozone molecules:

- The energy absorbed by an oxygen molecule break it in two oxygen atoms.

$$O_2 + h\nu \rightarrow O + O$$

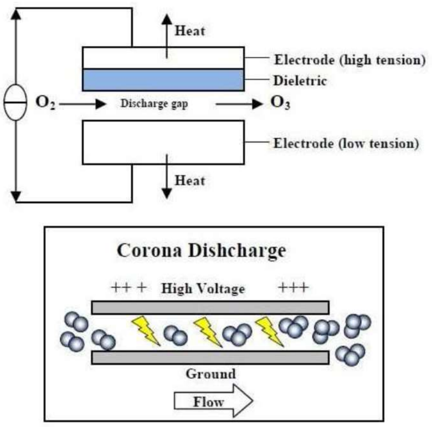
- Each one of these atoms is joined to an oxygen molecule to give another one of ozone.

$$O + O_2 \rightarrow O_3$$

- Finally, the ozone molecule is destroyed again absorbing more ultraviolet radiation.

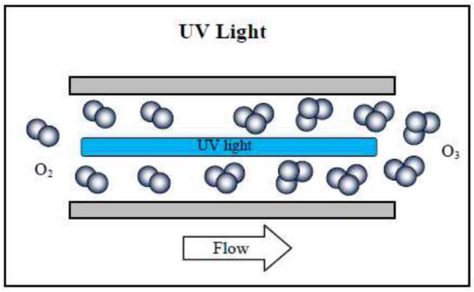
$$O_3 + h\nu \rightarrow O + O_2$$

- Ultraviolet energy is absorbed in a closed cycle of formation and destruction of the ozone.
- The ozone formed, after certain period of time, is degraded spontaneously in oxygen



Oxygen is forced between high voltage plates to simulate corona discharge. The oxygen is broken apart and recombines into ozone

Figure 1: Scheme of Corona discharge method [5]



Oxygen turns into ozone after it is hit with UV light from a UV generating bulb:

Figure 2: Ultra-violet lamp method [5]

Electrochemical (Cold Plasma) method consist in an electrical current applied between an anode and cathode in an electrolytic solution containing water and a solution of highly electronegative anions. A mixture of oxygen and ozone is produced at the anode. The advantages associated with this method are the use of low-voltage DC current, no feed gas preparation, reduced equipment size, possible generation of ozone at high concentration and generation in water [8].

Radiochemical ozone generation (RCOG) is based on high energy irradiation of oxygen that can also produce ozone. Although this technique is not yet used commercially in potable or waste water treatment, it is anticipated that in the future this will find much more widespread application [8].

In addition, ozone can be produced by chemical, thermal, chemo-nuclear and electrolytic methods [5].

3. EQUIPMENT FOR OZONE GENERATION

There are a wide range of equipment used for ozone generation including those of *Oxyzone Pty Ltd* and *Xylem*, which are presented in this paper.

The **Total Ozone System**, produced by *Oxyzone Pty Ltd* company (fig.3) from Australia, is a complete ozone generation package that delivers high strength ozonated water direct to the work area. It contains its own contact tank, pump, injector and degas and is a complete system ready to integrate with the user application [10].

*XYLEM′*S **WEDECO Modular and GSA/GSO ozone generators** (fig. 4), from Germany, are designed to produce ozone more effectively at high concentrations up to 16 weight % ozone. WEDECO ozone generators are ideally used for disinfection and oxidation of all kinds of process water in industry, laboratory and pilot plant application [12].

Figure 3: Total Ozone System [10]

Figure 4: GSO 50 generator (left) and GSO 10 – 30 [12]

4. APPLICATIONS OF OZONE IN FOOD INDUSTRY

Ozone can be applied in an aqueous solution or gaseous phase to decontaminate food-contact surfaces, sanitize equipment, recycle wastewater, and decrease pesticide levels on fresh produce.

Ozone in air has also received considerable research and commercial interest recently. Both benefit and lack of benefit of ozone in air use in fruit and vegetable storage rooms have been reported repeatedly.

Ozone in air at concentrations that can be breathed over long periods without irritation cannot be expected to provide effective sanitation of fruit and vegetable surfaces or storage rooms. The application of ozone in air concentrations that effectively kill pathogen spores exceeds 0.1 ppm and therefore requires measures to protect the employed workers. The active compounds produced by ozone in air generators are not clear at this time, because some produce more than ozone. Some of equipment are using ethylene scrubbing and spores from an air-stream that passes through the device, so the ozone concentration in the storage room air is not elevated. Ethylene destruction in air by ozone is a well-documented phenomena, and for those commodities that benefit by its removal, ozone may be of use, assuming the fruit are not injured by the gas [7].

Ozone in water is often described as an alternative to hypochlorite as a disinfectant or sanitizer, although they differ in many aspects. Ozone solubility in water is low, its maximum solubility at 20°C is 29.9 μg/ml; in practice, it is difficult to exceed 10 μg/ml, and many systems produce 5 μg/ml or less. Ozone in water above 1 μg/ml can liberate ozone into the air that exceeds safe levels (OSHA workplace maximum = 0.1 ppm). Significant advantages of ozone in water are that it decomposes quickly to oxygen, leaving no residues, and it has more potency against bacteria, cysts of protozoa, viruses, and fungal spores than hypochlorite.

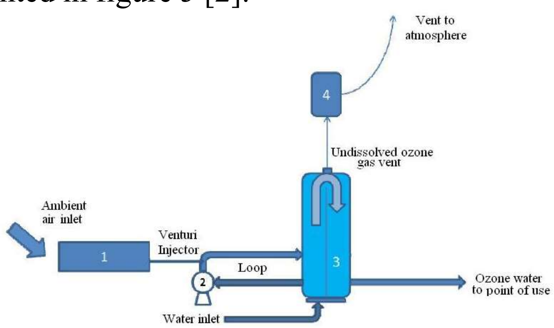
Ozone was reported to have a mode of action to control a plant pathogen not based solely on its antimicrobial activity. Ozone can oxidize many organic compounds, particularly those with phenolic rings or unsaturated bonds in their structure and can have a role in reducing pesticide residues in process water and mycotoxins in durable commodities [7].

Practical application of ozone as sterilizing means began with purification of air of warehouse. This way consisted in air saturation by a certain amount of ozone, sufficient for destruction of main types of pathogenic microorganisms. The made numerous experiments showed in paper [6] that when processing warehouse by ozone by a dose 2 - 35 mgO_3/m^3 within 60 – 240 minutes their full disinfecting is provided. Ability of ozone to destroy various microorganisms, including putrefactive bacteria, molds and fungus, allows to use it effectively for increasing the storage period of food products. Ozone destroys ethylene produced by vegetables and fruits, which promotes acceleration of maturation. The conducted researches showed that duration of storage of fruits and vegetables can be doubled on the average with simultaneous preservation of delicate aroma of fruit. So, when processing berries (strawberry, raspberry, grapes) using an ozone dose of 3 – 8 mgO_3/m^3, the term of their storage increases twice; after processing apples using an ozone dose of 4 – 9 mgO_3/m^3, their period of storage at the room temperature increases till 15 days. After processing apples using an ozone dose of 4 – 6 mgO_3/m^3, their period of storage, at a +5ºC temperature, increases till 5 months. Processing by ozone of fruits and vegetables increases terms of its storage 1.5 – 2 times, providing reduction of losses of stored production by 1.5 - 2.5 times. In the table 1 is presented the temporary methodical recommendations about ozone application for disinfection of storages.

Table 1: Recommendations for ozone processing of fruits and vegetables for long storage [6]

Production	Ozone concentration [mgO_3/m^3]	Ozoning time, [h], not less	Number of procedures in a week (reference)
Cabbages	7-13	4	1-2
Carrot	5-15	4	3 days periods 1-2 times in a month
Garlic	9-14	5	2-3
Onion	8-10	4-5	1-2 times
Grapes	3-8	3	3-4
Salad	9-12	2	4-5
Apples	4-9	5	2-3

Essentially, reduction of chemical contaminants in food products with ozone is based on two different procedures, i.e. washing with aqueous ozone solutions and treatment with ozone in gaseous phase. Both of them have advantages and disadvantages. Commonly fruits and vegetables are sprayed with aqueous solution of ozone or undergo passage through solution on an assembly line. Scheme of a typical installation used for preparation of ozone solution in water is presented in figure 5 [2].



Legend:
1. ozone generator,
2. injection pump,
3. contact tank,
4. ozone destructor

Figure 5 - Scheme of installation for saturation of water with ozone [2]

5. EFFICACY OF OZONE

Ozone is affected by both extrinsic and intrinsic factors (table 2) and it is difficult to predict ozone behaviour in the presence of specific compounds, other ingredients and environmental factors such as medium pH, temperature and humidity. Residual ozone is the concentration of ozone that can be detected in the medium after application to the target surface. Both the instability of ozone under certain conditions and the presence of ozone-consuming materials affect the level of residual ozone available in the medium. Therefore, it is important to distinguish between the concentration of applied ozone and residual ozone necessary for effective disinfection. It is advisable to monitor ozone availability during treatment [3].

Table 2 - Factors influencing efficacy of ozone [3]

Parameters	Factors
Extrinsic factors	
Water quality	pH, temperature, turbidity, organic matter, oxidizable inorganic materials (e.g. ferrous iron, manganous, sulfide, etc)
Ozone	concentration, contact time
Decontamination treatment	Application method (dipping, spraying and agitated, rubbed or static condition during exposure), produce/water ratio, single or multiple batches, rinse after sanitation, multiple washings
Intrinsic factors	
Microbial load	Characteristics of microbial strain, physiological states of the bacterial cells, natural or inoculated microorganisms, population size
Food product	Type of fruit and vegetable, characteristics of the product surfaces (cracks, crevices, hydrophobic tendency and texture), relation weight and surface area

Process engineers wishing to apply ozone most effectively should know all the chemical characteristics of ozone. Many of the potential applications of ozone are neglected due to lack of knowledge of the specifics of ozone chemistry and their potential to solve and eliminate problems. The main chemical characteristics of an ozonation process should always be reviewed prior to planning and implementation to optimize ozone application(s) [9].

Ozone has many advantages:

• It is the strongest oxidant and disinfectant available commercially for the treatment of aqueous solutions and gaseous mixtures contaminated with oxidizable pollutants and/or microorganisms.

• Although only partially soluble in water, it is sufficiently soluble and stable so that its oxidation and/or disinfection properties can be utilized to full advantage.

• As ozone does its oxidation/disinfection work, or when it autodecomposes, the stable end-product from ozone itself is oxygen.

• Ozone reacts with a large variety of organic compounds, although at varying rates.

• Oxidized organic byproducts of ozonation are oxygen-containing. Halogenated organics cannot be produced during ozonation, unless the bromide ion is present.

• Ozone is safe to handle because it cannot be stored, and thus, must be generated and used on-site.

Ozone has its disadvantages:

• High capital cost compared with other oxidation/disinfection techniques due to the fact that the ozone must be generated on-site, thus eliminating the usual savings from centrally produced chemicals.

• The currently most economical generation of ozone in commercially significant quantities (by corona discharge) is an electrically inefficient process, even given this fact, ozone can be and is often more cost-effective than alternative treatment techniques.

• The equipment required to generate ozone can be complex and intricate to install.
• Since ozone is the most powerful oxidizing agent available, it is also potentially the most dangerous of oxidants. This danger was recognized in the early stages of ozone research and techniques have been developed to insure the absence of ozone accidents.

6. CONCLUSIONS

Summing up, it is possible to draw the following conclusions on expediency of application of ozone for processing of fruits and vegetables:
- ozone is only one of many food sanitizing ingredients and processes being used, examined, or proposed to improve food safety;
- ozone is environmentally safe; is a good alternative sanitizer for fresh fruits and vegetables, it can destroy microorganisms through progressive oxidation of vital cellular components;
- when ozone is applied in aqueous solution for reducing microbial loads in fruits and vegetables, its effectiveness is dependent on the combination microorganism/food;
- the cost of processing of fruits and vegetables with application of ozone is several times lower, than when using chemical disinfectants, ozone receive directly on a place by means of special devices – ozonizers;
- ozone technology has existed for over a hundred years, its recent acceptance fuelled by environmental and health concerns now poses this technology for future longevity and increased successful usage, whether based on water purification, water recycling, air quality improvement, product extended storage and/or equipment surface sanitation.

ACKNOWLEDGEMENT

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MECHATRONIC DRIVE SYSTEM WITH AUTOMATIC SPEED REGULATION AND IMMUNITY TO LOAD CHANGES

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ABSTRACT

In some industrial applications is needed to control the speed of a machine part. Such applications are found in plastic injection machines, rolling mill, hydraulic presses, CNC machine tools, etc.. The system developed as an experimental application consists of a hydraulic cylinder, controlled by a proportional directional valve, coupled via a force transducer to the another hydraulic cylinder with the role to create a load. To obtain a variable load with stroke, one chamber of a secondary hydraulic cylinder was connected to an accumulator preloaded with nitrogen at a certain p_0 pressure. With the movement of the active hydraulic cylinder toward the secondary cylinder, load increases with accumulator ΔV variation. The system is controlled via an acquisition board by an application made in LabView. The application uses a PID block for speed control and allows the recording of experimental data, some results being presented in the article.

1. INTRODUCTION

The system developed as an experimental application consists of a hydraulic cylinder, controlled by a proportional directional valve, coupled via a force transducer to the another hydraulic cylinder with the role to create a load. To create a load variable with the movement , it was used a hydro-pneumatic accumulator as a buffer for the hydraulic cylinder with the role to create a load. With the movement of the active hydraulic cylinder toward the secondary cylinder, load increases with accumulator ΔV variation. The system is controlled via an acquisition board by an application made in LabView. The application uses a PID block for speed control and allows the recording of experimental data, some results being presented in the article. An example of an application where speed control is needed is for to driving the reels of coil winding machines specific to wire rolling mills [1].

2. SYSTEM DESCRIPTION

a. Mechanico-hydraulic part

The mechanico-hydraulic part of the system consists of a frame on which are mounted two hydraulic cylinders. The rods of hydraulic cylinders are connected together through a force transducer (stretch / compression). The active hydraulic cylinder CH1 (fig.1) is controlled by proportional directional valve PDV. At the rod of hydraulic cylinder CH1is connected a LVDT transducer necessary for speed control loop and for switching the direction of travel of the cylinder rod at the end of stroke.
The supply of one room of the CH1 hydraulic cylinder is done through a gear flow transducer. It allows bi-directional circulation of hydraulic liquid. At chambers of hydraulic cylinder are connected two pressure transducers PT1 and PT2. The CH2 hydraulic cylinder is used as a load for active hydraulic cylinder. The piston chamber of HC2 hydraulic cylinder is connected in a

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pressurized circuit. The initial pressurization of circuit is made with a manual pump. This circuit also contains an accumulator with the role to create a increasing variable load, a check valve CV, a pressure relief valve PRV, a suction circuit for filling the entire volume of hydraulic cylinder and a pressure transducer PT3. Along with movement of piston of hydraulic cylinder HC2 the force that opposes increase and decrease according to adiabatic change of state at compresion of nitrogen from accumulator. The pressure of nitrogen from accumulator is monitored with PT4 pressure transducer.

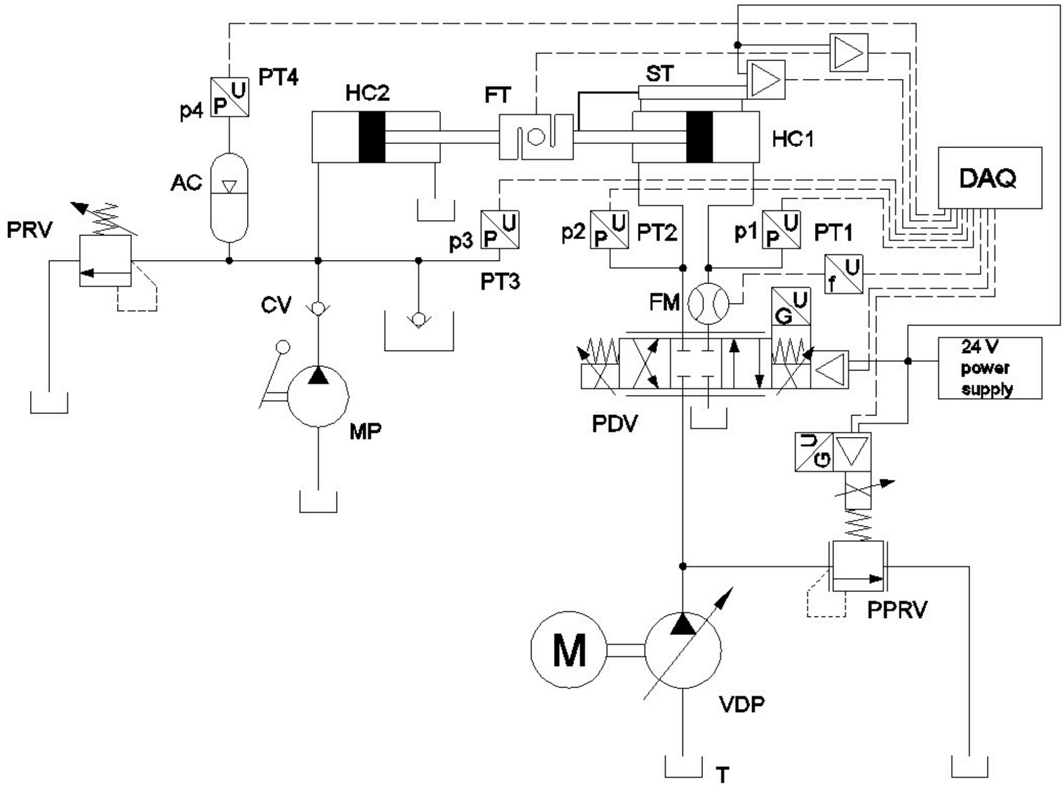

Figure 1

In figure 2 it can be observed the proportional directional valve 4WRPE size 6, design of Bosch Rexroth, that controll the active hydraulic cylinder CH1.

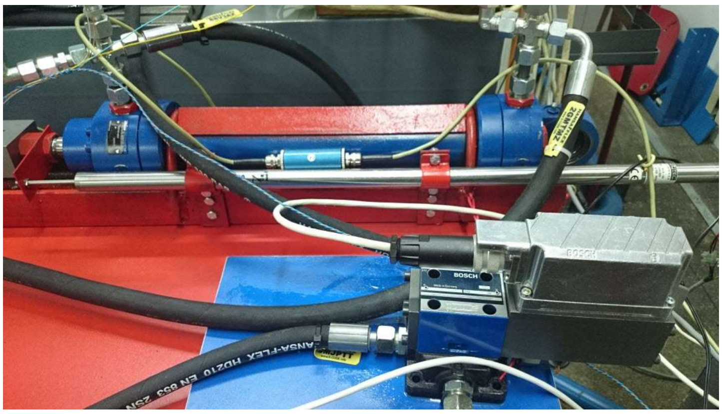

Figure 2

b. Control and data aquisition system

The system is realized by using a data acquisition board from National Instruments type USB-6218 (figure 3). At the analog inputs of the data acquisition board were connected pressure tranducers and force transducer with 4…20 mA current outputs, conversion into voltage being achieved by means of 249 Ω resistors. LVDT transducer with voltage output (± 5 V) and frequency/voltage converter of gear flow meter, with 0…10 V output, were connected directly to another analog inputs of data acquisition board. One of the analog outputs from data acquisition board was used for voltage control (0…10 V) of proportional pressure valve with on board electronics. With it was adjusted working pressure of the experimental stand. The other analog output of data acquisition board was used to control proportional hydraulic directional valve also equipped with integrated electronics.

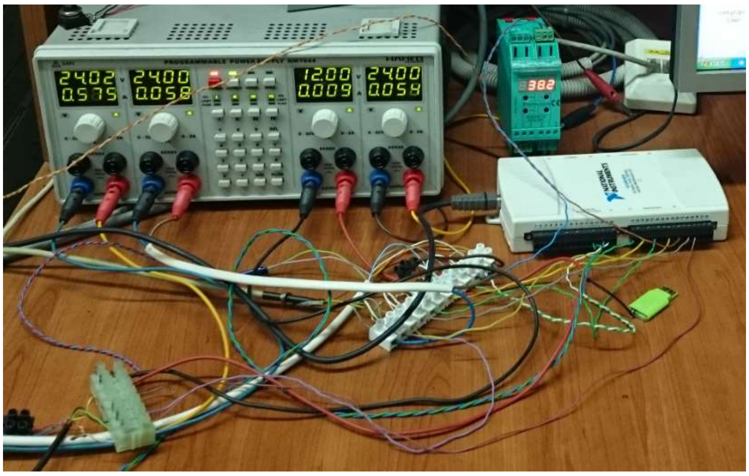

Figure 3

The application was made in the LabView software and has allowed performing of cycles of movement for the active hydraulic cylinder and record the variation of the various parameters of the system. For a constant speed movement of the rod of the hydraulic cylinder has been realized a speed regulator [2, 3] with a PID block from tool kits of Labview (figure 4).

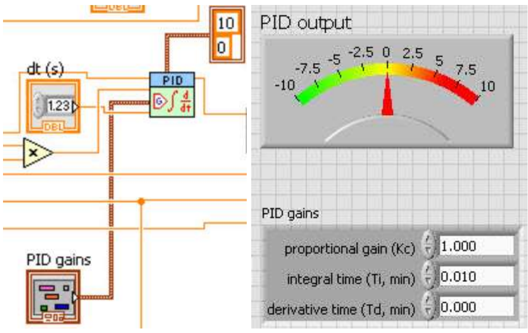

Figure 4

Process variable that in this case was the speed was obtained by derivation in relation to time of rod movement of hydraulic cylinder. In order that the movement of the actuator rod do not stop at the stroke end, has been inserted into the LabView application a trigger Schmitt circuit (Figure 5). The circuit switches the travel direction of the rod of hydraulic cylinder by reversing the control of proportional directional valve to the end positions (± 100 mm).
Thus the system can work cyclically, allowing achievement of several recordings, without the need to withdraw actuator rod for a new test.

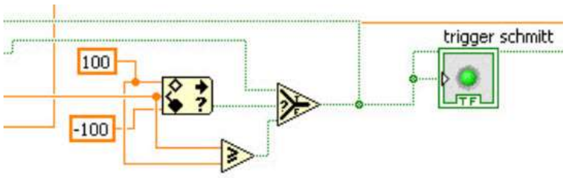

Figure 5

3. EXPERIMENTAL RESULTS

The experimental results were recorded in two panels with charts. In one panel were recorded hydraulic parameters (pressure and flow) Fig. 6, and in the other mechanical parameters (stroke, resulting force and speed) Fig. 8. In Figure 8 speed 1 is determined from the values of flow recorded by flow transducer, and velocity 2 is achieved by derivation of the movement in relation to time. In order to track various parameters relative to rod stroke of hydraulic cylinder, in the first panel was displayed the stroke too.

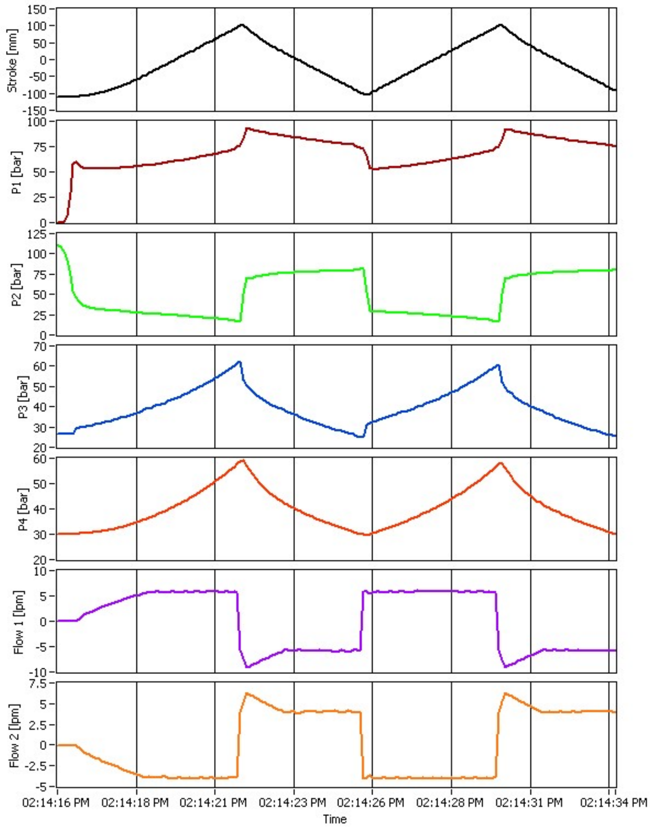

Figure 6

From figure 6 it can be seen that in the region of stroke ramps, the oil flow in the hydraulic cylinder is constant, which means that the hydraulic cylinder speed is constant. It can be seen that the pressure P3 from the chamber of hydraulic cylinder acting as load, and that of nitrogem from accumulator (P4) grow. However speed is automatically kept constant by the controller.

Depending on the volume and pressure of the gas in the accumulator can be determined the amount of liquid that can enter or exit. For adiabatic change of state applies the following formula:

$$p_0 \cdot V_0^n = p_1 \cdot V_1^n = p_2 \cdot V_2^n \qquad (1)$$

The volume of oil that can enter and exit the accumulator is shown by the formula:

$$\Delta V = V_0\left[\left(\frac{p_0}{p_1}\right)^{\frac{1}{n}} - \left(\frac{p_0}{p_2}\right)^{\frac{1}{n}}\right] \qquad (2)$$

For nitrogen n = 1,4. Adiabatic transformation diagram is shown in Figure 7.

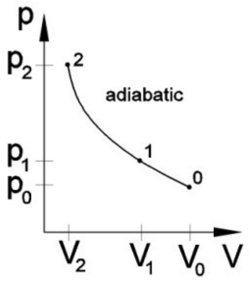

Figure 7

For an acumulator with V_0 of 8 liters pre-loaded with nitrogen at 30 bar calculated parameters [4] are shown in Table 1.

Table 1

$p_2 = 60$ bar	$\Delta V = 2$ l	$p_2 : p_0 = 2.1 : 1$
$p_1 = 35$ bar	$V_{0Tmin} = 8.04$ l	$p_{0\ Tmin} = 28.87$ bar
$p_0 = 30$ bar	$V_{0Tmax} = 7.19$ l	$p_{0\ Tmax} = 32.27$ bar

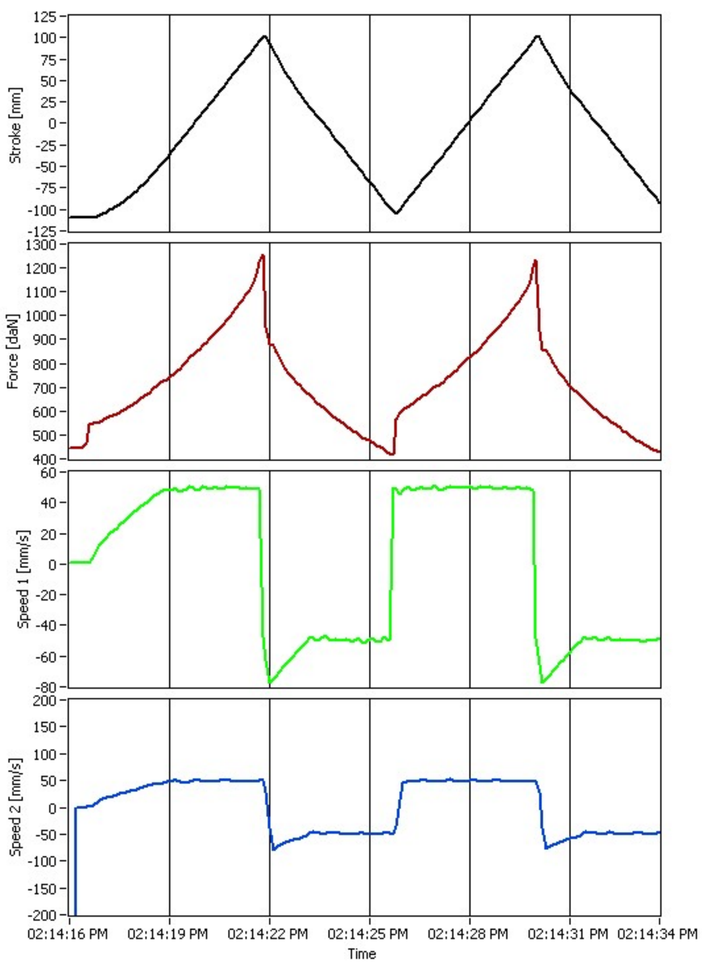

Figure 8

CONCLUSIONS

Results of the experiments showed that the system was able to get variable load by using a hydraulic accumulator as a buffer for hydraulic cylinder acting as a load.

The control system developed in LabView environment was able to maintain constant speed of linear hydraulic motor, independent of increasing or decreasing variation of the load.

The system allowed the record of various mechanical and hydraulic operating parameters.

With the help of such a system can be tested in laboratory the actuation systems for some industrial applications.

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HYBRID ENERGY SYSTEM BASED ON RENEWABLE SOURCES FOR BIO-ORGANIC AGRICULTURE IN GREENHOUSES

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ABSTRACT

The bio organic greenhouses based on alternative resources for producing heat and electricity, is an efficient option for sustainable development of agriculture, thus ensuring good growth and development of plants in all seasons, especially during the cold season. That system of greenhouses can be used with maximum efficiency in various agricultural lands, providing ideal conditions of temperature and humidity for short-term development of the plant, thereby increasing local production of fruits and vegetables. A major problem for implementation of these type of greenhouses at the local level, is represented by the difficulty of providing electrical and thermal energy from conventional sources, to ensure an optimal climate for plants development. A hybrid system based on renewable sources, solar, biomass, biogas and hydrogen energy is a good solution for the sustainable functioning of greenhouses.

1. INTRODUCTION

Development of renewable energy as a primary resource global energy and clean, is one of the main objectives of energy policies worldwide which, in the general framework of sustainable development, aimed at reducing energy consumption, increase security of supply, environmental protection friendly and sustainable energy technology development [1, 2]. Renewable sources represent good alternatives to fossil resources, which are limited in quantity and over exhaustion.

Agriculture is one of the most important sectors with the greatest potential for sustainable economic development [1-3].

In order to reduce production costs, it is necessary to implement a hybrid thermal power based on renewable designed and dimensioned according to requirements so that by contributing to this system, the production costs to be reduced significantly, considering that heating accounts for about 30% of total energy used in the greenhouse [4]. Integration in the greenhouses of a hybrid system based on renewable sources, to provide heat and electricity, is an important objective for sustainability and efficient commercial systems in order to increase production and reduce costs associated with heating and production of heat in order ensuring an optimal climate for the development of plants [5, 6].

2. HYBRID ENERGY SYSTEM. A STUDY CASE.

In this paper are identified specific elements of a case study on the concept of sustainable development of organic greenhouses, by integrating a hybrid energy system based on renewable energy.

The hybrid energy system is able to produce heat and electricity at any time, at reduced costs, having without a good efficiency and environmental pollution. An important requirement is to investigated the feasibility of equipment is installed in experimental greenhouse that, and evaluating the mutual benefits arising from this integration. The case study refers to a modular greenhouse, with an area of 90 sqm, airfoil form of tunnel with steel structure and round arches.

Gauge dimensions of the greenhouse are: L = 25m, W = 9m, H = 4m.

In Figure 1 is the concept and design of the greenhouse and in Figure 2 is shown a functional greenhouse [9].

This greenhouse model was selected because it presents good properties regarding strength and durability, supporting winds of 90km/h and snow loading layer (80kg /m + 25kg/sqm internal load) [10].

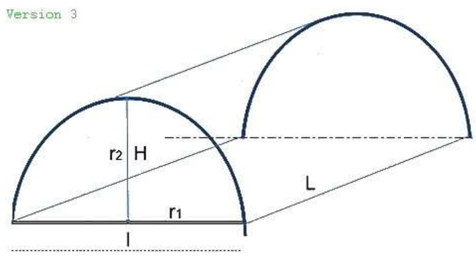

Figure 1: Elliptic design of the greenhouse

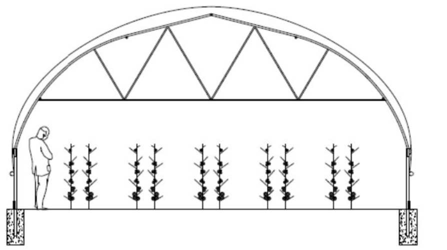

Figure 2: Functional greenhouse

According to SR 1907-3, it was calculated the energy for heating the greenhouses, considering the type of material used for insulation and coatings [11].

In Table 1 is shown the calculation of heat required for a modular greenhouse.

Table 1: Calculation of greenhouse heat demand

CALCULATION OF GREENHOUSE HEAT DEMAND			
Climatic zone	II	Wind area	II
Outside temperature	-15	Wind speed	7,00
Sealed greenhouse		Outside the village	
Insulation material: double-layer polyethylene film			
Indoor temperature	18		
1	d - the greenhouse wall thickness [mm]		
1,000	ë - Thermal conductivity greenhouse walls		
3	Embodiment of the greenhouse		
90	Surface land that is located greenhouse [sqm]		
190,41	A - Total greenhouse area [sqm]		
284,65	V - Greenhouse volume [m^3]		
79.23	**Q - heat requirement for calculating [kW]**		
9,68	Kconv - total coefficient of heat transfer by convection through the surface [W/mpK]		
1,70	n - tightness coefficient greenhouse		
0,10	πn - penetration coefficient [kJ/kg K]		

0,32	ξ - coefficient that takes account of indoor and outdoor air enthalpy
11,60	αi - heat transfer coefficient of surface to the inside [W/sqm K]
32,58	αe - heat transfer coefficient on the outside surface [W/sqm K]
8,48	KET - total coefficient of heat transfer by convection through the surface of the greenhouse, considered sealed [W/sqm K]
0,61	ΨA - coefficient that depends on the area of land that is located greenhouse
10.00	L - greenhouse length [m]
9.00	l - width greenhouse [m]
4.00	H - maximum height [m]
4.50	r1 - circle's radius = l/2 [m]
4.00	r2 - circle's radius = H [m]
90.00	S - greenhouse area [sqm]
204.93	A1 - total area when r1= l/2 [sqm]
175.90	A2 - total area when r1=H [sqm]
190.41	A ~ total area (mp): average between A1 and A2
318.03	V1 - greenhouse volume when r1= l/2 [m^3]
251.28	V2 - greenhouse volume when r1 r2=H [m^3]
284.65	V ~ greenhouse volume (m^3): average between V1 and V2

CALCULATION OF HEAT LOSS		
Double-layer sheet losses	15281.9	W
Loss through ground	1019.7	W
Other losses	16304.0	W
Effective thermal calculation	41.1	kW
Thermal calculation for heat generator choosing	46	kW
Heat generator efficiency = 0.9	41078	kcal/h
Overall thermal power	37	kW

Efforts to decrease energy consumption have directed the researchers to use alternative energy sources for greenhouse heating. Several types of passive solar systems and techniques have been proposed and used for the substitution of conventional fuels with solar energy as a low-cost technology [12,13].

Because the sunlight is not abundant in winter or during the nights, then a combination of renewable energy sources is very useful to be used in this situation. A greenhouse is a structure covered with transparent materials that utilize solar radiant energy and provide optimum growing conditions for plants [14]. Solar radiation is more efficient when the greenhouse is oriented east-west axis, and solar collection is performed both in summer and winter season [15].

2.1. HYBRID ENERGY SYSTEM COMPONENTS

The proposed hybrid system consists of the following:

2.1.1. Thermal energy production system:

- Thermal heating generator based on fuel wood and biomass is used to produce heat for the greenhouse needs. This equipment has a nominal heat output of 38kW, works very effectively gasification has a low fuel consumption, and shows superior performance on the performance of work, which is up to 93%. From thermal calculation performed, it results that this model of power with thermal power of 38 kW is sufficient to provide the energy requirements of the greenhouse at a rate of up to 70%, considering that its use is done mainly in winter.

- Thermal solar collectors panels with vacuum tubes, which are a great alternative to produce hot water using solar energy in summer.

The total area is 3.5 m², P max.=1260kWh, 666.34 kWh/m² (63 kWh /tube), 67% optical efficiency, maximum temperature 239°C. Using thermal solar panels for a period of 4-6 months per year, in the greenhouse can achieve significant savings on heat production.

Mixed hybrid heating system based on solar-hydrogen energy and biomass allows a saving of up to 30% of annual fuel used for heating and domestic hot water [16].

2.1.2. Electricity generation system:

- The assembly of photovoltaic panels, Off Grid 1 Kw, Pmax = 250 W, Imax = 8,34A.

- Fuel cell with polymer membranes (PEM), Pmax= 500 W, T=14,4 V, I=35A, hydrogen consumption 6.5 l/min.

- Proton exchange membrane electrolyzer (PEM), with capacity of 1.05 Nm3H_2/h at a pressure up to 30bar, U= 220V, Pmax=2kW.

The hydrogen produced by the electrolyzer is very efficiently converted into electricity using fuel cells with proton exchange membrane (PEM), which are actually electrochemical energy converters. This equipments has the advantage that can be used to produce electricity at any time using stored hydrogen, but only when necessary.

PEM fuel cells are the most promising type power generation, due to its advantages such as simplicity, low operating temperature and easy maintenance [17,18]. PEM fuel cells are the future of generators that provide electricity, station type, and portable using for this renewable energy sources [19].

Fuel cell system implementation - electrolyzer - store hydrogen in a demonstration greenhouses are a good alternative to traditional power networks solutions, considering that these shows equipment reliability and ensure electricity production in any season.

2.1.3. Electrical and thermal energy storage system:

- Mixed boiler for hot water heating and storage, with a capacity of 500l and thermal energy storage power up to 42 kWh.

- Pressure hydrogen storage cylinders, 50 liters capacity, volume 10m^3.

- Solar batteries with gel solution, U=12V, I=200Ah, are designed for photovoltaic systems and kits and used to store electricity. This type of battery uses innovative technology "Absorbent Glass Mat", which gives them the property to provide significant energy reserves that can feed many electrical consumers throughout its service life [20].

A schematic diagram of the constructed experimental system is illustrated in Figure 1.

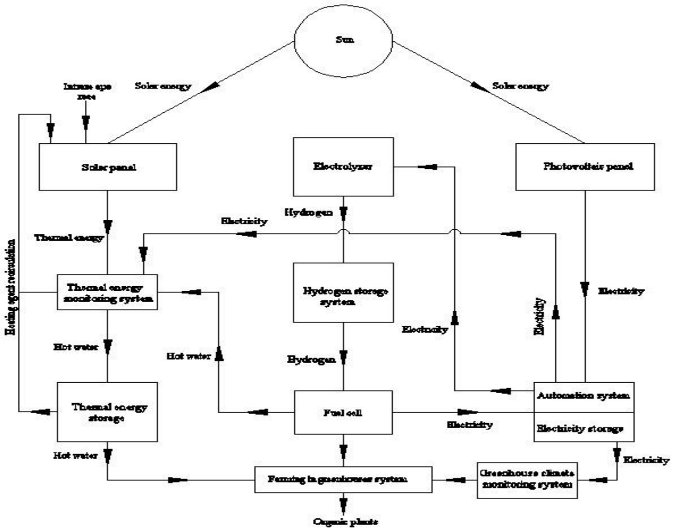

Figure 1. Schematic diagram of the hybrid greenhouse system

A major advantage of this sustainable type of greenhouse based on renewable sources, its modularity, once the hybrid system is sized and implemented by resizing individual components, can add unlimited various elements constructive structural, photovoltaic panels, thermal solar modules, cells combustion heating systems, ventilation systems, etc.

In the event that are conditions for biogas production to complement the energy requirement of the greenhouse, can also be integrated a small system to produce the fuel gas by decomposing organic matter [21].

In Figure 2 is represented the functional scheme of biogas system.

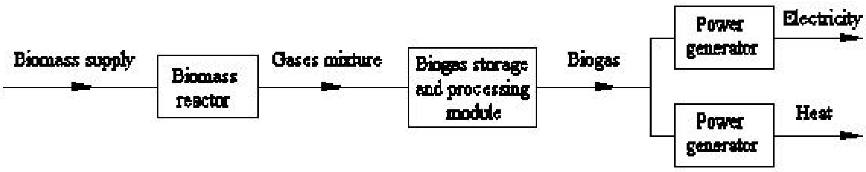

Figure 2. Schematic diagram of the biogas system

The use of biogas in the agricultural greenhouses, providing heat and electricity, is one of the most effective solutions to ensure their sustainability.

3. CONCLUSIONS

This paper presents the case study of a research project in progress, which has as main objective development of an integrated for the production of heat and electricity, a bio-organic emissions, using renewable sources with low polluting.

The study case analyzed in this paper, reveals that the development of a concept of sustainable greenhouse, which has an integrated energy system hybrid, based exclusively on renewable sources such as solar power, hydrogen energy, biomass and biogas can bring significant benefits on agricultural development and economic growth, by reducing energy consumption, increase security of supply and environmental protection.

Acknowledgements

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TEMPERATURE HUMIDITY INDICES CALCULATED FOR BUCHAREST BETWEEN THE YEARS 2009-2012

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ABSTRACT

Temperature – humidity indices is calculated based on several relationships depending on air temperature and relative humidity critical threshold is 80. The analysis of statistical data from the weather station at the Biotechnical Faculty of Engineering of the UPB Bucharest for the summer of 2009-2012. 2012 was the warmest since measurements are made in Romania, the number and persistence especially hot days with temperatures above 35 degrees, and tropical nights, more than 20 degrees. Bucharest has broken the record of temperature. The temperatures of the summer year 2012 was bigger than the temperature of the summer of the year 2007 , and the summer of the year 2012 are on the first position of the hottest summers of the past 62 years. The average summer temperature in 2012 was 0.3 degrees Celsius higher than the summer of 2007.

1. INTRODUCTION

The temperature-humidity indices is a bioclimatic index used to illustrate the temperature felt by the human body. It renders an apparent temperature, namely the temperature felt by the human body that cools slower at higher values of the relative humidity due to the reduction of the evaporation rate. Consequently, the sensation human body perceives depends not only on temperature, but also on humidity (Table no. 1). For example, we feel quite comfortable if there are 35°C but the relative humidity is only 20%, as the temperature we experience is 27.1°C. In case temperature remains constant but relative humidity increases (at 35°C and 100% relative humidity we feel a temperature of 40.4°C), there develops a discomfort sensation – fatigue, dizziness, heat cramps etc. (Table no. 2). Generally, most people feel comfortable if the index is below 70, but the discomfort sensation increases as the THI values increase [5]. This issue is also increasingly present and debated in the Romanian literature in the field as well [7].

The evaluation of the thermal sensation is often a crucial matter of indoor environments assessment since their quality affects the health safeguarding as well as the productivity of subjects1). Thermal sensation depends on the subject-environment heat transfer which is strictly related to subjective variables (metabolic rate and clothing thermo-physical properties) and four environmental variables (air temperature, mean radiant temperature, air velocity and relative humidity) [9].

Although all heat-related deaths and illness are preventable, many people are affected by extreme heat every year. However, in spite of the alarm signals triggered by the researchers and media, we consider that there still is an obvious lack of public recognition of the hazard induced by the exposure to extreme heat.

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All three summer months of 2012 had average temperatures above normal climatic located in the reference period 1961-1990.

In Romania, in August was marked by maximum temperatures that have passed 40 degrees Celsius, recorded regions expanded during peak periods of the two heat waves.

In August, it has broken the record for maximum temperature of absolute weather station at the University Politehnica of Bucharest Faculty of Biotechnical Systems Engineering. In Bucharest on 7 August 2012 was recorded 41.5 degrees Celsius, replacing the absolute maximum, recorded on 20 August 1945 (41.1 degrees Celsius).

The highest temperature of the summer season of 2012 was at Giurgiu on 7 August was 43.5 degrees Celsius.

The maximum temperature of 44.5 degrees Celsius, an absolute record among weather stations in Romania, recorded in August 1951 in a village near Braila (Ion Sion) but remained the highest value.

Table 1: The relation between environmental temperature (°C) and relative humidity (%) and the temperature felt by the human body [4]

Temperature	Relative humidity (%)										
°C	100	90	80	70	60	50	40	30	20	10	5
15	17.5	17.0	16.5	16.0	15.5	15	14.5	14	13.5	12.9	12.7
18	20.2	19.6	19.0	18.4	17.8	17.2	16.6	16.0	15.4	14.8	14.5
20	22.2	21.5	20.8	20.1	19.4	18.7	18.0	17.4	16.7	16.0	15.6
22	24.2	23.4	22.6	21.9	21.1	20.3	19.5	18.7	18.0	17.2	16.8
25	27.5	26.5	25.6	24.7	23.7	22.8	21.9	20.9	20.0	19.1	18.6
28	31.0	29.9	28.7	27.6	26.5	25.4	24.3	23.2	22.0	20.9	20.4
30	33.5	32.2	31.0	29.7	28.5	27.2	26.0	24.7	23.5	22.2	21.6
32	36.1	34.7	33.3	31.9	30.5	29.1	27.7	26.3	24.9	23.5	22.8
35	40.4	38.7	37.1	35.4	33.7	32.1	30.4	28.8	27.1	25.4	24.8
38	45.1	43.1	41.1	39.2	37.2	35.3	33.3	31.4	29.4	27.4	26.5
40	48.4	46.2	44.4	41.9	39.7	37.5	35.3	33.2	31.0	28.8	27.7

Low risk | Medium risk | Increased risk | Very high risk

Table 2: Effects of prolonged exposure to high temperature and humidity values [4]

27–32°C (54–64)	Caution – it is possible to feel a sensation of fatigue in case of prolonged exposure and activity. If a person continues the activity under such circumstances, there can appear heat cramps.
32–41°C (64–82)	Extreme caution – heat cramps and heat exhaustion are possible. If a person continues the activity under such circumstances, there can appear heat stoke.
41–50°C (84–100)	Danger – heat stoke is highly probable if continuing the activity.
> 50°C (>100)	Extreme danger – heat stoke is imminent.

2. METHODOLOGY

The Temperature – Humidity Index (THI) is generally calculated according to the formula:

$$THI = (T \times 1.8 + 32) - (0.55 - 0.0055\ U)\,[(T \times 1.8 + 32) - 58] \qquad (1)$$

where:

T = air temperature (°C), U = relative humidity (%).

If THI is: ≤ 65 it means comfort state; 66-79 it means alert state; ≥ 80 it means discomfort state [6].

As a monthly distribution, the hottest months are July and August, when both favored the entry of hot air masses from northern Africa and thermal convection. Reported the decade under review, the monthly level, the highest number of days that exceeded the critical threshold was registered in Bucharest in July 2012. Table 3 indicates the number of days in the analyzed years with values greater than 30^0C, 35^0C higher, exceeding 40^0C. High values of ITU affecting children and elderly or various diseases. To more than 70 of the ITU, most people feel comfortable, to between 75 and 80, about half of the population feels uncomfortable heat and values greater than 80, even if discomfort does not appear it is recommended for appropriate protective measures (consumption of liquid, sun protection, proper clothing, ventilation rooms, rest periods alternate with periods in working ventilated rooms).

Amid the high temperatures recorded in July-August 2012 and moderate moisture in the air layer near the ground, comfort temperature-humidity index increased progressively, reaching critical values and causing discomfort.

In 2012, this index has reached the critical threshold in Bucharest.
The highest temperature in June was registered in 1938: 38.4 degrees.

The hottest July day was recorded in 1939 was 39.6 degrees and the record being broken in August 2012 with temperature of 40 ^{0}C, registered in the city of Bucharest'. The summer of 2012 was the warmest since measurements are made in Romania, the number of days (51 days), with temperatures above 35 degrees above 20 degrees day and night.
It was considered the hottest summer in the last 62 years. It was considered and the driest year in the last six decades. August had maximum temperatures of 40 degrees Celsius, recorded on extensive regions. In the city of Bucharest on August 7, 2012, 43^0C in the shade.

Amid high temperatures registered during July-August 2012 and a moderate humidity in the air layer near the ground, comfort temperature - humidity indices increased progressively reaching critical values and causing discomfort.

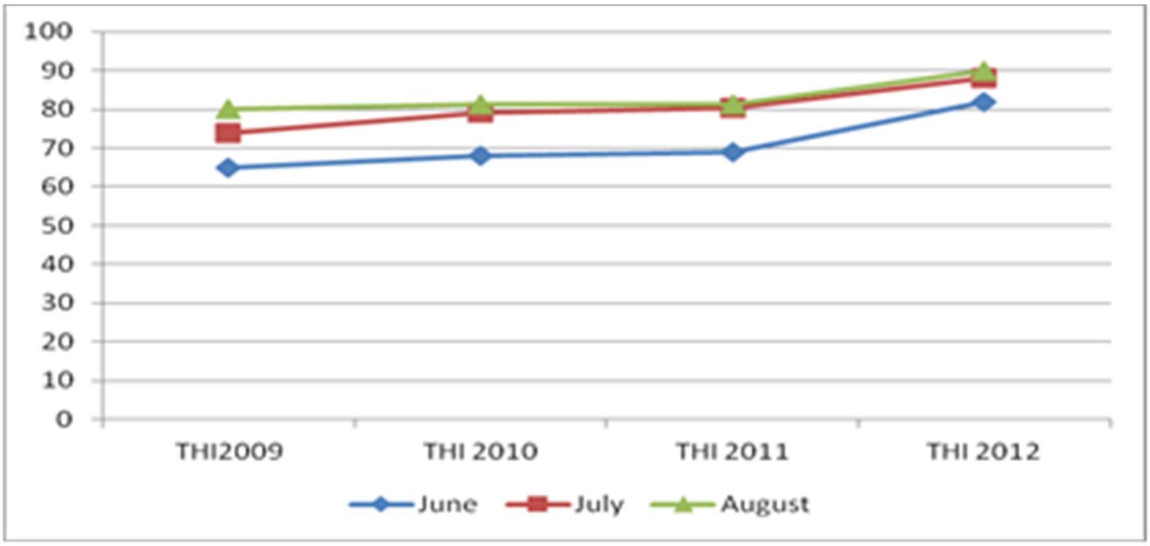

Figure 1: Temperature humidity index calculated in summer 2009-2012, based on the values of temperature and relative humidity recorded by the weather station at the Faculty of Biotechnical Engineering

Table 3: The number of days with temperatures above certain thresholds, June-August 2009-2012

Anul	No of days with Tmax ≥ 30, 35^{0}C June		No of days with Tmax ≥30, 35^{0}C July			No of days with Tmax ≥30,35, 40^{0}C August		
	≥30 ^{0}C	≥35 ^{0}C	≥30 ^{0}C	≥35 ^{0}C	≥40 ^{0}C	≥30 ^{0}C	≥35 ^{0}C	≥40 ^{0}C
2009	9	2	23	2	0	10	1	0
2010	1	1	16	3	0	24	9	0
2011	7	1	16	3	0	12	0	0
2012	17	5	6	23	0	3	23	3

CONCLUSIONS

Heat waves seem to become a constant climatic risk phenomenon in the south of the country during the warm season. Bucharest represents one of the most vulnerable regions of Romania due to its positioning in the path of extremely hot air masses penetrating from Northern Africa. Consequently, in the last ten years, the region has registered new and alarming thermal records. It notes that in the period under review were days when it was surpassed by the comfort of 80. It was observed that the August 2012 was the warmest (40 ^{0}C). The comfort index humidity - temperature exceeded the critical threshold across the country.

When it comes to the influence of such high values of the temperature humidity indices on human health, children and elderly people or those suffering of different diseases are mainly affected. At values above 80, even if the discomfort sensation is not obvious, it is recommended to take adequate protection measures.

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INFILTRATION-PERCOLATION EXTENSIVE SYSTEMS FOR URBAN WASTEWATER TREATMENT

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ABSTRACT

In the present paper there are presented the construction, operation and performances of infiltration-percolation extensive systems used mainly for wastewater treatment of small and medium communities (500 – 5000 inhabitants).

Then are reviewed representative examples of these wastewater treatment plants putting in evidence constructive particularities, obtained performances, areas where have been founded and their spreading in the world.

Considering the conditions and requirements for wastewater treatment in rural areas of Romania becomes extremely interesting to undertake studies for implementing such extensive systems.

1. THE CONSTRUCTION, OPERATION AND PERFORMANCES OF EXTENSIVE INFILTRATION – PERCOLATION SYSTEMS.

Infiltration – percolation systems are extensive installations for wastewater treatment wherein water subjected to process is passed through beds of a granular material with small granulation size. Wastewater treatment is done mainly using two simultaneous processes, namely:

- *superficial filtering (mechanical process)*, where suspended solids from the wastewater (both of mineral and biological origin) are removed at the surfaces and in the pores of the filterable beds, resulting beside an advanced reduction of the mineral load from the water subjected to the treatment, and a significant reduction of its organic load (particulate COD) too;
- *anaerobic fermentation of organic load (biological process)*, through which the dissolved pollution from the wastewater (ammoniacal and organic nitrogen and dissolved COD) is biochemically transformed by a biological film of aerobic bacteria formed on the surfaces of particles of the granular material of the beds, especially on their surfaces, but also inside them; so, the infiltration-percolation beds become real biological reactors which provides a very high support surface area for biological film formation; the aeration inside the granular beds is produced and is even intensified both by convection caused by the infiltration movement of the wastewater through the surfaces of the bed, and by diffusion of the atmospheric air inside in the material of the beds by adsorption in their porous media.

Biochemical oxidation of organic matter and nitrogen inside the filterable beds is accompanied by the development of the bacterial culture (thickening of the biological film) process which should be conducted such there are avoided the clogging of the granular media with bacterial biomass and the occasional losses of bacterial biomass by entrainment by the infiltration water. The auto-adjustment of biomass quantity can be controlled by the way in which the wastewater influent supply in done, namely following a cycle composed of alternative phases:

- *operative phases when the filterable beds are fed with wastewater influent*, during 3 or 4 consecutive days, when it is provided the nutrition of the biological film;
- *inoperative phase when the supply of the filterable beds with wastewater influent is interrupted,* when the growth of the bacteria from the biological film is much reduced, because the "food scarcity regime", phase which must be dimensioned as duration, so that the biological treatment processes can be quickly restart, when the wastewater influent supply is restored.

In this regard, the infiltration-percolation systems are usually composed of a total of filterable beds, which is a multiple of three, divided into 3 groups, filterable beds from each group being successively supplied with wastewater, such that to obtain for each bed an operative phase followed by an inoperative phase double as duration. It can be noted that by this controlled management of bacterial film development, it is avoided the need to separate from the treated water effluent of the eventual pieces of biological film detached from the granular media of the beds because of thickening, taking into account that this type of system of wastewater treatment can not be provided in the structure with settling equipments.

Constructively (see figure 1), the infiltration – percolation beds are composed of: *the distribution system of wastewater influent*, formed by a network of perforated pipes, *the infiltration layer of granular material* and *the system of purified water collection*, formed by a network of drainage pipes placed in a selected rock bed, placed under the layer of granular material. Noted that if the basic land on which are built filterable beds it is impermeable, then the infiltration bed it is realized directly in it, without any kind of isolation (see figure 1 left), while if the basic land where the infiltration bad are constructed it is permeable, then the infiltration bed are isolated to basic land with a impermeable geomembrane (see figure 1 right).

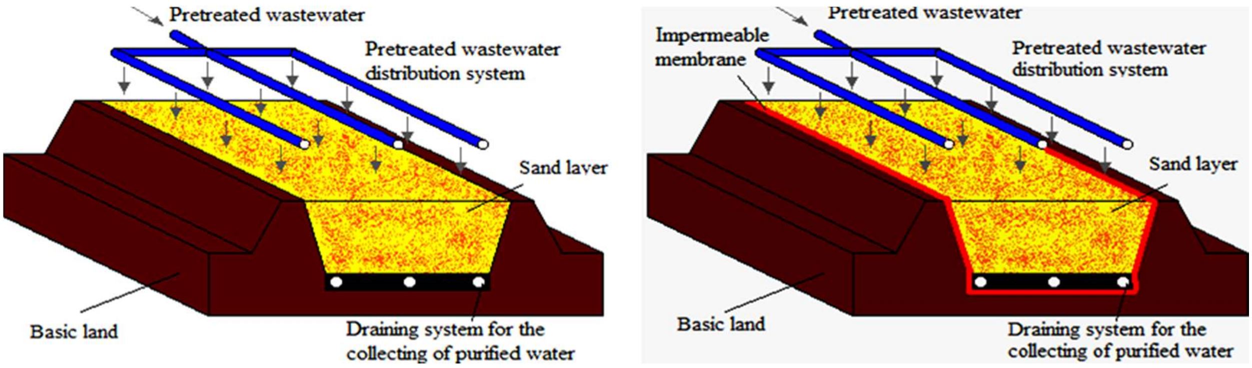

Figure 1 – Construction of filtration beds of infiltration – percolation extensive system

The influent distribution system on filterable beds must achieve a uniform distribution as possible, so to be used the entire surfaces of the beds and to ensure a homogenization of hydraulic loads of application of the influent. Mentioning that the influent distributed on infiltration – percolation beds is not raw sewage, as it comes through the sewers systems, but a mechanical pretreated wastewater in order to eliminate suspended solids, roughs and settleable, and to prevent fast clogging of filterable beds; for this purpose the infiltration-percolation system is provided with *a preliminary mechanic stage*, consisting of a sieving system and settling tank and with *a buffer storage tank* for the mechanically pretreated wastewater.

The supply with influent of the infiltration beds is done in batches, either by temporary flooding of the infiltration beds, or by uniform sprinkling on their upper surfaces. It can be mentioned that this operation is performed by rapid emptying, with high flow rates of the buffer tank. The intermittent supply with influent of the filterable beds favors, apart from the balanced managing of the bacterial biomass development, the maintenance of high concentrations of oxygen in the granular beds, especially because the diffusion phenomena of air by adsorption of air on the porous material of granular beds, which occur in particular in the periods of inactivity between two consecutive feeds. Usually, at one feed phase they are concomitantly wetted only one single bed from each group, with hydraulic loads having values of hundreds m^3/m^2.day. Noted that the upper surface of filtration beds, where the distribution of wastewater influent is made, should be permanently kept clean, to be in contact with the atmospheric air.

The granular material constituting the filterable beds is usually *sand*, with silicate-based constitution, which must have the following characteristics for ensuring the optimal functioning: the sand must be clean, the sand grain size d10 between 0,25 – 0,4 mm, the degree of uniformity of the sand particle size UC between 3 – 6, and the content of fine material, with grain sizes smaller than the minimum required, must be less than 3 %. These characteristics of the granular material need to be ensured for the entire exploitation period of infiltration-percolation system. Constructively, the filterable beds can be built on the basic soil surface, or buried in the basic soil. Circulation of water through the infiltration-percolation beds can be with horizontal flow, in which case the thickness of granular beds is between 0,8 – 1 m, or with vertical flow, in which case the thickness of granular material can reach up to 3 m. Note that if the filterable beds have a sufficient thickness of granular material, they additionally ensure the possibility to eliminate the contamination with pathogenic microorganisms of the effluent (are obtained reductions of 1000 times the number of pathogenic microorganisms for each 1 m thickness of filterable beds).

The performances obtained by the infiltration-percolation systems are the following:

- excellent reductions of BOD_5 (under 25 mg/l), COD (under 90 mg/l), and suspended solids SS (under 90 mg/l) from the water subjected to process;
- virtually complete nitrification, but limited denitrification (reducing the content of nitrogen up to 40% in installations with vertical flow and up to 50% in installations with horizontal flow);
- the reduction of phosphorus is relatively high (about 60-70%), in the first 3-4 years of operation, after which decreases progressively until it will be canceled, after a period of 8-10 years of operation;
- the possibility of elimination of contamination with fecal bacteria, if the filterable beds have appropriate thickness.

2. INFILTRATION-PERCOLATION EXTENSIVE SYSTEMS USED IN URBAN WASTEWATER TREATMENT

Infiltration-percolation extensive systems for wastewater treatment were built in many parts of the world, mainly in rural areas of western European countries. The following examples are representative of such plants.

So, in the town of Mazagon, a seaside resort located on the Atlantic coast in the South of Spain with a stable population of 850 people, increased seasonal up to 20,000 people, it was built a pilot treatment plant with an extensive infiltration-percolation system which was designed to process wastewaters from 1700 population equivalents. The system was built on an existing sand dune that separates the ocean from a lagoon, and it is composed [3, 5] of a *mechanical pre-treatment unit* (especially for sediment removal), made of a 170 m^3 primary settling tank, a *storage tank* and three pairs of *infiltration-percolation beds* with surfaces of 200 m^2 each (see figure 2 left). The feeding of the infiltration-percolation beds with pre-treated wastewater influent, controlled by a self-releasing siphon, is sequentially done by the total gravitational emptying of the storage tank (approximately 100 m^3 wastewater), with durations of 40-50 minutes (corresponding to a 130 m^3/h average flow rate). At a feeding sequence, a pair of infiltration-percolation beds is fed by a distribution system with perforated pipes (see figure 2 right). The command of feeding with wastewater of the different infiltration-percolation beds is done manually by a system of valves.

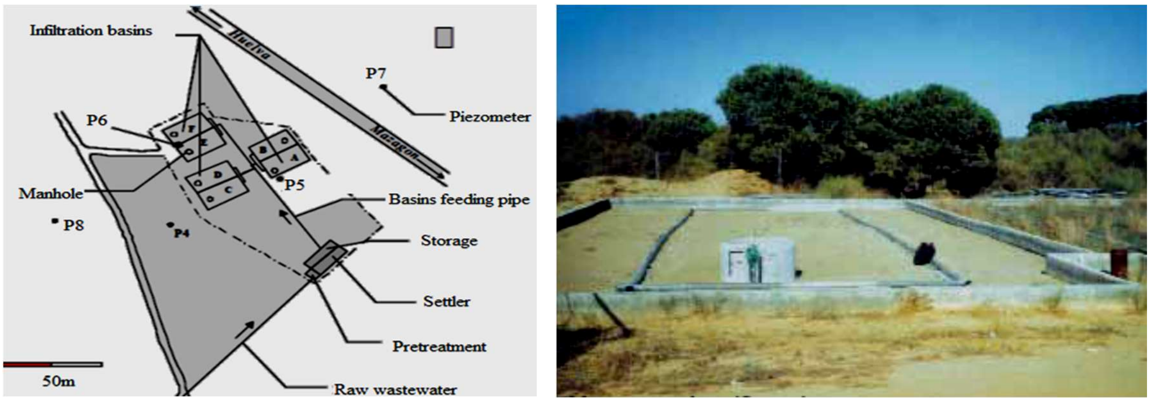

Figure 2 The extensive infiltration-percolation system of Mazagon (Spain) [3, 5]

The infiltration-percolation beds are constituted of homogeneous sand with content of 94% SiO_2, 0.24 mm effective size (d50) and 2.3 uniformity coefficient (UC). The thickness of the infiltration-percolation beds is 2 m.

The behavior and performances of the plant were investigated between March and August 1993 [3, 5] and revealed the following [3, 5]:

- the distribution of the wastewater influent on the surfaces of the filterable beds was relatively not homogeneous (only half the surface was flooded after 5 minutes of feeding, 75 % after 12 minutes and about 90 % after 21 minutes);

- the percolation velocity of the influent through the granular beds has values between 1.1-2 m/h, so after two hours after the beginning of the feed approximate 95% of the volume of the distributed water exceeded two meters in depth;

- there are obtained excellent performances of oxidation of the organic and ammonia and organic nitrogen loads, namely: 90% CBO_5 was removed (approx. 60% of the amount in the first 0.3 m from the surface of the bed thickness) and more than 98% N-NH_4 (35-50% of the amount in the first 0.3 m from the surface of the bed thickness);

- during the experiments, the feed with wastewater influent of the filterable beds was done once or twice a day, but after the analysis of the oxygen recovery inside the filterable beds it result that the feed one a day is optimal;

- the disinfection performances were mediocre (reduction with 1.2 Ulog of total coliforms, with 1.6 Ulog of faecal coliforms and with 1.3 Ulog of faecal streptococcus).

In France, infiltration-percolation extensive systems are commonly used for sewage treatment of small and medium towns (500 – 5000 population equivalents) especially in rural areas. In terms of construction, these extensive infiltration-percolation systems with beds of quartz sand are in agreement with the requirements presented above, in chapter 1, and generally can be divided into two main categories, namely:

- infiltration-percolation basins - are built on the surface of the base ground, frequently waterproofed by geomembranes, are feed with wastewater by sprinkling or flooding their surfaces by perforated pipes distributors and have regularly the thicknesses of the granular beds greater than 1.5 m;

- buried filters - are built buried in the base ground, are feed with wastewater underground, directly in the granular beds by specific distributors and have regularly the thicknesses of the granular beds greater than 0.7 m.

The structure of the extensive infiltration-percolation basins systems is shown in the principle scheme from figure 3.

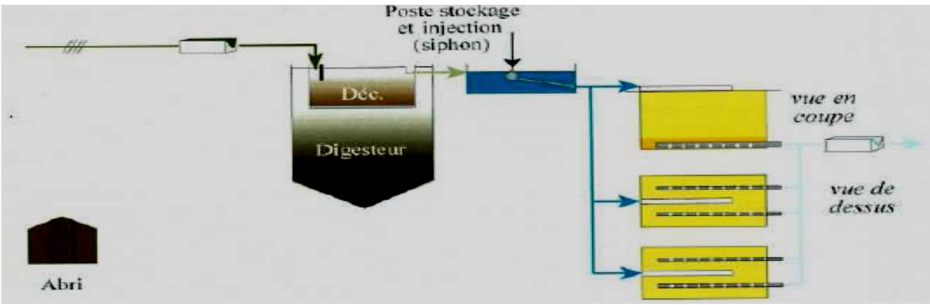

Figure 3 The structure of the extensive infiltration-percolation basins systems [6]

This type of extensive system is used in many locations from the territory of France (see figure 4 left where is shown the distribution of these systems in different departments). In figure 4 right there are presented aspects from the extensive infiltration-percolation basins system of Merle-Leignec.

Figure 4 The territorial distribution of the extensive infiltration-percolation basins systems in France and aspects from one of these extensive systems [7]

The structure of the extensive systems with buried filters is shown in the principle scheme from figure 5

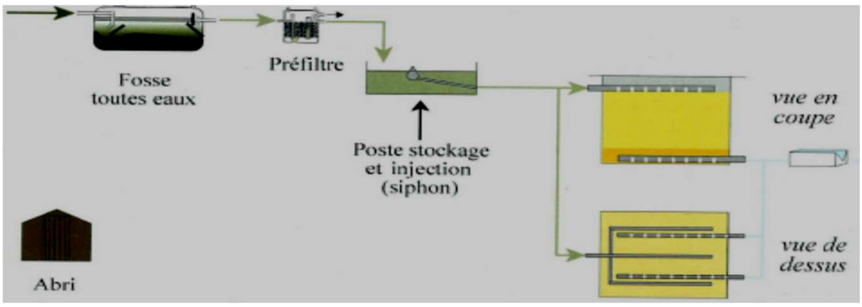

Figure 5 The structure of the extensive systems with buried filters [6]

This type of extensive system is used too in many locations from the territory of France (see figure 6 left where is shown the distribution of these systems in different departments). In figure 7 right there are presented aspects from the extensive infiltration-percolation basins system of Crespin (Aveyron).

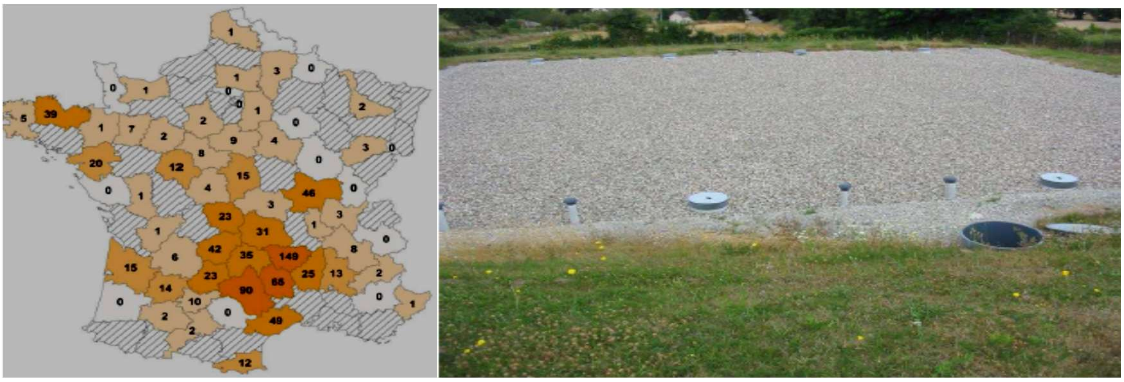

Figure 6 The territorial distribution of the extensive systems with buried filters in France and aspects from one of these extensive systems [7]

3. CONCLUSIONS

Infiltration-percolation extensive systems are commonly used for sewage treatment of small and medium communities (500 – 5000 population equivalents), especially in rural areas.

Main advantages of using infiltration-percolation extensive systems are the following: excellent results of reducing BOD_5, COD and SS from the treated wastewater; high level of nitrification; significant capacity of disinfection, which can be considered; reduced cost of investment and operating costs in comparison with those of similar intensive installations; surface area required for foundation is much lower than for other extensive wastewater treatment plants.

Constructive simplicity, low costs and high performances make this type of extensive plants to be intensively studied in Europe and beyond [1, 2, 4] in order to optimize the working process and implementation in more and more areas of the world.

Considering the conditions and requirements for wastewater treatment in rural areas of Romania, becomes extremely interesting to undertake studies for implementing such extensive systems.

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PREPARATION OF LIQUID AND GELLED BIOTHANOL FROM AGRICULTURAL RESIDUES

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ABSTRACT

The important component of bioenergetics is a biofuel as a bioethanol prepared from biomass accumulated solar energy by photosynthesis in the green plants. The first generation bioethanol is a product of fermentation of fructose, sucrose, glucose contained in agricultural residues as fruits, grapes, sugar beet, cane, maize, wheat, potatoes etc. and then isolated by single and fractional distillations. The bioethanol is a liquid fuel at room temperature with environmental risk leading to fire during indoor applications. The current study is discussing a gelled bioethanol so called bioethanol gel that is safe to use indoor for a local heating. The proposed inorganic salts are used for drying of bioethanol and for bioethanol gel preparation. The critical analysis of indoor applications of bioethanol, bioethanol gel and methanol gel are discussed.

Key words: first generation biofuel, bioethanol gel, fermentation, distillation, inorganic salts

1. INTRODUCTION

The agricultural residues as fruits are part of the sources for first generation biofuel as a bioethanol. The different between first and second generation biofuels are discussed in reviews [1,2]. The first generation biofuels are using food crops and the second generation biofuels is oriented to use lignocellulosic crops [3-5]. The third generation biofuel is so called Algal fuel and is produced from biomass by algae organisms [6]. The fourth generation biofuels are discussed as a capturing machine for CO_2 out of atmosphere and lock it up in branches, trunks and leave. The metabolic engineering of algae is applying for biofuel production [7].

The goal of the paper is a preparation of safe alcoholic products by fermentation as a bioethanol in the liquid and gelled forms for indoor applications by burning.

The main tasks are: (i) preparation of liquid bioethanol, (ii) preparation of bioethanol gel and (iii) critical analysis of liquid and gelled bioethanol and methanol gel for indoor applications

2. EXPERIMENTAL

2.1 Preparation of liquid bioethanol

The agricultural residues as fruits in our case are pears used for alcoholic fermentation. The first step included mechanical grinding of fruits for better fermentation after that. The second step is connected with preparation of optimal sugar-water solution for fermentation and activation of yeast. The concentrations of sugar-water solutions at 1 part sugar and 2, 3, 4 and 5.5 parts water at different temperatures are prepared. The refractometer model RSG 100/ATC with temperature correction is used to measure concentration of sugar at temperatures 20 ºC, 21 ºC and 22 ºC. This temperature diapason is closed to the room temperature of fermentation process. The ratio 1:5.5 is 15.8% sugar and acid fermentation is possible to start. The ratio 1:2 is 28.9% sugar and it is not suitable for alcoholic fermentation. The ratio 1:3 is 25% sugar and it is a critical point for alcoholic fermentation. The ratio 1:4 is selected for realization 22 % sugar concentration for alcoholic fermentation. The solution is prepared below 60 ºC, which is a critical temperature for caramelization of sugar. The citric acid is added to sugar-water solution to invert sugar and to realize monomers. This procedure is useful for realization of better condition for working yeast during fermentation according the chemical equation:

$$[C_6H_{10}O_5]n + nH_2O \rightarrow nC_6H_{12}O_6$$

The baker's yeast is activated separately in 22% sugar solution and after that is mixing with pears pulp and sugar-water solution at 37 ^oC.

The fermentation is carried out in bioreactor with controlling temperature, concentration of sugar and pH. The apparatus for simple distillation is used to separate bioethanol. The simple distillation is controlled by temperature and a moment concentration of the sample of distillated alcohol is measured with a refractometer.

The drying process of bioethanol was done with anhydrous $CuSO_4$ which was prepared by thermal dehydration of $CuSO_4.5H_2O$. The cupper sulfate is insoluble in bioethanol and it catch the water and form low hydrates insoluble in bioethanol with color from white to pale blue.

The composition of bioethanol is determined by Gas Chromatograph Agilent 7890A.

2.2 Preparation of gelled bioethanol

The gelled bioethanol is prepared by mixing 100 ml liquid bioethanol, saturated solution of 17 g calcium acetate and 40 ml water. The white bioethanol gel is stored in the glass jar with a cap to prevent evaporation of bioethanol from gelled product.

3. RESULTS AND DISCUSSIONS

The alcoholic fermentation is exothermic process according the chemical equation:

$$C_6H_{12}O_6 \rightarrow 2CH_3CH_2OH + 2CO_2\uparrow , + Q$$

The sugar is converted to bioethanol by baker's yeast and the decrease of sugar concentration during fermentation process is presented on Figure 1.

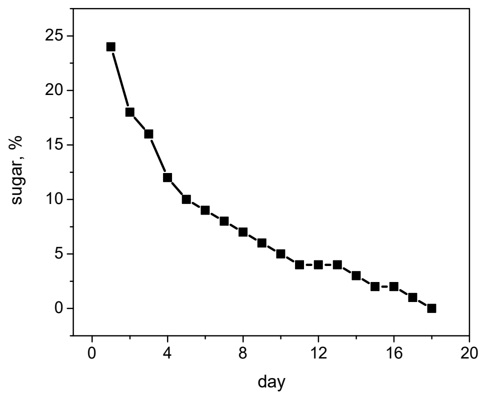

Figure 1: The sugar concentration changing during fermentation process.

The first stage of fermentation is during 2 days from beginning with increasing the temperature and decreasing concentration of sugar. The second stage of fermentation is during the next 3 days and intensive separation of carbon dioxide and decreasing of sugar concentration is observed. The third stage of strongly fermentation process is observed the next 2-3 days with intensive separation of carbon dioxide, increasing the temperature and decreasing the concentration of sugar. During these stages of fermentation the stirring of material is important for homogenization and separation of carbon dioxide. The last forth stage of fermentation is a slow process at low concentration of sugar. The concentration of bioethanol increase and drastically decrease of yeast is observed. After 18 days fermented material reach 0 % sugar, high concentration of bioethanol and it is suitable for distillation.

The bioethanol is separated by single distillation of fermented material. The alcoholic distillate contains water, alcohols, ethers, fusel oils acids, glycols and etc. The cleaning process of bioethanol is done by adding active carbon. The bioethanol is concentrated by simple distillation and the results are presented on Figure 2.

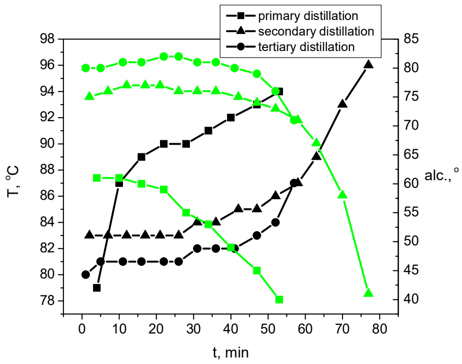

Figure 2: The changes of bioethanol concentration and temperature during the primary, secondary and tertiary simple distillations.

The primary distillation start at 78.6 °C, 60 ° acl., and finish at 94.8 °C when concentration of alcohol is 40 ° alc. In this way by repeating single distillation the bioethanol is concentrated till 95 ° alc. The bioethanol at higher concentration than 95 ° alc. is drying by molecular sieve or inorganic anhydrous salts. The drying process of bioethanol is done with anhydrous $CuSO_4$ which was prepared by thermal dehydration of $CuSO_4.5H_2O$. The cupper sulfate is insoluble in bioethanol and it catch the water as low hydrates insoluble in bioethanol and changing the color from white to pale blue.

The gas chromatograph spectrum of 65 ° bioethanol is shown on Figure 3.

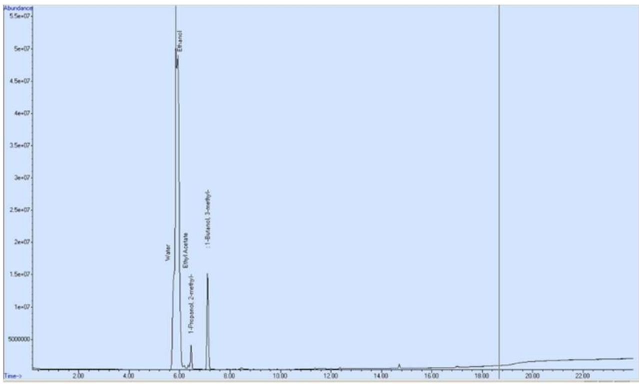

Figure 3: The gas chromatograph spectrum of bioethanol after the second simple distillation.

The main components of the sample are ethanol, water, ethyl acetate, propanol and butanol. The dominant concentration of components is ethanol. The presence of methanol was not detected.

The design of aluminum burner for liquid bioethanol utilization is presented on Figure 4. The color of the flame of bioethanol is colorless. The color of the flame is visible when inorganic salts are added to bioethanol as sodium chloride for yellow color.

Figure 4: The burner and system for indoor utilization of liquid bioethanol.

The fire risk for indoor applications is minimal when is using a gelled bioethanol instead a liquid bioethanol. The bioethanol gel is a natural non-toxic friendly product compared to the toxic methanol gel. These advantages of liquid and gelled bioethanol are used for indoor application as a fireplace for a second local heating source and aromatherapy.

4. CONCLUSIONS

The optimal experimental set up is presented for preparation of liquid and gelled bioethanol by fermentation of agricultural residues as fruits, single distillation, drying and burning in indoor fireplace.

The specific effects of inorganic salts in bioethanol preparation and indoor utilization are clarified as (i) a cupper sulphate for drying of bioethanol, (ii) calcium acetate for preparation of bioethanol gel and (iii) sodium chloride for yellow color of the flame of burned alcohol.

The liquid bioethanol and gelled bioethanol are promised advanced safe fuels for indoor applications than toxic methanol gel.

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A REVIEW ON THE DURABILITY OF BIOMASS PELLETS

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ABSTRACT

Due to the threat of climate change, the need to reduce the emissions of greenhouse gases and with increasing oil prices there is need for increasing the use of biomass in energy production. Pelleting is a promising technology which converts the energy of biomass into a more useful form through densification in order to ease handling, storage and transport. This paper presents some aspects on the types of biomass that care used worlwide for the production of pellets and the current status of pellets production in Romania. Also, there are presented some of the methods used for the measuring of pellets durability and the influence of some factors (such as: particle size, forming temperature, moisture content, bulk density) on the durability of pellets obtained from different types of biomass, since durability is considered a measure of pellet quality.

1. INTRODUCTION

The threats of global warming caused by increased emissions of greenhouse gases, rising fossil fuel prices and the need for energy independence have led to an increased demand and use of biomass in energy production.

Biomass refers to living and recently dead biological material that can be used as fuel for energy production, and may also include biodegradable wastes that can be burnt as fuel [8]. Biomass is a renewable energy source because its supplies are not limited. Trees and crops are grown continuously, and waste will always be produced. Some of the main advantages of using biomass for energy production are: high availability due to the amounts of biomass growing permanently; reduced emissions of greenhouse gases; environmental sustainability; low cost of recollection [9]. The use of biomass provides less dependence on fossil fuels in order to increase security supply, helps to maintain stability against potential price shocks and to reduce imports of fossil fuels [1]. Biomass is the third largest source in the world for the production of electricity and the main source for the production of thermal energy [13].

Major technologies for the capitalization of biomass are: direct combustion of wood biomass, mixed combustion of wood biomass and coal, pyrolysis, gasification, pelleting / briquetting, anaerobic digestion for biogas production, ethanol, biodiesel and methanol production.

Pelleting is a combination of sequential steps (Fig. 1) where biomass is compacted under high pressure to obtain a densified material, named pellet. The pelleting process offers multiple advantages: increased energy density of the biofuel makes its combustion more efficient; reduced handling of biofuel; lower storage and transport costs; improved overall biomass quality; stability and durability [11], lower dust levels and higher heating values; lower pollution [4].

Although pellets can be obtained from different types of biomass, the industry has focused primarily on the production of pellets from wood waste (from forests, pruning of trees, sawdust

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or logging residues). When pellets are produced from non-wood biomass, they are called mixed biomass pellets [17].

Figure 1: Stages of pellets production [10]

Agricultural residues are the largest biomass feedstock in the world, considering that about 1.5 Gt of straw from cereal crops are annually produced worldwide [2]. Their degradation has potential undesirable consequences, such as the emission of greenhouse gases, so using them as a renewable energy source for pellets production contributes to the mitigation of CH_4 emissions from soil and CO_2 emissions from the use of fossil fuels [5]. Agricultural residues, such as cereal straws and stalks (wheat, rice, rye and barley), husks, corn cobs, corn stalks, sugarcane tops are commonly used in the production of pellets.

Some energy crops including miscanthus, switchgrass, sunflower, rape, hemp, poplar, willow, sorghum and alfalfa can be used for pellets production [8]. Pellets can also be obtained from different types of residual biomass derived from the production of oil (sunflower, oil, ect). For example, pellets from olive cake are produced on a commercial scale in the Mediterranean countries of Eastern Europe, and marketed as viable energy source [11].

The global pellet market has experienced a rapid growth and is expected to have a faster growth in the near future [6]. With a production of 11.5 million Mt in 2013 (50% of global production), the European Union is the biggest wood pellet producer globally [21]. In 2013, Romania's pellets production capacity was of 480.000 tones, of which 360.000 tones were made by four large producers. The remaining 120.000 tones, with significantly lower quality, were made by small producers for household use. In 2014, Romania's pellets production increased to about 740.000 tones / year. For 2020, is estimated that our country's production capacity of pellets will exceed 1.2 million tones / year [15].

2. METHODOLOGY

The use of some types of biomass in the production of energy is restricted by their low density. For example, the density of agricultural straws and grasses ranges between 80–150 kg/m^3, respectively 150–200 kg/m^3 for wood biomass. For a cost-effective use in energy production, these materials must be densified. The increase of biomass bulk density reduces costs and technical limitations in operations like feeding, storage, handling and transport of bulk feedstocks [19].

Durability is the most important physical quality of pellets. Pellet quality varies with physical, chemical and mechanical properties of biomass pelletizing parameters (compression force, temperature, etc.) and with post-production conditions (cooling, storage). Moisture, particle size, steam conditioning/preheating temperature, addition of binders, are some of the factors affecting the durability of pellets.

Durability is defined as the ability of pellets to remain intact at shock and friction when handled during storage and transport. Particle density is commonly taken as a measure of durability, e.g. high particle density leads to a high durability [16].

Durability is a characteristic used for quantifying the quality of pellets by measuring the percentage of broken pellets [14] and is of particular interest in the wood pellet industry and trade. When pellets are delivered by trucks and blown into storage rooms with high speed, pellets with low durability are crushed and turned into saw dust. Low durability causes disturbances within pellet feeding systems, dust emissions, and increases the risk of fire explosion during pellet handling and storage. Among the methods used to determine the durability of pellets, there are: the Ligno, the Holmen, the Dural, the Tumbler tester.

With the Ligno tester (Fig. 2), the pellets are exposed to shocks caused by air stream, so that the particles collide against each other and the walls of tester. The test chamber has a pyramidal shape and air stream comes from below the chamber. A sample of 100 g sieved pellets is placed in the chamber and an air stream of 70 mbar is blown for 60 seconds into the tester. The dust is removed, the remaining pellets are weighed and then durability is calculated [14] as ratio between weight after tumbling and weight before tumbling, multiplied by 100 [7, 18].

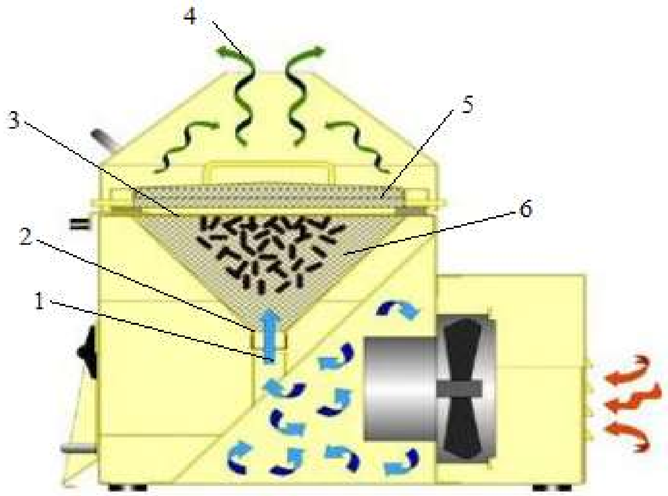

Figure 2: Ligno tester [22]
1-air inlet; 2-metal wire cloth; 3-steel screen lid; 4-air outlet; 5-removable filter frame with filter paper; 6-pyramidal chamber for pellets

With the Holmen tester, 100 g of sieved pellets are placed in the chamber, blown about from 30 to 120 seconds (based on the pellet diameter) by air stream (air velocity 20 m/s) [22]. The air and pellets are circulated through right-angled bends, impinging repeatedly on hard surfaces, leading to pellet attrition. Then, the samples are sieved again using a sieve with holes of about 0.8 of the pellet diameter [14].

The Dural tester is a grinder which produces and applies a consistent impact and shear to the pellets. The blades apply a constant impact and shear to the pellets placed in the canister. For a testing time of 30 seconds, the amount of sample required is 100 g. Sieving and calculation for durability are similar to those described for the Ligno tester[14].

The Tumbler device was adopted by the ASABE (Standard S269.4). A sealed rectangular box with inner sizes of 300x300x125 mm is equipped with a 230 mm long baffle, which extends 50 mm into the box, to enforce the tumbling effect. The baffle is symmetrically placed to a diagonal of one side of the box. The container rotates on an axis perpendicularly centered to the sides of the box [16]. After tumbling 500 g of pellets for 10 minutes at 50 rpm, the pellets are sieved (holes diameter is 0.8 of the pellet diameter), and the durability is calculated as described in the Ligno method.

Pellets durability is high when the computed value exceeds 80%, medium if the value is between 70-80%, and low for values below 70% [18]. Pellets with durability higher than 97.5% measured by a Tumbler test defined are considered high quality biofuels [14, 16].

3. RESULTS

Fasina [3] conducted a study on the physical properties of peanut hull pellets and found that pellets durability increased initially with moisture content, reached a maximum value of 90.3% at 9.1% moisture and decreased as the moisture content increased beyond 9.1%.

Among other variations, Miranda et. al. studied the influence of moisture content (M) and bulk density (BD) on the durability (DU) of pellets obtained from 10 types of biomass: pyrenean oak (PO), pyrenean sylvestris (PS), cork powder (CP), pine sawdust (SW), vine shoots (VS), olive branches (OB), barley straw (BS), wheat straw (WS), olive pomace (OP) and grape pomace (GP) [12].

Table 1: Properties of pellets from different biomass types [12]

Property	PO	PS	CP	SW	VS	OB	BS	WS	OP	GP
M [%]	6.35	9.5	8.02	9.3	10.8	6.5	7.2	9.4	6.86	7.05
BD [kg/m^3]	678	675	697	650	700	582	644	620	780	824
DU [%]	95.41	97.2	96.79	98.2	98.8	97.5	95.5	94.4	91.41	85.83

The highest durability were obtained for moisture contents between 6.5-10.8% (Fig. 3), Pellets with very low moisture contents (OP and GP), had the lowest durability, probably due to insufficient agglomeration. Most pellets, with densities of 582-700 kg/m^3 had high durability. The highest densities were obtained for agroindustrial wastes (OP and GP) showing the lowest durability.

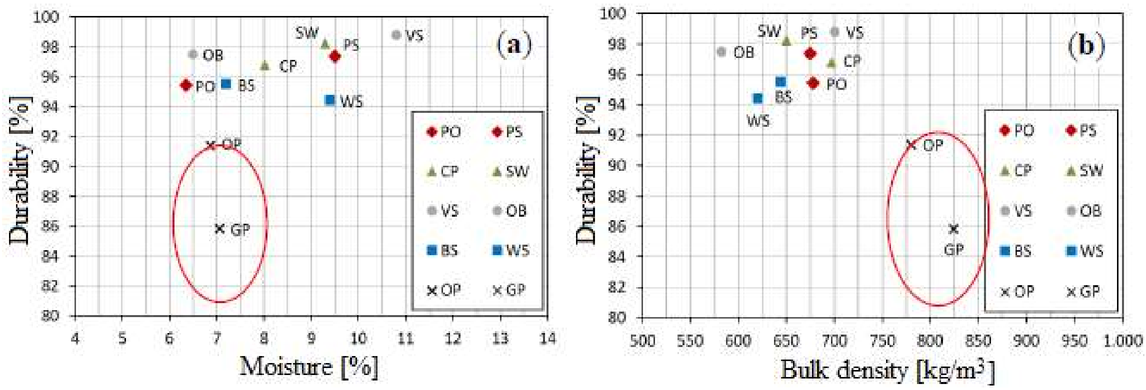

Figure 3: Relationships between moisture and durability (a), respectively bulk density and durability (b) [12]

Theerarattananoon et. al. [18] studied the physical properties of pellets obtained from corn stover, wheat straw, sorghum stalk and big bluestem, and the effects of moisture content on bulk density and on pellets durability. Pelleting has increased significantly the bulk density of the pellets, from 46–60 kg/m^3 to 360–500 kg/m^3. Bulk density decreased as pellets expanded due to the increase of moisture content (Fig. 4a). For corn stover and wheat straw pellets, increasing the moisture content from 9% to 14% did not affect the durability, while increasing the moisture content beyond 14% reduced the durability (Fig. 4b). For big bluestem pellets, the increase in moisture content from 9% to 11% did not affect the durability but the durability decreased as moisture content increased beyond 11%. For sorghum stalk pellets, the durability increased initially with moisture and reached a maximum value of 89.5% between 14-16% moisture content.

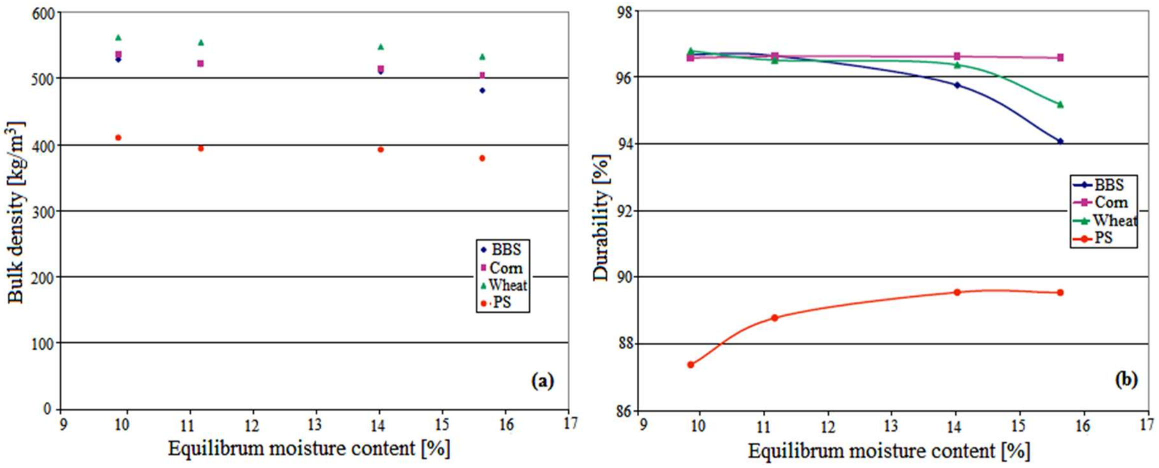

Figure 4: The effect of moisture content on bulk density (a) and durability of pellets (b) [18]

The influence of forming temperature (30-80ºC) and compaction pressure (150-250 MPa) on the durability of pellets obtained from corn cob, husk and stalk was studied in paper [21]. By increasing the compaction pressure from 150 to 250 MPa, the durability of cob and stalk increased from 35% to 50-60%, and from 28% to 40% for the husk. The highest durability, close to 80% for husk and 90% for cob and stalk, can be achieved for temperatures of 60 ºC, respectively 80ºC.

Ishii and Furuichi [5] determined the optimal moisture content required for the production of rice straw pellets with high heating value, respectively the influence of particle size and forming temperature on the durability of rice straw pellets. The optimal initial moisture content was between 13-20% under a forming temperature of 60 or 80ºC. Pellets durability was not influenced significantly by the size of shredded rice straws (5, 10 and 20 mm). The optimized conditions provided high quality rice straw pellets with ≥12 MJ/kg for the lower heating value and over 95% durability (Fig. 5).

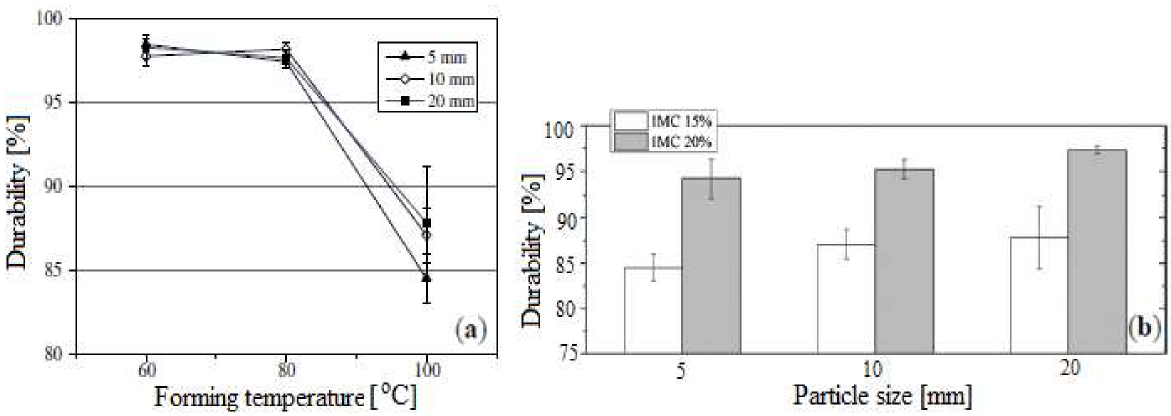

Figure 5: Influence of forming temperature (a), respectively particle size (b) on durability [5]

4. CONCLUSIONS

Biomass is an environmentally friendly form of renewable energy and its use helps reducing global warming. Fuel pellets can be manufactured from various types of biomass feedstock, including wood waste, agricultural residues and energy crops.

Durability is a measure of pellets quality and it is influenced by many factors. These factors are related to biomass properties (moisture content, particle size), production conditions (forming temperature, use of steam, binders, compression force, and other characteristics of the pelleting equipment) and post-production conditions (cooling, storage).

Although not all countries yet have sufficient resources or the necessary technology for large-scale production of pellets, over the last decade the pellets market has known a growing trend. High durability is very important for handling, transport and storage of pellets.

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3D MAPS OF PRESSURE DISTRIBUTION AT SOIL - TIRE INTERFACE

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ABSTRACT

Footprint is the interface through which the forces applied by agricultural machinery on the surface of soil are transmitted into soil depth. These forces, particularly if they are applied on soils with high moisture content, lead to artificial compaction. Shape and size of the footprint, and also the depth at which stresses are transmitted into the soil are influenced by wheel load and tire inflation pressure. This paper presents the results of experimental tests conducted in laboratory conditions, aiming to determine the influence of wheel load and tire inflation pressure on pressure distribution in the footprint between the tire of an agricultural trailer and a rigid surface. A mesh-type sensor was used for measuring of pressure in the footprints corresponding to four tire inflation pressures and four wheel loads. For each test were obtained the 3D maps of pressure distribution at soil-tire interface.

1. INTRODUCTION

Soil compaction is the reduction of soil volume and the increase of bulk density, mainly produced by the compressive loads (or wheel loads) applied on soil surface by agricultural machinery [9].

Compaction is one of the most dangerous forms of degradation of agricultural soil that has numerous negative effects. In terms of environmental effects, compaction alters soil structure, reduces water and air infiltration, increases the risk of surface runoff and flood, reduces pesticide decomposition and increases pesticide leaching into groundwater, increases erosion and sediment transport, accelerates the potential pollution of surface water by organic waste and applied agrochemicals [4, 13]. As for the agronomic effects, compaction increases soil strength and limits root penetration into the soil, leading to poor development of plants and decreased yields of agricultural crops [4, 10, 11].

Some of the factors influencing the artificial compaction of agricultural soil are presented in Figure 1.

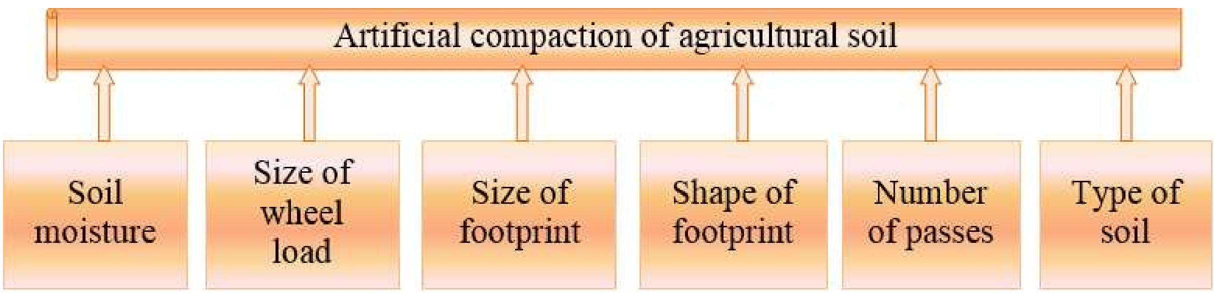

Figure 1: Main factors influencing soil compaction [1]

The process of artificial compaction consists in the following stages: the agricultural machinery applies stresses on soil surface; size of wheel load determines the size of stress

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applied on the soil; size of wheel load influences the depth at which stresses are distributed into the soil through the footprint; as a reaction to the stress applied through the footprint, the soil becomes compacted [7].

In contact with the soil, the tire leaves a footprint whose shape and size depends on: soil type and its physical characteristics, type of tire (stiffness, tread), tire inflation pressure and wheel load. Footprint area is the portion of wheel or tire that comes in contact with a supporting surface [14] and has a major role in relation to crop production and the environment [2].

Estimation of footprint area is essential in the calculation of contact pressure and in the prediction of severe risks of compaction [3]. Contact pressure at the soil-tire interface can be measured as a good indicator of the potential of compaction of agricultural soil [5]. Although estimation methods are available to predict the footprint area of agricultural tires, determination of the true 3D contact area in real-time is difficult and often relies on accurate methods for measuring of tire deflection [8].

For agricultural soils, due to higher tire inflation pressures, smaller footprint areas are formed, soil deformation is larger and stress is distributed deeper into the soil. At lower tire inflation pressures, tire deforms more, footprint area increases, mean pressures in the footprint are lower, soil deformation is lower and stresses are distributed to shallower depths [1].

Prevention of soil compaction is a significant measure in order to maintain or improve soil quality. Minimizing or preventing soil compaction can be achieved by reducing the contact pressure, hence by decreasing wheel load and / or increasing the footprint area between the soil and tire of agricultural machinery [6].

2. METHODOLOGY

The experiment was conducted in laboratory conditions, at the National Research - Development Institute For Machines And Installations Designed To Agriculture And Food Industry, INMA Bucharest.

The agricultural machinery used in the experiment was a biaxial transport trailer type RM5, equipped with agricultural tires, type Danubiana 11.5 / 80-13.5, profile D179 (tire width 29 cm, tire diameter 84.5 cm). First, the empty trailer was weighted in order to determine the initial load on the tested rear wheel (4.56 kN). Then, wheel loads were varied by adding 1, 2 and 3 metallic plates into the agricultural trailer.

Figure 2: Testing with 21.18 kN wheel load, at tire inflation pressure of 300 kPa (left), respectively 180 kPa (right) [12]

In all cases, the distribution of load on each wheel of the trailer was determined using a RW-10PRF weighing machine type platform. By adding the metallic plates, were obtained additional wheel loads of 12.8 kN; 17.11 kN and 21.18 kN. During the experiments, for each wheel load, tire inflation pressure was modified (180 kPa; 220 kPa; 260 kPa; 300 kPa).

Stresses at soil-tire interface (contact pressures) and the areas of footprints were determined by interposing, between the soil and tire, a mesh-type Tekscan Industrial Sensing sensor for measuring of contact pressure, connected to VersaTek Handle electronic data acquisition system (Figure 1). Tests results were recorded in the I-Scan software, which displays in real-time: 2D and 3D footprint, pressure distribution in the footprint, values of footprint area, contact pressure, maximum pressure and their variation in time. For each value of wheel load and tire inflation pressure, during the tests were recorded, by means of the I-Scan software, the distributions of contact pressure at the soil-tire interface, and also their 3D outline.

It should be mentioned that the value of contact pressure indicated by the software is an average of the pressures recorded on each sensel of the mesh-type pressure sensor that came in contact with the tire of the agricultural trailer during experimental testing.

3. RESULTS

Experimental data, for the input and output parameters considered and analyzed in this study, are presented in Table 1. Contact pressure can be computed as the ratio between wheel load and footprint area.

Table 1: Values of experimental parameters

Wheel load Q [kN]	Tire inflation pressure p_i [kPa]	Footprint area A [m^2]	Contact pressure p_c [kPa]
4.56	180	0.03120	146.153
	220	0.02976	153.226
	260	0.02572	177.294
	300	0.02341	194.788
12.8	180	0.06416	199.501
	220	0.05751	222.570
	260	0.05375	238.139
	300	0.05028	254.574
17.11	180	0.08190	208.913
	220	0.07590	225.428
	260	0.07026	243.524
	300	0.06648	257.370
21.18	180	0.10000	211.821
	220	0.09364	226.185
	260	0.08497	249.264
	300	0.08179	258.956

From the analysis of 3D outline of the footprints shown in Figures 3-6 it can be seen that as the tire inflation pressure increases, footprint area decreases. Given that wheel load is applied in a smaller area, is obtained an increase in the contact pressure. As the wheel load increases, at constant tire inflation pressure is obvious the increase in the footprint area. From the 3D maps it can be noticed that the peaks indicating the maximum contact pressure are recorded on the outline of the footprint area, near the tire edges.

It can be seen that at constant tire inflation pressure, by increasing wheel load was obtained a significant increase in the footprint area, from about 0.0312 m^2 for a load of 4.56 kN to 0.1 m^2 for a wheel load of 21.18 kN.

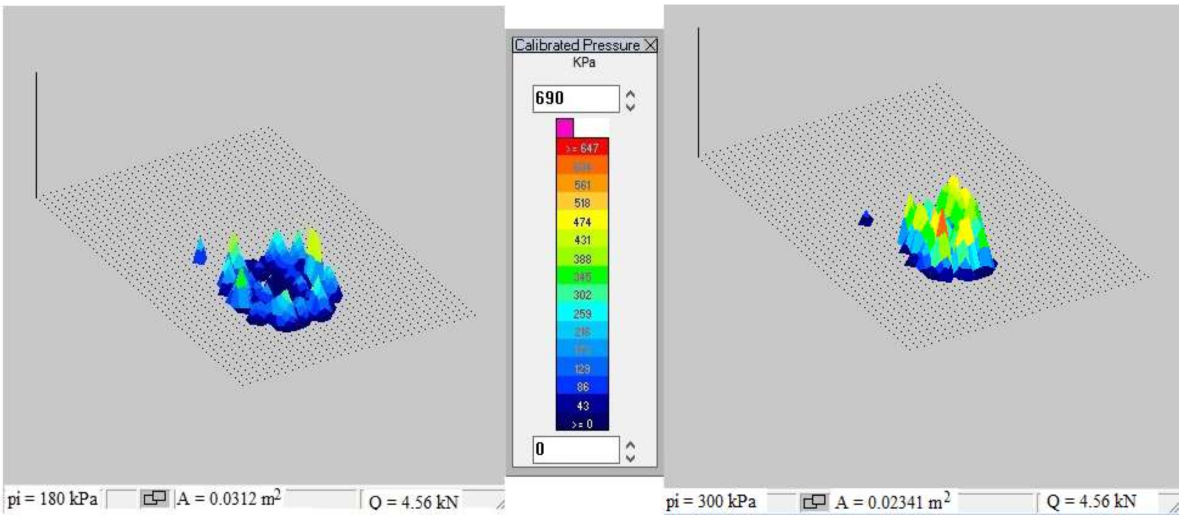

Figure 3: 3D pressure distribution in footprints for 4.56 kN wheel load, at tire inflation pressures of 180 kPa (left) and 300 kPa (right)

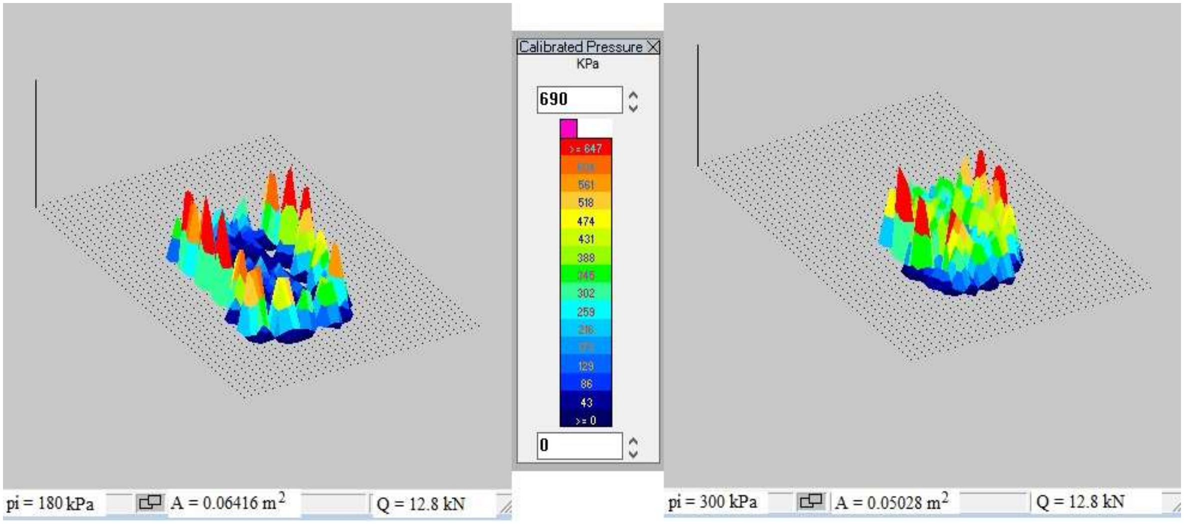

Figure 4: 3D pressure distribution in footprints for 12.8 kN wheel load, at tire inflation pressures of 180 kPa (left) and 300 kPa (right)

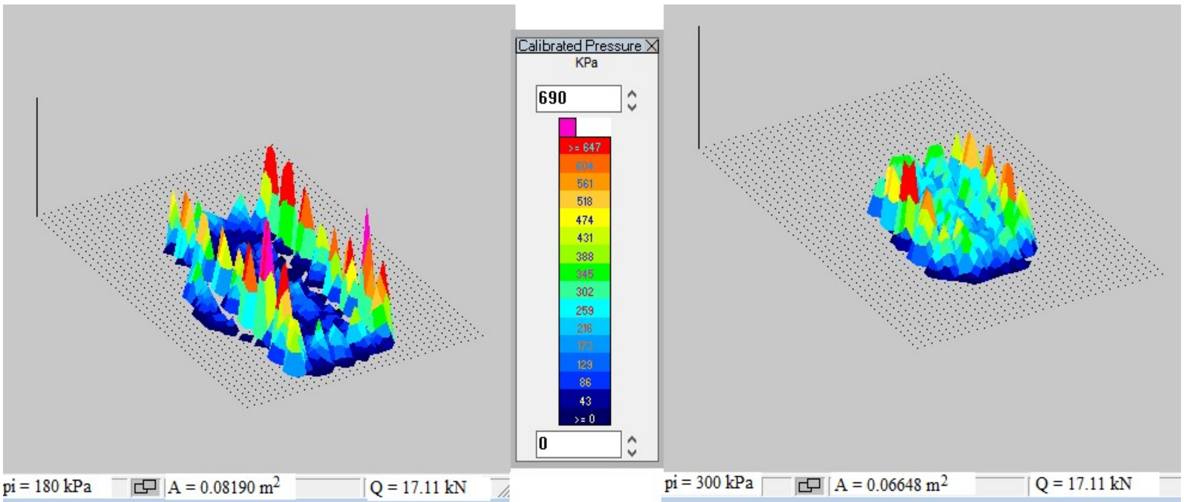

Figure 5: 3D pressure distribution in footprints for 17.11 kN wheel load, at tire inflation pressures of 180 kPa (left) and 300 kPa (right)

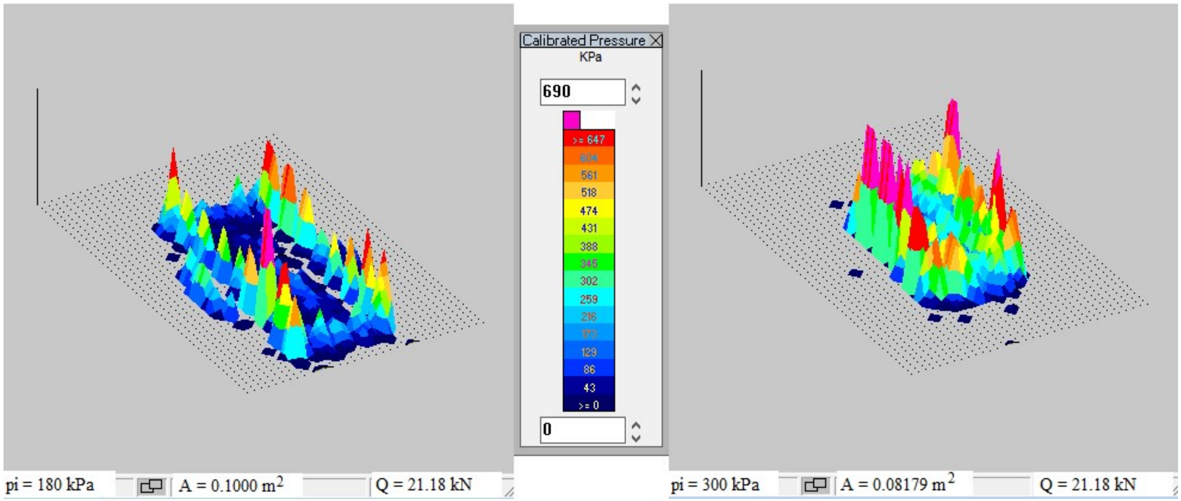

Figure 6: 3D pressure distribution in footprints for 21.18 kN wheel load, at tire inflation pressures of 180 kPa (left) and 300 kPa (right)

The shape of footprint has changed significantly during the tests. For example, at minimum tire inflation pressure (180 kPa), for minimum wheel load (4.56 kN) the footprint shape is somewhat elliptical, while for maximum wheel load (21.18 kN) footprint shape tends to be rectangular with slightly rounded corners (Figure 7).

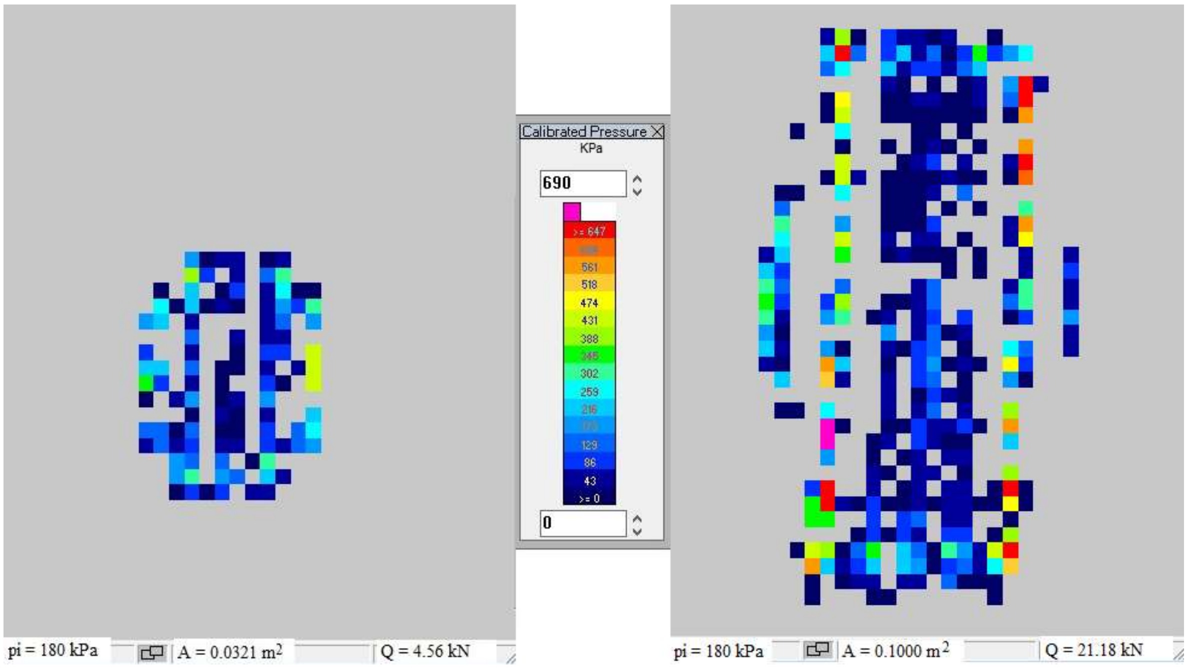

Figure 7: Footprints shape at tire inflation pressure of 180 kPa, for wheel loads of 4.56 kN (left) and 21.18 kN (right)

At constant wheel load, for minimum tire inflation pressure, the footprint has rather rectangular shape, and by increasing tire inflation pressure is obtained not only a smaller footprint area, but also a change in footprint shape.

4. CONCLUSIONS

In contact with the soil, the tire of agricultural machinery forms a footprint whose shape and size depends, besides soil type, on wheel load and tire inflation pressure.

At constant wheel load, footprint area decreases with increasing tire inflation pressure. Thus, for 4.56 kN wheel load and tire inflation pressure of 180 kPa was obtained a footprint area of 0.0312 m^2, value which has decreased to 0.0234 m^2 by increasing tire inflation pressure to 300 kPa.

At constant tire inflation pressure, footprint area increases with increasing wheel load. For tire inflation pressure of 180 kPa, was recorded the increase of footprint area from 0.0312 m^2, at wheel load of 4.56 kN, up to 0.1 m^2 for a wheel load of 21.18 kN.

Contact pressure is mainly determined by tire inflation pressure and wheel load, and also by tire dimensions and tire stiffness.

Values of contact pressure vary between 146-195 kPa at a wheel load of 4.56 kN and they increase with increasing wheel load. Thus, for a wheel load of 21.18 kN, contact pressure varies between 212-259 kPa at tire inflation pressures between 180-300 kPa.

ACKNOWLEDGEMENT

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SPECIAL STATION FOR LIVE-ONLINE-DYNAMIC MONITORING OF WATER QUALITY

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ABSTRACT

The present theoretical and experimental researches of the authors have been carried out for the realization of a special station for monitoring the aquatic environment. Being thought as a watermark for pollution warning of surface flowing waters, the designed station realizes the live-online-dynamic monitoring of the quality indicators of investigated aquatic environment, through its set up directly in situ. The SWQM station also integrates, besides intelligent sensors, an IT hardware-software system for data acquisition, processing and transmission to the local terrestrial system centre. Thus equipped, the special monitoring station becomes an operational watermark in the infrastructure of the networks for surface water quality monitoring. The physical model thus designed allows the continuous evaluation in situ of the monitored surface water health status, with the purpose of warning in case of pollution.

1. SWQM – THE SPECIAL STATION FOR WATER QUALITY MONITORING

The water quality monitoring (WQM) is permanently considered a topical issue in environmental protection activities. Its importance is given by the needs of quality of life and sustainable development. From an ecological point of view, monitoring the aquatic environment is the systematic and continuous surveillance system of its status, through its components that are strongly influenced by natural and anthropogenic factors. From a technological standpoint, the system operates similarly to a hierarchical informatics system on three levels (local, regional and central). According to the first monitoring level (local - in situ) Fig. 1 shows the SWQM station for continuous measurement of indicators of the surface waters quality. SWQM's IT system is designed in order to obtain a decentralization of environmental information system.

a)  b) 

Figure 1: The SWQM station in situ for the smart water quality monitoring

The monitoring station is a floating or submerged mechanical structure, depending on the command given by the onboard controller that is used for monitoring the water at surface or at various depths. Being energy independent and adaptable to environmental conditions, the SWQM station is equipped with intelligent sensors (IQ) for live-online monitoring of quality indicators of the environmental components of water. The monitoring station is equipped with a modular and scalable data acquisition system, and allows local in-situ measurement, recording, processing and validation of the measured environmental data. The possibility of remote data transmission by means of "wireless" communication techniques, in conjunction with warning in case of industrial or natural accidental pollution, makes from SWQM an effective tool for the environmental protection of the investigated area.

Flowchart from Fig. 2 presents the approached research methodology, concerning the design and implementation of the SWQM station. The iterative calculation flow between the input and the output, is optimized by the imposed mechanical, hardware, software and environmental constraints. 3D CAE (Computer Aided Engineering) techniques were used, through the following software environments: CAD (Catia V5); CFD (Ansys Fluent V6.3); FEM (Nastran Ansa V3).

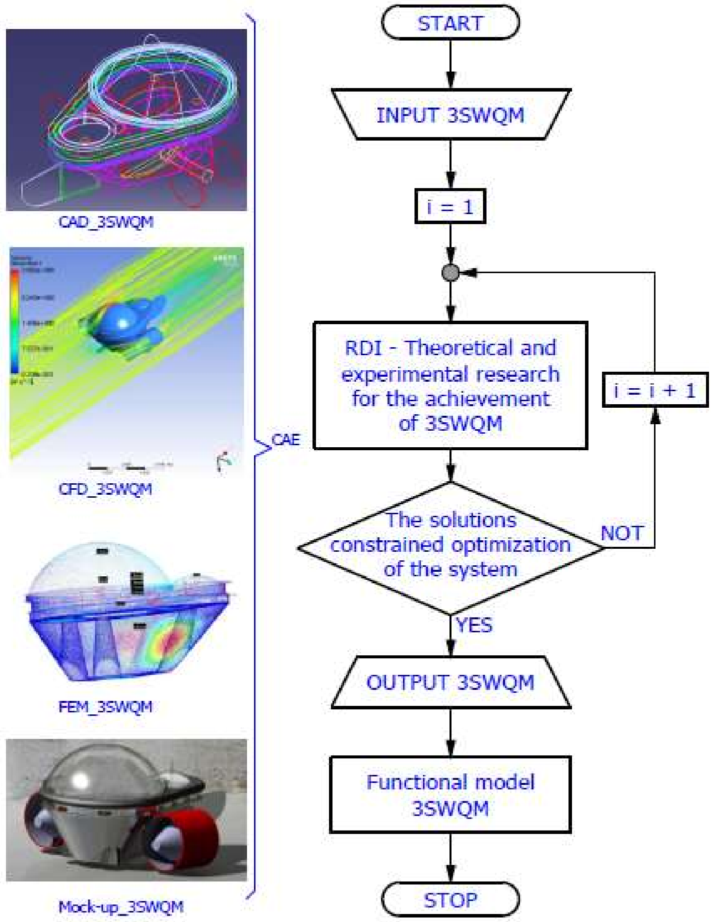


Figure 2: CAE flowchart regarding the design of the SWQM station.

The following equipment are boarded on the station: multiparameter probes, model YSI 6820V2; digital/analogous signal adapters; controller model NI, type CompactRIO System; rechargeable batteries 2 x 12 VDC; photovoltaic cells; DC hydrogenerators; automation box; peristaltic pump for immersion; signaling beacon; communication antenna. The increasing interest which is currently manifested for reduced size monitoring stations (the trend being AUV's), led to the development of the 3SWQM model that is intended mainly for impact monitoring. The geometrical characteristics of the station and the monitored quality parameters are:

- Overall dimensions: $\{L, B, H\} = \{1.00 \times 0.75 \times 0.50\}$ m;
- Weight: max. 59 kg;
- Min. working depth: 1.00 m;
- Water speed: min. 2 knots (1.028 m/s);
- Antenna: telephone and data connection (GSM, GPRS);
- Photovoltaic panels: 10 W;
- hydrogenerators: 2x20 W;
- Accumulator: 2x12 VDC, 24 Ah;
- Real-Time Controller: NI CRIO SYSTEM type, for the acquisition, processing, validation and transmission of data "online";
- Peristaltic Pump: 10 W, water tapping for station immersion;

- light signaling: LED beacon - multicolored flashing (optional);
- Total installed power: 36 W
- Floating body: composite material resistant to mechanical shocks;
- 3SWQM is equipped with a multiparameter probe, type YSI 6820V2, that monitors:
  - ROX (Optical Dissolved Oxygen): 0 to 500%;
  - Dissolved Oxygen: 0 to 50 mg/l;
  - Conductivity: 0 to 100 mS/cm;
  - pH: 2 to 14 units;
  - Temperature: -5 to +50°C;
  - Turbidity: 0 to 1000 NTU, resolution 0.1 NTU;
  - Redox Potential: -999 to +999 mV, resolution 0.1 mV;
  - Depth: 0 to 61m, resolution 0.001 m;
  - Ammonium/ammonia/nitrate/nitrogen: 0 to 200 mg/L-N;
  - Chloride: 0 to 1000 mg/l, resolution 0.001 to 1 mg/l;
  - Rhodamine: 0 to 200 μg/l, resolution 0.1 μg/l;
  - Chlorophyll: 0 to 400 μg/l, resolution 0.1 μg/l. [5]

Fitted with the YSI 6820V2 multiparameter probe, the 3SWQM station continuously determine the status of 11 water quality parameters. General quality indicators and those from groups EN - for oxygen, RN – nutrients, TO - other chemical indicators, are predominant. Quality indicators from the TS group (toxic pollutants) are missing because they are not yet available sensors for real-time monitoring of heavy metals.

2. LIVE-ONLINE-DYNAMIC MONITORING SYSTEM FOR WATER QUALITY

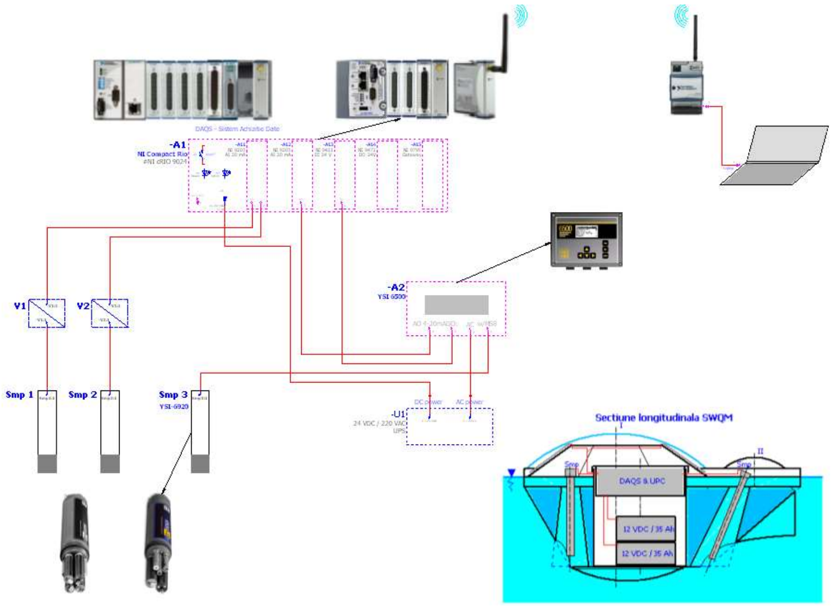
From the list of 66 quality indicators recommended by the environmental legislation in force for determining the quality of surface waters, only 24% may be selected as status parameters for dynamic online monitoring with IQ sensors and multiparameter probes. Use of analyzers with unified output signal (0 ÷10V and / or 4 ÷ 20 mA) increases this percentage to 36%. Quality indicators which cannot be determined by in situ direct measurement, are determined by sampling and laboratory analysis.

As stated, the 3SWQM was equipped with three multiparameter probes, model YSI Class 600, with a signals adapting processor in unified signal 4 ÷ 20 mA type YSI 6500. In this context, figure 3 represents the monofilar diagram of the connections, for the system responsible for data acquisition and measurement of water quality parameters. Positioning of embarked equipment is also represented on a longitudinal section through 3SWQM.

The unified electric signals of the measuring chains for water quality indicators, are introduced in a real-time controller for: data acquisition; analyzing, storing, viewing, and remote data transmission; risk warning in case the aquatic environment is polluted. In this regard, the 3SWQM station is fitted with a „NI CompactRIO system" platform, modular and scalable for application flexibility. The platform will also be the station's local DAQS - water mark. The modular platform can have between 4 and 8 slots, depending on the number of required hardware modules for the monitoring application.

The monitoring program implemented in the "NI CompactRIO system" controller, performs real-time measurement, data visualization and acquisition, of the water quality parameters. Data acquisition involves data measurement via sensors, connectivity with the data acquisition system (modules of the DAQS platform), signal conditioning (amplification, galvanic isolation, filtering, linearization, signal adapting) and analog-digital conversion. Data recording is done in the station's local database.

Figure 3: The connections diagram of the system for data acquisition and measurement of water quality parameters.



The processing operations consist of warnings when threshold MAC values are exceeded (according to environmental legislation in force - concentrations of certain elements of water quality). The program is developed in "Real Time LabVIEW application". The visual interface shows in individual screens or pages, the real time measurements for the state parameters of water quality, according to groups of indicators, as follows:

Page 1 - general screen, or front work page; interface between the operator and the monitoring system (see Figure 4 *a*);

Page 2 - screen for the group of state parameters of the 3SWQM structure (internal tension and vibration);

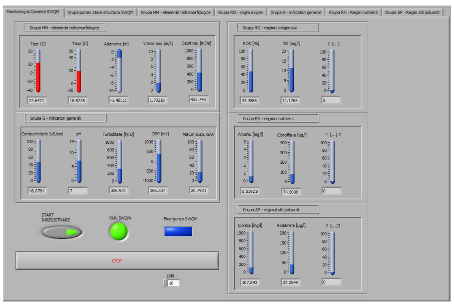
Page 3 - Screen for the group of hydro morphological elements (HM: air and water temperature, water depth, water speed and flow) is shown in Figure 4 *b*;

Page 4 - Screen for the group of oxygen regime (OR: ROX, DO);

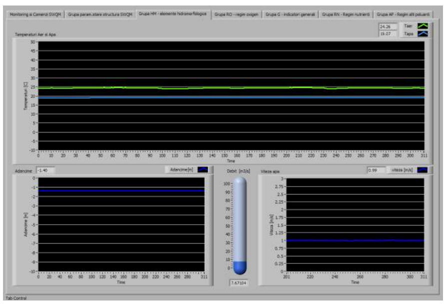
Page 5 - Screen for the group of general indicators (GI: conductivity, pH, ORP, turbidity);

Page 6 - Screen for the group of nutrients regime (RN: nitrates, chlorophyll);

Page 7 - Screen for the group "Other Pollutants" (OP: chlorides, rhodamine, backup).



a)



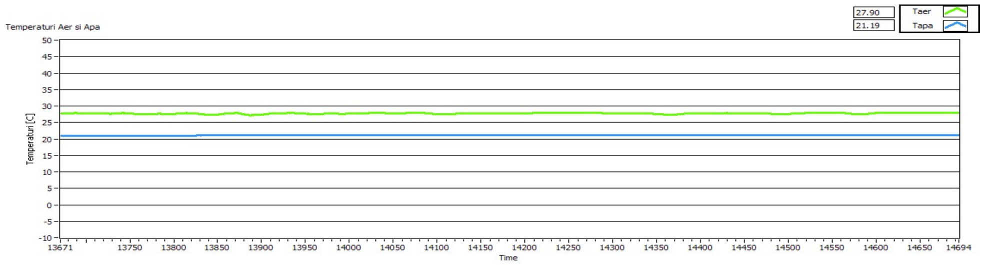
b)

Figure 4: Interface screens between the operator and the water quality monitoring system

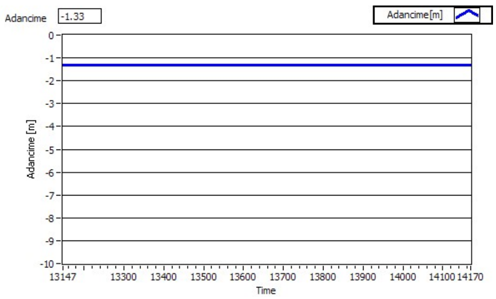
The quality of a body of water is determined by the study and analysis of experimental measurements of water status parameters, in time and in different sections of the water body subjected to investigation. For this paper, the water body selected for investigation is the Colentina river. Between June and September 2015, there have been several campaigns to monitor the water quality of the water body by installing the 3SWQM station in several sections of the river. The monitoring station was used to make continuous measurements of water status parameters, and data recording was made as "data logging".

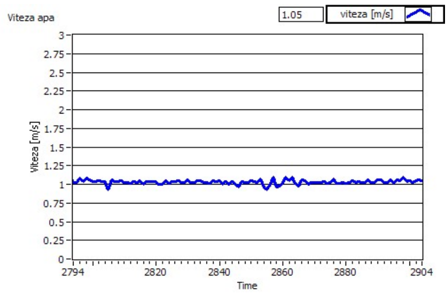
As an example, recordings of the hydro morphological features of the river section from figure 1 *b* (Colentina River at the entrance to Lake Herăstrău) will be presented. The operator interface of the monitoring program that was developed in LabVIEW 8.6, displays through "Screen page 3" the real time variation of the status parameters from HM group: air temperature, water temperature, water depth, water velocity, flow rate (Figure 4 *b*). The water state parameters are averaged at predefined time intervals, and are registered in the 3SWQM database, for the section of the water body where experimental measurements were made. In order to view recordings, screenshots of the real time variation diagrams of hydro morphological features were made (Figure 5).

A monthly average water flow of ~ 7.8 [m^3/s] was determined.



a) Air temperature (green), water temperature (blue)





b) water depth   c) water speed

Figure 5 – Screenshots of the real time variation diagrams of hydro morphological features

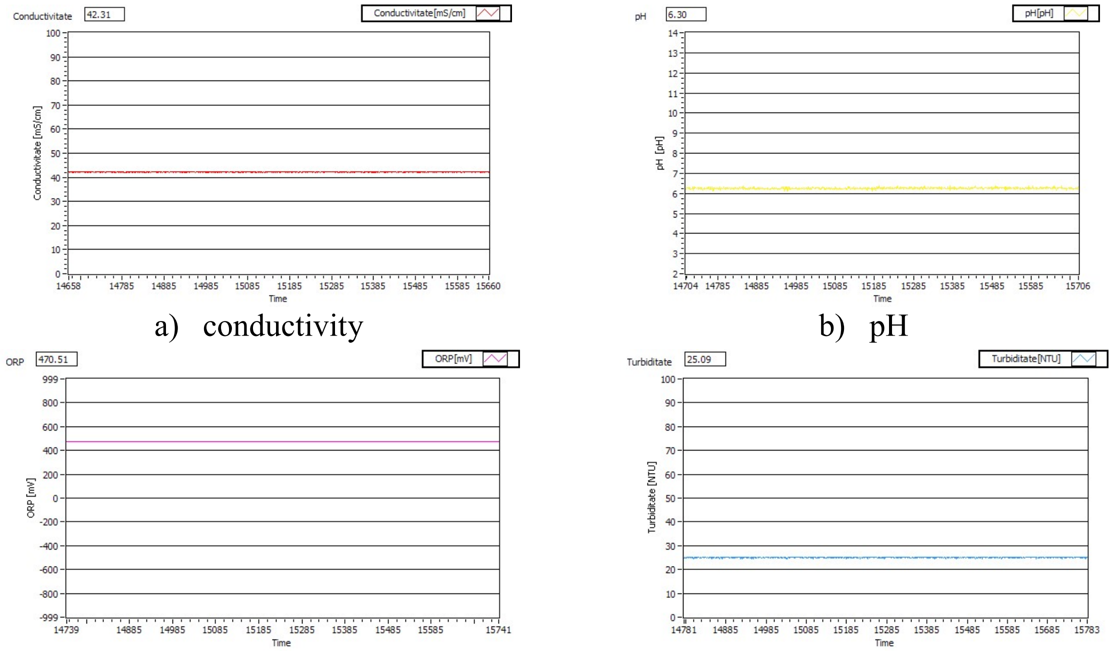
To draw the diagrams of hydro morphological characteristics variation on larger timeframes or during monitoring campaigns, data from the HM characteristics file from 3SWQM database are processed in Microsoft Excel.

Figure 1 *a* shows the 3SWQM station, installed in another section of the investigated body of water. This section is specifically chosen in the port area, because port activities can generate accidental discharge of pollutants, causing alteration in lake water quality. The operator interface of the monitoring program shows in „Page 5 Screen" the real time variation of the water status parameters, from the „General Indicators" group (GI): conductivity, pH, redox potential (ORP) and turbidity. Measured values are averaged over predefined time intervals through software parameterization (60 ÷ 3600 s), and recorded in the local 3SWQM database for the selected water body section.

Figure 6 shows LabVIEW screenshots with GI group diagrams for various monitoring time intervals, for the concentrations of quality indicators: a) conductivity; b) pH; c) Redox potential (ORP); d) turbidity. It is interesting to study the interrelation of the variations of these quality indicators from the GI group, with the variation in concentrations of the elements from the other quality groups, and to report all of them to temperature variation.

After analyzing the performed measurements, it was found that:

i. Investigated water body faces no serious problems of contamination with pollutants;
ii. The lake water may fall in quality *Class I* reported to concentrations of some indicators, or in *Class II - good quality* for the concentrations of other quality indicators;
iii. Transition of the investigated body of water from one class to another for several times in a calendar year, recommends a continuous, real time monitoring;
iv. In terms of quality, the lake water is good for aquaculture and/or fishing activities.



a) conductivity
b) pH
c) Redox potential
d) turbidity

Figure 6: Screenshots with GI group diagrams, for various monitoring time intervals

3. CONCLUSIONS

The 3SWQM special station intended for "live-online dynamics monitoring", adds novelty to the floating stations for monitoring the surface water quality. It is versatile, easy to handle and install in situ, autonomous and adaptable to winter weather conditions. By integrating multiparameter probes, the station allows real-time dynamic monitoring of the aquatic environment. Transition from surface monitoring to level monitoring can be done easily, by commanded or board controller programmed immersion. YSI600 multiparameter probes allow interchangeability for different configurations of sensors. Thus, depending on fitted equipment, the station can be used both for surveillance monitoring and for the investigation one, for all categories of surface water.

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CHANGES IN THE FORESTRY REAL ESTATE IN THE LAST 25 YEARS

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ABSTRACT

Romania was a country, which in ancient times, has enjoyed numerous mineral and natural resources, with a diversified relief. In 1948 there was nationalization of all soil and subsoil resources and businesses of any industry. After the 1989 Revolution, people have regained owned properties to nationalization, including forests. The paper aims to present the evolution of forest since 1989, and the changes that have occurred over the years in the relevant legislative land.

1. INTRODUCTION

The first data known stipulated that the forests were taking up to 80% of the land surface in Romania during the first centuries of mankind. As the society was developing, the forest clearance started being a common practice that would lead to building roads, fortifications and expansion of the agricultural areas.

At the beginning of the 19th century, the woodlands in Romania covered 35-45% of the total ground surface; this acreage has gradually but steadily shrunk, thus reaching 27% in 1974. Today, the percentage lowered below the ecological optimum. Such reductions come from pollution, out-of-control clearing and excessive pasturage. A further reason would be the forest drying, due to the energetic sector that utilizes a fuel with a high concentration of sulfur.

Romania has now a wooded land surface of 27.3%, lower than the European average (32%). In spite of the fact that the difference does not seem significant, what worries is that the mountain area is more depleted of greenery, compared to the plains, where this surface is diminished (circa 10%).

Out of the total of the forests in Romania, 51% falls into the property of the state and is managed by the State Forestry Administration – Romsilva, while 49% is privately owned and managed by private forestry structures. The umbrella organization that is in charge with the forestry real estate is the Ministry of Water, Forest and Environmental Protection.

2. PAPER CONTAIN

Romania is an European country that still has virgin forests on a large area. But the challenging issue for these forests is their defective protection, as only a small part of them enjoys the status of being protected and included in such spaces. These forests have survived in time thanks to the fact that they are hardly accessible, lack of forest roads and the low economic value due to the age of the trees.

As the property right changed in the 90's, the virgin forests find themselves in a greater danger. The surging demand for wood mass will make their owners disregard their worth, they will even neglect the ‚protected' status of these areas, hence they will exploit the wood mass illogically and destroy unique spaces in Europe and worldwide.

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Romania should provide a durable development of the forestry real estate from both the perspective of the wood mass and also from the wild flora and fauna, thus maintaining a percentage as large as possible of the present one for the future generations.

It should be imperative that the humans become more aware of the priority that the forest has for them and for the environment they live in. The forest renders a series of functions, among which we can mention:

- ✓ the protection function of the environment, which involves the hydrologic and protection function of the waters, the anti-erosion function of the forest, the protection function against the climate factors;
- ✓ social functions of protection, which consist of: recreational function, aesthetic-landscape function, scientific function, hygienic and sanitary function;
- ✓ the production function, including the plant and animal biomass production.

Besides these functions, the forest also has an economic importance, as it is a natural resource, needful to the durable development of our country. The economic value of the forest derives from the volume of wood mass per cubic foot. The structure of the wood mass comprises very valuable essences in terms of economic advantage, such as coniferous 39%, beech 37% and oak species 13%.

From the total of yearly forestry production, the percentage of the wood products is of 70–75%, where the difference comes from the capitalization on the non-wood products in the forest: medicinal plants, edible and decorative plants in the wild flora, namely mushrooms, ferns, moss, lichens, natural resins, mistletoe, etc.

Apart from the above, the forest has also another function, namely of tourism. Romania features a string of out-of-this world touristic routes that might be capitalized on. Similarly, woods accommodate a wild fauna, which can be taken advantage of via hunting, game meat, skins and trophies.

Wood is used on a large scale in manufacturing finite products and also for energy production in the world. There has been a longtime competition among wood and other materials, such as synthetic products, concrete, steel, ceramics, glass and fossil fuels. The decision of using wood or its equivalent competitors as raw material or source of energy in diverse situations is made in the context of the influence of the cultural, technical, financial factors and of the legislation/regulation framework.

The forestry ecosystem has degraded in time, due to the harmful action of population. The development of the society has led to different degrees of degradation, depending on the stage which the society is at. The ecological impact has been constantly increased, triggering various degrees of degradation of the ecosystem, sometimes with irreversible consequences.

The shrinking of the forested area has come from the deforestation conducted for sundry reasons, such as the expansion of the agricultural surface and of the pasturages, the need for heating fuel and construction materials. The atmosphere pollution, drought and acid rains have also caused the reduction of the forest surface areas.

The effects of such process in the forestry real estate are to be found in the emergence of certain surfaces taken by vegetation specific to the steppe and savannah areas, with a visible impact upon the soil layer.

There have been attempts to correct the errors above by cultivating the deforested surfaces with fast-growing species, which have brought about changes in the biocenotic balance in those regions. The replacement of species that are resistant to some conditions with others that are better adjustors yet more fragile can very well lead to some events that will even modify the landscape in those territories. For instance, the substitution of the fir-tree with pine or spruce with superficial roots, on the mountain slopes, can mean their caving-in.

Nevertheless, deforestation remains the top enemy of the woods, as it leads to more dangerous torrents and, consequently, to the pluvial soil erosion. The building of the forestry road required for wood exploitation is another factor of a significant disturbance of the forestry ecosystem. As a result of the deforestation, the soil particles move in large quantities in the areas of plains, due to the air draughts travelling at higher speed.

The illegal deforestation done by the Romsilva or private forest ranges, based on work plans, will be punished by contraventional fines or criminal case files, depending on the gravity of the situation.

The illegal fellings have been recorded in the counties of Alba, Arges, Gorj, Prahova and Bacau, since the forested areas are larger there. Such fellings are also influenced by the landscape, as the forested areas in the plain counties are smaller than in the mountains.

In order to prevent the illegal fellings and in accordance with the EU regulations (EU Regulation 995/2010), the Ministry of Environment, along with the Romania WWF Danube Carpathian Programme, have drafted the map of the risk areas regarding the prevalence of the illegal wood fellings at the national level. The map of the risk areas constitutes a useful starting point, which complies with a practical approach. This is the reason for which the analysis unit at the production unit, basin or the forest body (the plain area) has been established.

The indicators to be considered were the wood volume that is illegally exported reported to the volume that is illegally exploited; the surface and the spreading of the forestry real estate that is not managed by a forest range; the number of the sanctions received by the forest ranges; the number of the sanctions applied to the forest rangers.

According to the National Institute of Statistics at the national level, the wood mass collection is featured in the below table. For the last 15 years, it can be noticed an average wood mass volume of 16.774,6.

Table 1: The wood harvested in the 2000-2014 period

Year	**Volume** UM: 1000 m³ (including bark)	**Year**	**Volume** UM: 1000 m³ (including bark)
2000	14285	2008	16705
2001	13410	2009	16520
2002	16383	2010	16992
2003	16692	2011	18705
2004	17082	2012	19081
2005	15671	2013	19282
2006	15684	2014	17889
2007	17238	-	-

Source: http://www.insse.ro/cms/files/Web_IDD_BD_ro/index.htm

In the last 7 years, according to the National Institute of Statistics, nationally, the gross annual increase standing timber (GAI) measured in 1000 m³ including bark, was:

Table 1: Gross annual increase of standing timber

	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
GAI	24523.0	24764.7	25021.3	25268.1	25475.8	25670.5	25874.3

Source: http://www.insse.ro/cms/files/Web_IDD_BD_ro/index.htm

The felling of trees is not allowed in the forests stipulating soil protection functions (where the slope exceeds 35º), safety of water streams and dams, flora and fauna or in the recreational forests – only tree removal and pruning for hygiene purposes is permitted.

In the protected areas, the tree cuttings are not strictly forbidden, but there are variations in dependence on the type of these areas, the management plan of that area and the administration plan (the work plan).

To protect the woods and have an appropriate capitalization on the ligneous and non-ligneous products provided by the forest ecosystem in 2016, the Romanian Government aims to set up a specialized structure within the control of the forest regime under the jurisdiction of the Directorate General of state forests with the central public authority in charge with forestry.

Similarly, another objective is to organize and have the Forest Guard operate, thus establishing criteria, performance indicators and of conduct for its personnel by issuing the required normative acts, which will provide the protection of the forestry real estate and eliminate the illegal cutting.

It is necessary to achieve a legal framework that will provide the reimbursement of countervalue for the products that the forest owners do not collect, due to the restrictions in place for their properties set up by the work plans, which will lead to restrictions in collecting the wood mass.

For the safeguard of the virgin forests, which still hold a significant part of Romania, a National Catalogue of the Virgin and Quasi-Virgin Forests' should be drafted, according to the Forestry Code art 26, par 3 (Act 46/2008), as an official instrument of their recording and administration for a strict protection.

As for the following years, Romania should:

- ✓ develop a system of monitoring and information regarding the forestry management, by integration of the work plans in a GIS format;
- ✓ provide the continuity of the supply and valorification of the updated results of the National Forest Inventory;
- ✓ start a plan for transfering the lands from private property to the public area of the state in the zones of strict and full protection of the national parks and of the virgin forests;
- ✓ improve the interorganizational partnership for increasing the forested surface area by identifying the lands that can be forested and the appropriate technical solutions.

3. CONCLUSIONS

Since the accession of Romania to the European Union in 2007, our country has adjusted its policies and strategies in the field of forest management and forestry economy to the European Union ones, thus creating the necessary institutions and the pertinent legal framework.

Among the European Union objectives, there are the forest protection, creating and conservation of the natural areas and reservations, fighting against the soil erosion, regulating the trading of the products derived from the forest and of the wood mass.

To this purpose, Romania amended and completed the Forest Code adopted in 2008, in the attempt to assist the owners of forest lands and economic agents operating in this sector. This act has indeed its upsides and downsides but it has aimed to be an improvement to the old Forest Code.

In spite of all its efforts, Romania is being now challenged by a bad forest management, out-of-control deforestation and excessive spending from the EU funds and the state budget.

When talking about the real importance of the forests, it should also be prevalently quantified the contribution brought to the lowering the amplitude in temperatures, the attenuation of the extreme weather phenomena, the control of the drought and flooding, the reduction in the carbon emissions and the retention of the greenhouse gases.

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ASPECTS REGARDING THE INCREASE OF DURABILITY FOR ACTIVE WORKING BODIES OF EQUIPMENT FOR WORKING THE SOIL IN A CONSERVATIVE SYSTEM

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ABSTRACT

The paper presents a series of considerations regarding the researches conducted in order to increase durability, to reduce the wear of chisel type active bodies of equipment for processing the soil in a conservative system, by applying a series of innovative processes (3).

1. INTRODUCTION

By the optimal processing of soil is attempted to achieve a soil work to ensure the optimal conditions imposed by a particular plant, respectively soil loosening for the free access of air and water into the soil, while preserving it [1], [2].

A classic operation for the mechanical processing of soil aims at:

- Destroying the crust at soil surface and large lumps;
- Loosening the soil to increase the pore volume, improve water and air permeability, while removing soil compactness;
- Homogenizing the soil, incorporating chemical and organic fertilizers, covering plant residues, manure and vegetation;
- Protecting against soil erosion;
- Preparing a proper seed bed.

In the process interaction within the process of soil tillage, two elements intervene: the soil and the tool (active body) [8], as it moves forward through the soil, a relative movement taking place at the level of the interface between the two elements, due to the adhesion and friction between the soil and the active body [11, 12]. Active bodies are subjected to high variable strains, the intensity of wear for them being much higher compared to the one of the other parts within the machine, reason for which they are called high wear bodies [4, 5, 6, 7].

Soil structure determines the degree of wear for active bodies, the more high hardness particle it contains, the more abrasive it is [9], determining its premature wear and the change of geometry, especially for the cutting part, leading to the increase of resistance during operation and implicitly of fuel consumption [3].

Two main forces act on the active bodies: friction and striking [4], their action determining the occurrence of wear, which manifests under two aspects: friction (sliding) and impact (collision) [10].

2. METHODOLOGY

In order to increase the durability of active bodies of an equipment for processing the soil in a conservative system (combiner), the active bodies for soil processing of the specific

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technical equipment were achieved by using procedures of covering with composite materials for an increased durability, high reliability and lower maintenance costs.

The **body for soil processing**, which has the role to dislocate the soil on a depth of up to 25 cm, to lift, to mix and turn plant residues, is fitted of the frame of the technical equipment for the conservative processing of soil.

The main components are: a rigid support (fig. 1, pos. 1) on which a chisel (fig. 1, pos. 2) is assembled with detachable screw-nut type elements.

The active bodies of the chisel were subjected to a hard charge with experimental additive materials, obtained from high entropy alloys, ensuring increased durability, high reliability and lower maintenance costs, compared to the materials and the thermal treatments applied with classic technologies.

Figure 1. Body for soil processing

3. RESULTS

Charging by welding of active areas subjected to the effects of intensive wear as result of the abrasive and corrosive action of the work environment (processed soil) was achieved in three versions:

- **Version 1 – Charging by manual welding with experimental electrodes of the type rod with composite core** (fig. 2) containing wolfram carbons and chemical elements for achieving metallic matrixes with resistance to abrasion.

a.

b.

Figure 2. Charging by manual welding with experimental electrodes of the type rod with composite core (a. working bodies, b. chisel type blades)

Net weigh of chisel blades after charging:

1E = 1.678 kg

2E = 1.668 kg

3E = 1.692 kg

In figure 3 are presented the experimental electrodes used for charging by manual welding.

Figure 3. Experimental electrodes used for charging by manual welding

In figure 4 are presented aspects during the operation of charging by welding with coated electrodes. Parameters of the welding regime: Is=120A, Us=32V, electrode with a 4 mm diameter and thick coating with alloying elements and carbons.

Figure 4. Aspects during charging by welding with coated electrodes

- **Version II – Charging by welding using the MIG/MAG procedure** (fig.3) using wires that allow deposits with high hardness and resistance to wear.

For "chisel blade" elements, intensely strained, was applied the charging by welding in the front part of an addition material having a high resistance to wear (tubular wire SK ABRA MAX O) (fig. 5). Tubular wire SK ABRA-MAX O/G (according to DIN: 8555: MF 6-GF-65-GT) allows to obtain a deposit with a thickness between 6 and 8 mm in maximum two crossings, with very high hardness, increased resistance to abrasion with low impact and solid erosion, having an estimated hardness of 65 HRC and wear index with SiO_2 of 0.7 %.

Its processing can only be made by polarizing, without being possible to cut it with oxyacetylene flame.

Table 1 - Chemical composition of tubular wire for hard charging of active element subjected to intensive wear, in weight percentages (%)

Wire type	C	Mn	Si	Cr	Mo	Nb	W	V	B	Fe
SK ABRA-MAX O/G	2	0.5	0.9	8.5	4.5	5.5	5	2	3.4	residues

Net weight of chisel blades after charging:

1M= 1.709 kg

2M= 1.723 kg

3M= 1.708 kg

a.

b. c.

Figure 5. Charging by welding with MIG/MAG procedure (a. working bodies, b. chisel blades, c. charging procedure)

- **Version III – Charging by WIG welding** (fig. 6) with experimental welding with high entropy alloys (FeCrAlxCoNi).

a. b.

Figure 6. Charging by WIG welding (a. working bodies, b. chisel blades)

In figure 7 are presented the experimental electrodes of the type steel with wolfram carbons core for charging using the WIG procedure.

Figure 7. Experimental electrodes of the type steel with wolfram carbons core

In figure 8 are presented aspects during charging by welding using the WIG procedure. The parameters of the welding regime: Is=142 A, Us=15-16 V, electrode with a 4 mm diameter of the type sheath filled with carbons and powders of alloying elements.

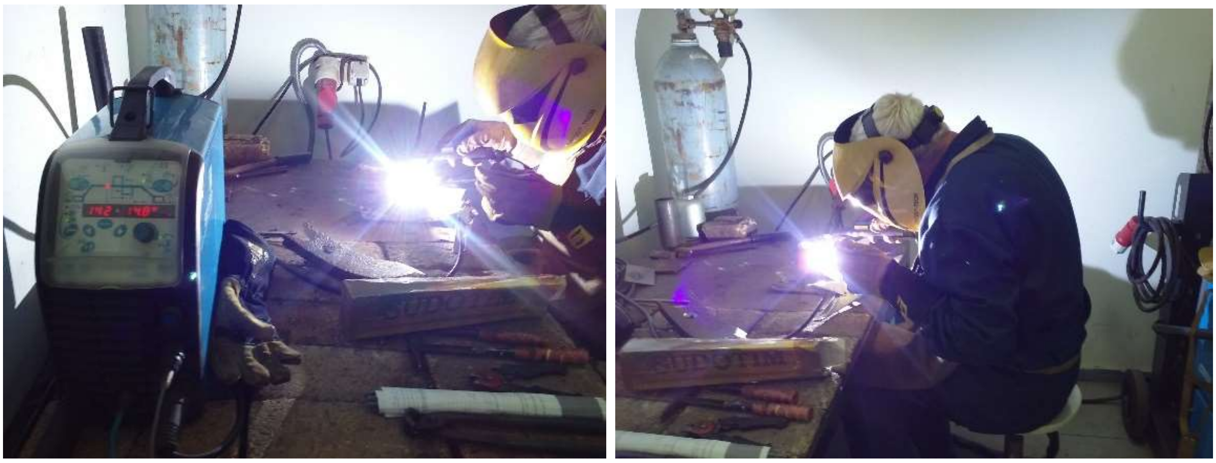

Figure 8. Aspects during charging by welding with WIG procedure

Net weigh of chisel knife after charging:

1W=1.641 kg
2W=1.661 kg
3W=1.660 kg

In parallel was also achieved a static structural analysis of the active body (fig. 9 and 10) in order to identify if it is adequately dimensioned and so that there is no risk of occurrence of deformations of even ruptures.

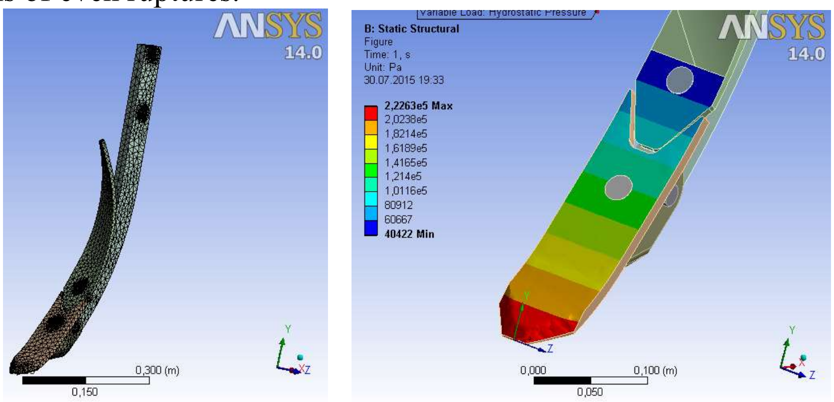

Figure 9. Static structural analysis of the active working body

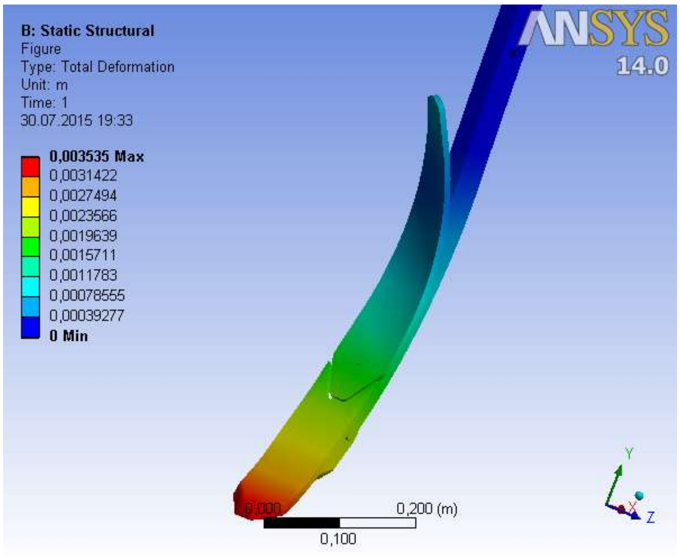

Figure 10. Von-Mises equivalent tension

3. CONCLUSIONS

The purpose of these researches was to identify a series of innovative technologies that will allow applying new alloys, with special properties in order to increase the resistance to the friction between soil and the active body for processing the soil, as to reduce wear and increase their service life.

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ENERGETIC RECOVERY FROM THE HERBACEOUS PLANT *AGRIMONIA EUPATORIA* IN THE FORM OF BRIQUETTES

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ABSTRACT

Agrimonia eupatoria (common agrimony) is a herbaceous plant from the Rosaceae family, known under various popular names: church steeples, sticklewort, fever weed, mountain lovage, cancer tail, etc. The energetic recovery for this invasive type of weed especially in the plain areas of Romania through the process of compaction allows achieving qualitative energy briquettes. Thus, within the article will be studied the process of compacting common agrimony stems as well as the calorific value and ash content resulted from the briquettes obtained.

Keywords*:* *briquettes, common agrimony, calorific value, ash content.*

1. INTRODUCTION

Common agrimony, scientifically known as ***Agrimonia eupatoria*** is a perennial herbaceous plant, with a high stem of up to 100 cm, branched towards the top, with long leaves of 8-16 cm. Leaves are formed from 5-9 large leaflets, having small leaflets between them. The entire plant is covered with silky hairs. At the top of the stem and of the ramifications there is a spike-like inflorescence, composed of numerous 5 petal yellow flowers. The plant blooms from the basis to the top, so that on it can be found at the same time, flowers and fructifications. Fruits are surrounded by a crown of thorns re-curved at the top. It blooms beginning with the month of June until August. If grows among bushes, forests, orchards, on the side of roads, being an invasive plant, common in both plains and at the mountains, considered very harmful for agriculture [1]. Thus, the research for using this plant in energetic purposes would determine a new approach for agrimony.

Figure 1: Agrimonia eupatoria

The use of conventional energy sources releases an important quantity of greenhouse gases into the atmosphere, among them the most important being carbon dioxide (CO_2). The excessive use of non renewable resources has negative consequences on the environment, increasing the greenhouse effect, acid rains and the concentration of dust in the atmosphere.

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Climate changes are a characteristic of our planets history, the Earth undergoing during its history a series of major climate changes, and a progressive warming process. As regard the renewable energy, the European Council imposes for the EU a mandatory target for these resources in a share of 20% before 2020. Also, it is mandatory for member states to use at least 10 % bio-fuels for transportation before 2020, [3, 4, 5]. In the last 10 years, in the developed countries were finalized the technologies and equipment necessary for the efficient production and burning of briquettes from sawdust, straws, miscanthus, herbs and other forms of biomass (being possible to include common agrimony), [2].

Nowadays, these briquettes are economically competitive compared to generic fossil fuel and natural gas, having as a plus, the advantage that they are neutral from the point of view of heating the planet, due to lower greenhouse gas emissions. It is considered that during combustion, briquettes release into the atmosphere the same quantities of carbon dioxide that the plants have absorbed from the atmosphere in the process of photosynthesis which has generated the biomass used to produce the briquettes.

2. METHODOLOGY

Starting from a raw material constituted of common agrimony chippings, with a 4 mm granulation a 12% moisture, was aimed to obtain cylindrical briquettes in a die, by pressing the material with a piston. At the beginning of the compression process, the outlet end for the compressed biomass is kept closed until reaching a limit compression pressure of the piston, afterwards it opens allowing the release (evacuation) of the briquette formed. In order be able to drive the piston, a force machine with a maximum capacity of 100 kN was used. The force machine used as a compaction system (fig. 2), being assisted by a computer, allowed to control the forward speed of the piston and respectively to record the Force-Displacement diagram.

Figure 2: Experimental compaction stand and common agrimony briquette

In order to determine the lower calorific value, a calorimetric system type **CAL 2K** was used, figure 3, formed of. [6]: the calorimeter itself; bomb calorimeter; nacelle; combustion adapter; oxygen station; analytical balance with a precision of 0.1 mg.

Figure 3: Determinining the calorific power for common agrimony briquettes

Operating manner: the material sample for determining the calorific power is introduced in the nacelle and it is weighed. A cotton thread is introduced in the centre of the ignition wire and the other end is introduced in the sample, to propagate the combustion inside it. The nacelle situated in its support is introduced into bomb calorimeter and is hermetically sealed. The bomb is then filled with oxygen at the pressure of 20-30 bars from the oxygen station, connected to an oxygen tank. The ignition adapter is attached and then is introduced the interior vessel of the calorimeter, following the level indicator. In order to prepare the measurements, the following being introduced in the measuring menu: the measured sample weight, the type of operation that will be conducted (calibration or actual measuring), the type of bomb calorimeter and the correction values the heat generated from burning the cotton thread (implicit value is 50 J) or from other sources. When everything is ready, the lid of the calorimeter is closed and the equipment starts the measuring operating. First, the interior vessel is filled with water, and then the combustion takes place, the final stage consisting in equalizing the temperatures of the interior and the exterior vessels, by transferring the heat from the interior vessel to the exterior one. After that is completed, the measuring process ends, and the value of the measured calorific power is displayed.

There are two types of calorific power: **higher calorific value** (Q_s) where the water vapours formed during combustion are condensed, giving their latent heat of vaporization,[2] **lower calorific value** (Q_i) where the water vapours formed during combustion remain in a gaseous state and, as a result, they do not give their latent heat of vaporization.[1]

It is believed that water vapours resulting from combustion come from burning hydrogen and from the water initially contained in the fuel. For fuels not containing hydrogen or water, for example carbon, carbon monoxide and sulphur, because water is not formed during combustion, the higher and lower calorific value are equal. In thermal-energetics, until recently it was not economically efficient to condensate the water vapours resulting from combustion, so it was easy and convenient that the design and operation of installations to be based on the lower calorific value. With the advent of condensing boilers appeared the necessity to use the higher calorific value. The higher calorific value at a constant volume of sample ($Q^a_{s,V}$) of a fuel is represented by the number of units of heat released by the complete combustion of a mass unit of the fuel prepared for analysis, in an atmosphere of oxygen in the bomb calorimeter, under standard conditions. The combustion products are formed from carbon dioxide, sulphur dioxide, gaseous nitrogen and oxygen, liquid water in equilibrium with its vapours and saturated with carbon dioxide and solid ash. [6]. $Q^a_{s,V}$, is experimentally determined by complete combustion in the bomb calorimeter of a known quantity of fuel, the heat released from combustion being transferred to the colorimetric system comprising a known amount of water, the temperature of which is recorded. [4]Lower calorific value at a constant pressure of an initial sample ($Q^i_{i,p}$) of a fuel is represented by the number of heat units which can be released by complete combustion of a mass unit of fuel in the initial state in an atmosphere of oxygen, at constant pressure. The products of combustion are all at a temperature of 25 °C and are composed of carbon dioxide, sulphur dioxide, gaseous nitrogen and oxygen, water in state of vapour and solid ash. $Q^i_{i,p}$, is obtained by calculus:

$$Q^i_{i,p} = (Q^a_{s,V} - 212H^a - 0{,}8O^a)\frac{100 - W^i_t}{100 - W^a} - 24{,}5W^i_t \qquad (1)$$

Where:

- H^a and O^a are the percentages of hydrogen and oxygen from the mass for analysis,
- W^i_t and W^a are the percentages of moisture in the initial mass, respectively from the mass for analysis,
- And the coefficients 212, 0.8 and 24.5 take into account the mass heat of water and water vapours, respectively the mass latent heat of vaporization of water, expressed in units from IS.[6]

The value that usually interests in energetic is $Q^i_{i,p}$, which in common language is called lower calorific value and is denoted Q_i. For condensing boilers, interest is given to the higher calorific value at constant pressure of the initial sample $Q^i_{s,p}$, being usually denoted Q_s. Calorific value of solid fuels relates to 1 kg of fuel and is expressed in MJ/kg. [6] After conducting experimental tests, the following calorific values for common agrimony briquettes were determined.

Table 1

Sample number	Lower calorific value Common agrimony briquattes [MJ/kg]
1.	*17,876*
2.	*18,064*
3.	*18,051*
4.	*17,975*
5.	*18,090*
6.	*18,071*

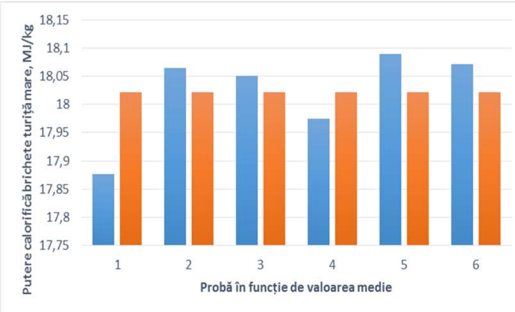

Figure 4: Graphic representation of calorific power for common agrimony briquettes

3. CONCLUSIONS

The calorific value (heat of combustion) represents the number of units of heat released by the complete combustion of a mass unit of fuel conditions specified in standards. The chemical reaction of burning is typically an oxidation of the hydrocarbons, resulting in carbon dioxide, water and heat. Calorific value of solid fuels (and of heavy liquid ones which do not evaporate) is measured with the bomb calorimeter, whereas that of gaseous fuels (and of liquid, volatile ones) with the calorimeter with circulating water. It can be calculated as the difference between the enthalpies of the combustion products and the ones of the fuel, if they are known. Using the data determined experimentally with the bomb calorimeter, an average lower calorific value of briquettes produced from common agrimony of 18021 MJ/kg was obtained. In comparison, the average lower calorific value of Miscanthus briquettes is known to be situated between 15500 and 19500 MJ/kg, depending on their humidity. The high value for the calorific power of common agrimony briquettes offers a good perspective for this plant to b used as alternative energy source, being possible to use it to obtain solid biofuels (briquettes, pellets, etc.)

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ASPECTS REGARDING THE WORKING PROCESS OF THE SIMPLE PRESS WHEELS OF THE PLANTERS AND SEEDERS

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ABSTRACT

This paper presents some aspects regarding construction and working process of the press wheel of agricultural machinery for planting and seeding, particularly with examples at the *miscanthus* planters. Also, there are presented some theoretical elements concerning the working process of these working bodies of the agricultural machinery, regarding rolling resistance, the level of compaction and to estimate the compaction depth achieved by the press wheel. These parameters express the working indices of press wheels, necessary to achieve a contact between seeds, rhizomes or planting material and the soil around it, in order to obtain a good germination and the formation of roots adequate for sprouting and vegetation. Further, is presented a finite element analysis for press wheel and its support for a stable position during the working process, for a normal push of the wheel on the soil.

1. INTRODUCTION

In the composition of agricultural machinery for planting and seeding are distinguished the press wheels, so necessary for ensuring a good contact between comminuted soil and the planting material.

In figure1 is presented a schematic diagram of a *miscanthus* rhizomes planter section MPM-4 and the overview of it.

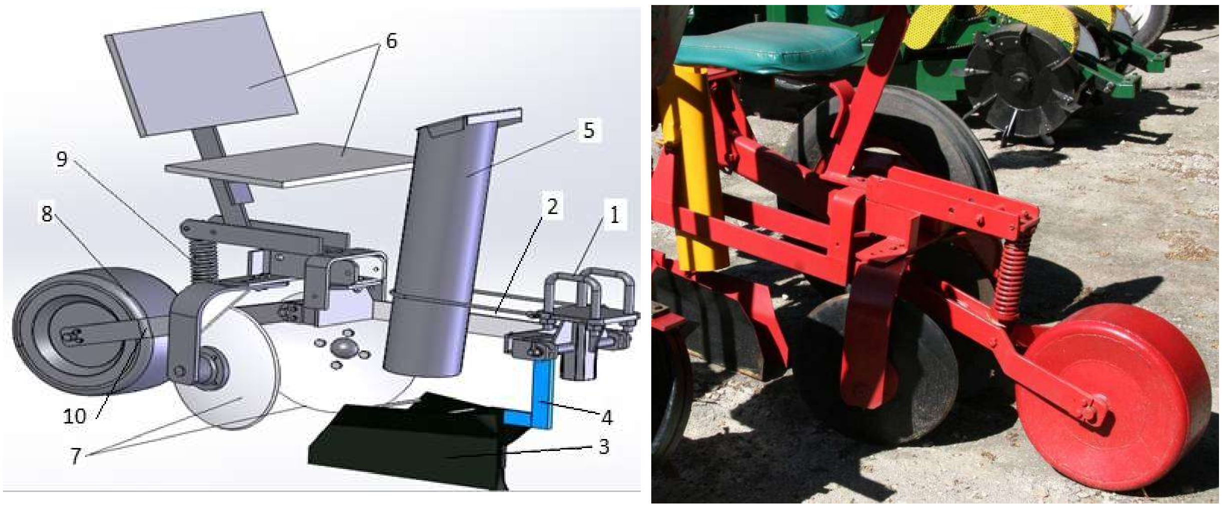

Figure1: The *miscanthus* rhizomes planter section MPM-4, [1,3,6]

1.bridle for mounting on framework car; 2.the framework section; 3.coulter; 4.coulter support; 5.rhizomes leading tube; 6.operator's seat; 7.cover disks; 8.press wheel; 9.coil spring for pressing adjustment

If the *miscanthus* rhizomes planter sections are provided with concave disks for covering, then behind them is disposed a metal press wheel or with tire in order to press the soil obove

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the planted rhizomes. Such a press wheel (metallic or with a tire) is used both in the case of rhizomes or bulbs planting and also for seeding planters, [3,9].

For the cylindrical metallic wheels the soil pressing is uniform throughout their width, with the danger that rhizome buds to be affected. To prevent this phenomenon can be used press wheels with profiled tires that in the central area have a smaller diameter than on the lateral sides, so that in central area the soil is less compacted, [2,3,9].

The press wheels from the planting and seeding planters have different shapes, when is planting seedlings being necessary the existence of two press wheels arranged in V.

Figure 2: Types of press wheels for planting and seeding planters, [3,10]

Figure 3: Types of rubber press wheels used for planting and seeding planters, [3,10]

The soil compaction above the rhizomes covered from ditch can be achieved with simple press wheels, metallic or tires (straight or shaped) or with two inclined wheels, fitted with wings and inclined. The wheels with profiled tires better protect the rhizomes buds so they can germinate and sprout faster, [3,9].

The metallic press wheel from the *miscanthus* rhizomes planter MPM-4 is made from metallic sheet with 1.5 mm thickness and it is fitted with a push mechanism with a compression spring.

The press wheels of the section constitute the push bodies of the soil over the planted rhizomes in order to achieve the best possible contact with the soil and allow the water supply of the rhizomes roots.

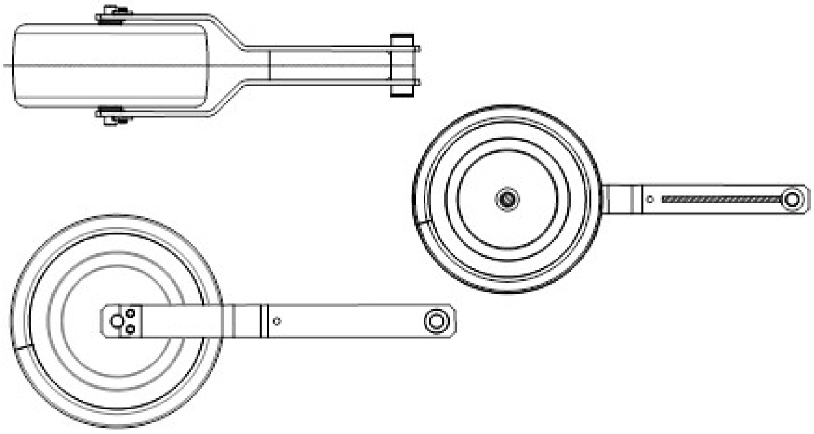

Figure 4: Cylindric metallic press wheel, [3]

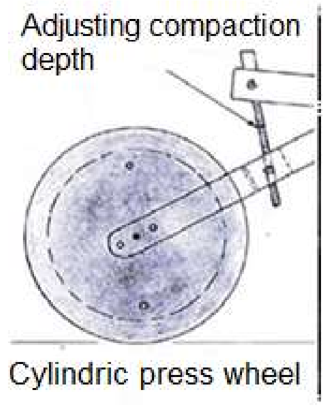

Figure 5: Press wheel and the mechanism of adjusting of pressing on soil, [2,3]

2. METHODOLOGY

For the press wheel on which act the load G_t, composed of its own weight together with a part of the weight of the framework, as well as from tensioning force of the coil spring for pressing adjusting (see fig. 6), were written the equations for the tensile force, the compaction depth and for the soil relative deformation, [4,5,7,9]. Under the action of the tensile force F_t, the press wheel of G_t weight is running on the surface of the loose soil, compressing the upper layer of soil to a depth h.

The soil compression is produced on AC zone (Figure 6), the soil particles being moved towards the advancing direction and pressed down, in front of press wheel forming a bump.

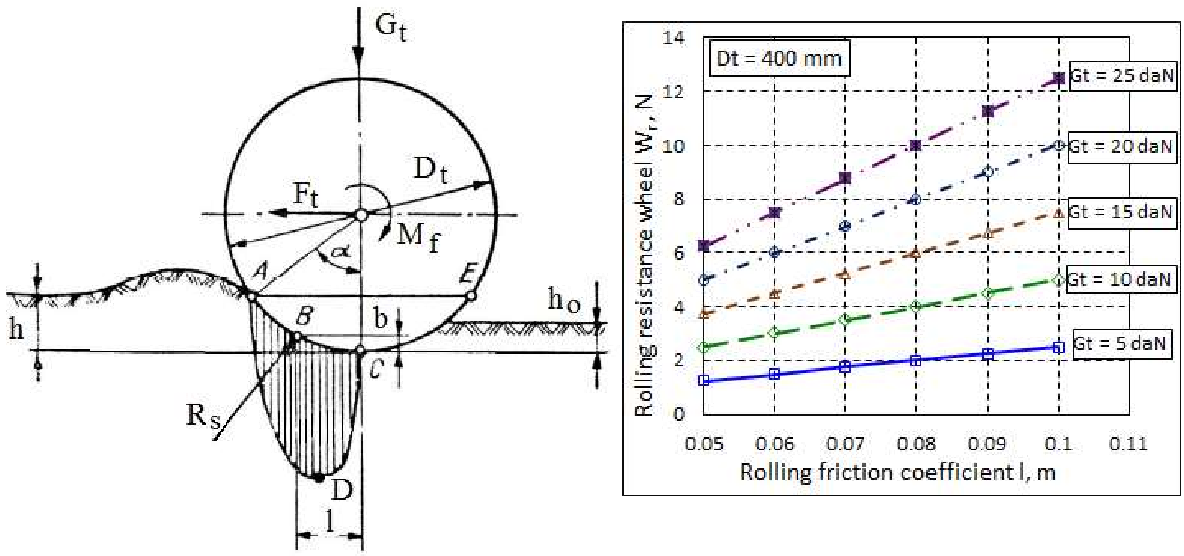

Figure 6: The working process performed by press wheel, [5]

In the working process, on the press wheel the following forces and moments are acting:

G_t – press wheel weight; R_s – soil reaction (the forces resultant that oppose at the soil compression); M_f – the friction moment appearing in press wheel shaft bearings and F_t – traction force. In G_t weight was also included the F_e force from the adjusting spring of soil pressing.

If ignored M_f, applying the isolation bodies theory from technical mechanics, then the traction force, for a considered nominal mode of operation, is determined from the sum of the moments acting on the wheel:

$$X = F_t = \frac{x}{y} \cdot Y = f \cdot Y \qquad F_t = G_t \frac{2l}{D_t} = f \cdot G_t = W_r \qquad (1,2)$$

where: X and Y are reactions, tangential and normal, of the tread surface on the press wheel (X – rolling resistance force); l – rolling friction coefficient, expressed in units of length (point B is the application point of the drag forces); f = l/y rolling resistance coefficient; W_r - rolling resistance press wheel.

If it is considered b = 0 (figure 6), then $f = 2l/D_t$. According to the literature f has the values: f = 0.25…0.30, for processed fields, [5, 8].

Among the technological parameters of press wheel we can mention: the compaction depth, wheel dimensions and the pulling force.

The tensile stress compression in the compaction process, when compaction is by static action, is determined by the relationship:

$$\sigma_{\max} = \sqrt{\frac{q \cdot E_{st}}{R}} \leq 0.9\,\sigma_r \quad \text{(Pa)} \qquad (3)$$

where: q is the specific linear loading of the wheel (q = G_t/B (B – the wheel width)) and R – the radius of the press wheel; E_{st} – the static deformation modulus of the soil; σ_r – the tensile strength of the soil layer over which passes the press wheel, [8,9].

Also, the relative deformation ε after passing the press wheel is influenced by specific load on the wheel q (N/m), by the thickness of loose soil H_a (considered approximately 0.20 – 0.25 m), but also by the deformation modulus of loose soil E_o (Pa), [8,9]:

$$\varepsilon = \frac{20 \cdot q \cdot \beta}{E_o \cdot R^{0.5} \cdot H_a} \qquad (4)$$

where: β is a coefficient of proportionality.

Determination of MPM-4 press wheel strain by FEM. The analysis of press wheel assembly was performed, after being drafted the wheel model in SolidWorks software, by using the structural analysis program Ansys Physics. The structure (Figure 7) was analyzed by using the Finite Elements Method by meshing with finite elements of solid abbreviated type SOLID 185, elements used in the three-dimensional structures analysis. These elements are defined by eight nodes with three degrees of freedom on each node, namely translations along the Ox, Oy and Oz axes. The elements are used to model material with plastic behavior, hyperelastic and materials with large deformations. After completing the process of meshing resulted 84063 nodes and 38182 elements. From the results obtained from the analysis is presented equivalent tension variation (fig.8). In fig. 9 there are presented the variation in deformation of press wheel structure on the Ox, Oy and Oz directions of three-dimensional coordinate system and in fig. 10 is presented the variation of press wheel total deformation under the weight of pressing.

From fig.8, it is found that the maximum equivalent tensions in the press wheel structure do not exceed 6 MPa (60 daN/cm^2), the maximum values being located in the support and traction bar, while in the wheel coating tensions are really small (of the order 0.08 Pa).

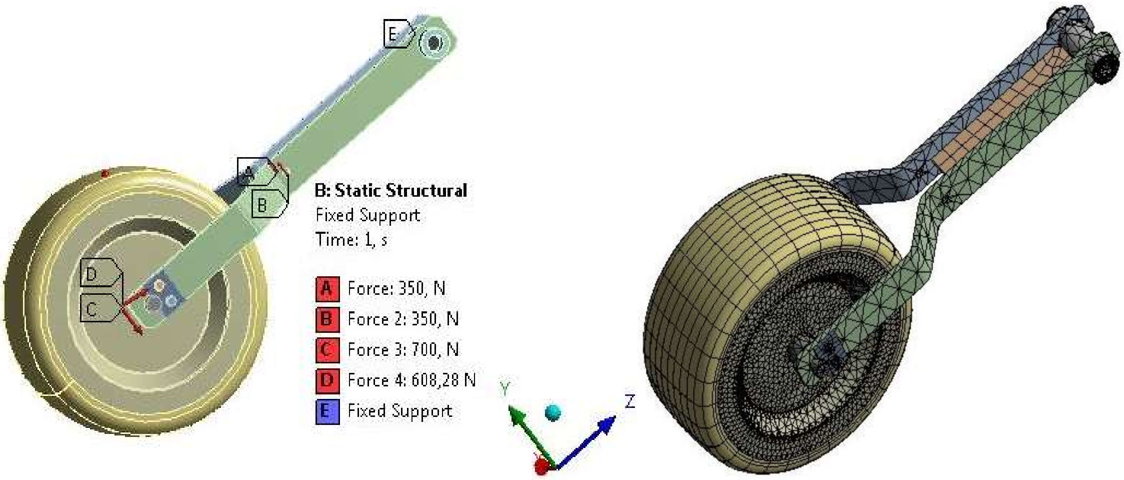

Figure 7: The geometric model of the analyzed structure and the loading and blocking system, [3]

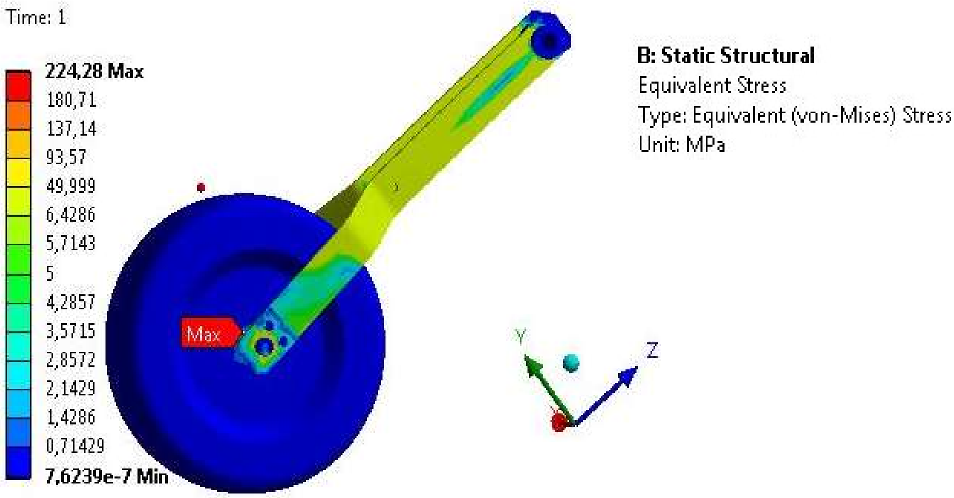

Figure 8: The variation of equivalent tension from FEM analysis of press wheel structure, [3]

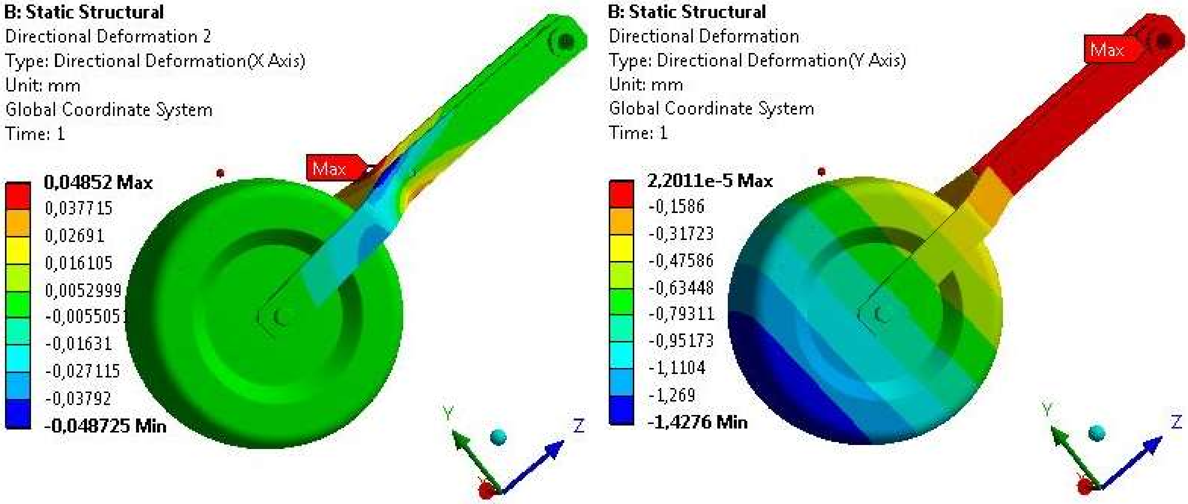

Figure 9: The variation of deformations in the rigidized press wheel on the Ox and Oy directions, [3]

Some important strains are located in the area of wheel axle (of the same order as in the drawbar). Taking into account that for OL37, the admissible strength is 160 MPa, it follows that for the construction of the wheel and its support can be used any type of steel, but it must be taken into account the abrasion stress given by the processed soil, the construction material being necessary to be alloyed with elements which give resistance to wear.

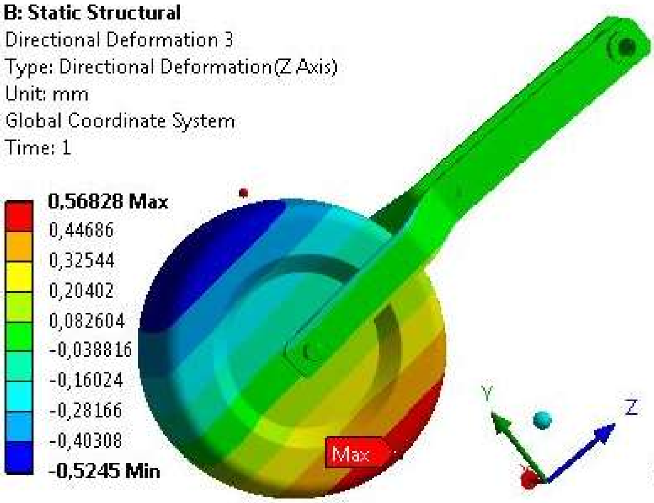

Figure 10: The variation of deformations in the rigidized press wheel on the Oz direction, [3]

CONCLUSIONS

Regarding the deformations in the press wheel structure and its traction lever, from fig.9 is found higher deformations on the Oz axis (along the support lever), these having maximum values of about 0.56 mm in the contact area of the wheel with soil, while in the support lever these have mean values of 0.08 mm, along it. On the Oy axis (perpendicular to the direction of the lever) it is found that the preponderant strain is the compression and the maximum deformation is about 1.4 mm, located in the lower end of the wheel cover. In the rest of structure, the strains do not exceed deformations of 0.05 mm on the Ox axis (in the transverse direction of movement), mainly in the middle area of the support lever, 0.6 mm on Oy axis, in the area behind the wheel axle (tensile strain) or 0.52 mm (compressive strain), on Oz axis, in the upper part of the wheel cover (see fig.10).

The data presented in this paper may be useful both for designers and those using the seeding and planting machinery equipped with press wheels, mainly metallic.

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TYPES OF AERATORS USED IN WASTEWATER TREATMENT PLANTS

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ABSTRACT

Water is vital for sustaining all forms of life on earth. The growth of human population has led to industry development which means, in addition to producing necessary goods, the consumption of natural resources, including water. Wastewater is the liquid end product or by-product of an municipal, domestic or industrial activity. The most efficient way to control and limit pollution is wastewater treatment before discharge into the receiving water course. Wastewater contains constituents that, if present in excess, will affect the quality of groundwater and other nearby water sources, and in the same time, will affect human life. The purpose of wastewater treatment is to improve water quality, so that it can be discharged into the environment without harming environmental factors. This paper presents the types of aeration systems used in the biological stage of a wastewater treatment plant.

1. INTRODUCTION

Pollution is one of the major problems of mankind nowadays. It is obvious that the natural environment deteriorates gradually and that ecosystems cannot adapt to the pressure of human activities. Ecosphere self-regulation is no longer possible.

The growth of human population has led to industry development which means, in addition to producing necessary goods, the consumption of natural resources, including water [1].

Water pollution is mostly due to the industrial development, population growth and urban discharge into rivers and lakes of wastewater, more or less treated. Wastewater is the liquid end product or by-product of an municipal, domestic or industrial activity. In the modern view, the protection of water quality means that the industry deals with issues of water resources quality [2]. Currently, a determinant key of water quality is wastewater, which is seen as today's only practical means of combating water pollution [3].

Council Directive 91/271/2002 is the legal basis on legislation related to wastewater. This Directive, transposed by H.G. 188/2002, defines water treatment as the ''removal from wastewater of toxic substances, microorganisms, etc., aiming to protect the environment, the envoy first, and also soil and air''[4].

The presence of biodegradable organic compounds reduces oxygen levels in lakes and rivers, resulting in fish death and bad odours. Other organic materials, such as pesticides, detergents, fat, oil and grease, and solvents create toxic effects and esthetic inconvenience and they bioaccumulate in the food chain. Due to the problems mentioned above, the treatment of domestic wastewater becomes necessary [2]. A wastewater treatment plant separates solids from the liquid and consists of two basic stages: primary treatment and secondary treatment. In the primary treatment stage, larger solids are removed from wastewater by settling. Secondary treatment is a large biological process for further removal of the remaining suspended and dissolved solids. Secondary treatment removes up to 85% of the remaining organic material through a biological process of cultivating and adding sewage microorganisms to the wastewater. This process is accomplished in a trickling filter or an aeration tank.

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Aeration is one of the methods which helps in the removal of various contaminants found in the wastewater.

2. THEORETICAL ELEMENTS

In waste water treatment, for certain specific treatments, the transfer processes of gaseous components in/off water are important (introduction of atmospheric oxygen in the water, removing carbon dioxide and hydrogen sulphide from the water, introduction of chlorine or ozone in the water). Among these, the most representative treatment and widely used in practice is the introduction of gaseous oxygen in the effluent, in order to remove organic impurities under the action of a biomass of aerobic bacteria, for chemical oxidation of hardly biodegradable or mineral compounds, or to eliminate gaseous compounds for improving water taste [5]. The oxygen comes most often from the atmosphere, and in this case the process is called *water aeration.*

Wastewater aeration process is performed by secondary sewage treatment plants, also called biological treatment. Usually, the wastewater doesn't contain gaseous oxygen due to the organic pollution load. Dissolved oxygen is naturally found only in clean natural waters (i.e., unpolluted) [6]. The process of water aeration is quantified by the *oxygenation capacity.*

There are two methods for determining the oxygenation capacity of a system: unsteady state method and steady state method.

The steady state method is based on the implementation of a biological process in an aeration tank (bioreactor) which contains activated sludge, in which all state parameters of the process remain constant and a certain amount of oxygen is introduced continuously to maintain a constant level of dissolved oxygen (between 1-2 mg/l). This method is more accurate and more difficult to apply in practice.

The unsteady state method is much simpler to perform, and it is equally accurate and reliable. The principle of this method is the following: a gas forming part of an atmosphere in contact with a liquid in which it is soluble, will pass into a solution up to the point at which gas concentration in the liquid is in equilibrium with the concentration of the gas in the atmosphere.

The equilibrium point is determined by the coefficient of absorption K_s (Eq. 1), which is the value of gas concentration in the liquid when the atmosphere is composed entirely of the considered gas:

$$K_s = \frac{\ln D_{t1} - \ln D_{t2}}{t_2 - t_1} = \frac{2{,}303 \cdot (\log D_{t1} - \log D_{t2})}{t_2 - t_1} \tag{1}$$

where: K_s – coefficient of absorption, which in this type of experiments, is conveniently expressed in [h^{-1}]; D_{t1}, D_{t2} [mg/l] – two selected readings of oxygen deficit concentration in fluid; t_1, t_2 [h] – corresponding values of time to achieve adequate oxygen deficits D_{t1}, D_{t2} [6].

The oxygenation capacity R of a system is defined as the rate of absorption of oxygen during the aeration process of completely de-oxygenated water. The oxygenation capacity is determined by the following relation:

$$R = K_s \cdot F \cdot C_{s(10)} \cdot V \tag{2}$$

where: R [g/h] - water oxygenation capacity; K_s [h^{-1}] - coefficient of absorption; F – temperature correction factor; $C_{s(10)}$ [mg/l] - oxygen saturation concentration at 10ºC; V [l] – the volume of liquid in the system [6].

Figure 1 showns how the variation of oxygen available in the aeration basin depends on the degree of water purification. Perfect knowledge of the processes and factors influencing the aeration process, as well as that of their best correlations, leads to biological treatment with maximum efficiency and to neutralizing the organic substances.

Figure 2 indicates the electricity requirements for primary production in an activated sludge plant. Aeration is based bioscrubbers wastewater treatment and control the performance and operating economy of the entire wastewater treatment plant. Cost analysis for wastewater treatment stations repeatedly show that the aeration is from 50% to 70% of the general budget of the station officials. Without the right aeration technology and a properly designed aeration system can not be obtained cleansing guaranteed performance and operating costs [7,8].

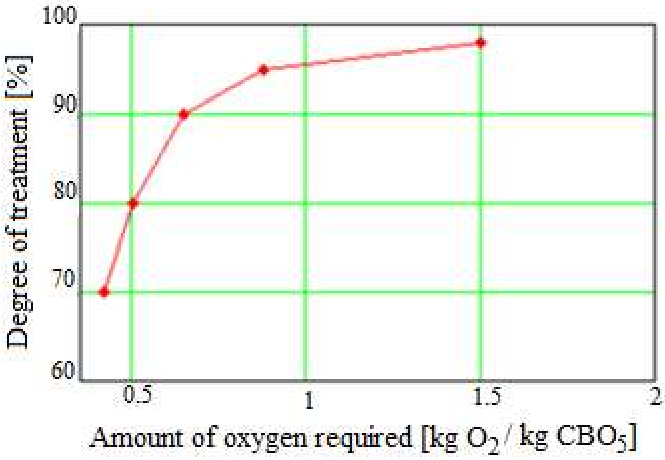

Figure 1: The way of change of the oxygen required for aeration in the tank depending on the degree of purification of water [7]

Figure 3 presents the technological process of the biological stage of a wastewater treatment plant. After settling, the wastewater falls into a pool - aeration basin - where is put into contact with sludge flocs, infused with oxygen and nutrients, for biochemical processes of degradation of organic substances. Neext, newly synthesized cellular material must be separated in the secondary clarifier. Part of the sludge is recycled, and the other part is removed as excess sludge from the settling sludge in the household.

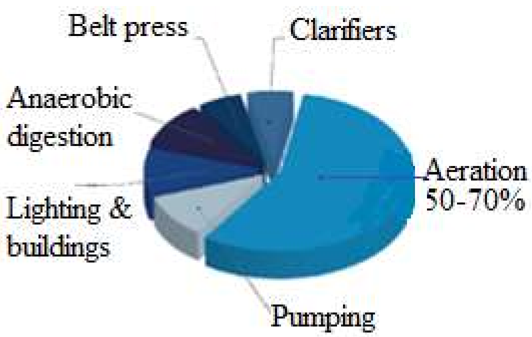

Figure 2: The level of energy used in a typical station for wastewater treatment [7]

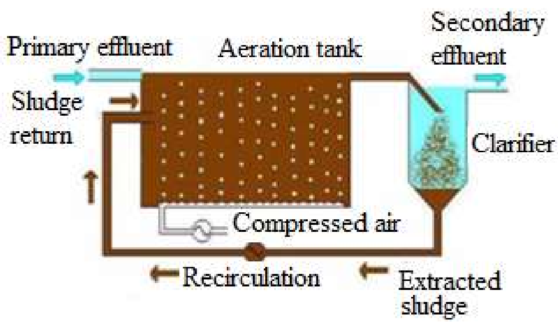

Figure 3: Schematic diagram of a biological treatment plant [9]

Aerators are typically used for wastewater applications like sewage and effluent treatment.

Typical applications for floating aerators include oxygenation of harbours, rivers, canals, lakes and reservoirs, but they can be equally used well for sewage and effluent treatment in balancing tanks, in concrete aeration channels or in low cost lagoon type aeration systems.

3. TYPES OF AERATION TANKS USED IN THE BIOLOGICAL STAGE OF WASTEWATER TREATMENT PLANTS

If activated sludge wastewater treatment has an important role, aeration tanks form and maintain the activated sludge. Aeration tanks are building whose plane shape may be radial, rectangular or square. In terms of construction, an aeration tank has the form of a rectangular concrete pool, where biological treatment takes place in the presence of a mixture of activated sludge and wastewater. To ensure continuous contact of the two components of the mixture, constant stirring is required to ensure their breathalyser constantly the oxygen needed by aerobic colony existing in the activated sludge in the form of flakes (Figure 4). Besides stirring and aerating, the mixture in the tank aims to maintain a quasi-constant concentration of activated sludge as a result recirculating a part of sludge settled in the secondary clarifier [10].

Generally, the equipment operates in the water and under the influence of atmospheric oxygen. For this reason, corrosion-resistant materials are preferred, such as stainless steel, cast iron, bronze and other non-ferrous materials like ceramics, plastics etc.

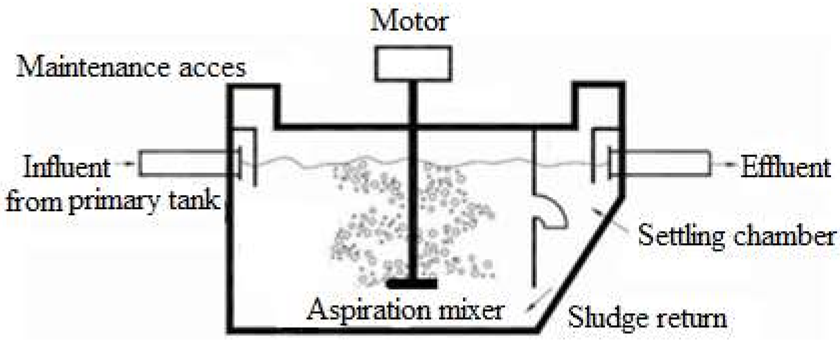

Figure 4: Schematic diagram of a surface aeration tank [10]

The biological process requires oxygen taken from the atmosphere, which is introduced in reaction basin through three categories:

a) pneumatic methods - the atmospheric air is compressed and introduced by means of the reaction tank equipment in the form of: fine bubbles, medium bubbles and large bubbles.

b) mechanical methods - when are put in contact with activated sludge basin content and ambient air through an intense mechanical mixing.

c) mixed methods - which use both air insufflation devices and mechanical agitators [11].

Generally, the functioning scheme of the pneumatic equipment for wastewater oxygenation comprises four distinct phases: the air supply; purifying the feed air; the distribution of the purified air; dispersing air into the water table.

If the pneumatic aeration tank requires it, oxygen is introduced with the air. Thus, compressed air is introduced through a series of underwater pipes provided with nozzles or porous plates.

Aeration tanks are characterized by the introduction of air bubbles into the water. Depending on their size, the bubbles can be: fine bubbles (with diameter between 1-1.5 mm) (Figure 5); medium bubbles (diameter 1.5-3 mm); large bubbles (diameter over 3 mm) (Figure 6). Fine bubbles are obtained by porous diffusers or air distribution through membranes with very fine holes. Medium bubbles resulting from the air distribution tubes provided with orifices whose diameter is between 1-5 mm and is spaced less than 5 mm from each other. Large bubbles are the result of air distribution through pipes or plates drilled with holes opening over 5 m [12].

Figure 5: Fine bubble aeration systems[13]   Figure 6: Large bubble aeration systems [14]

If mechanical adhesion achieves strong water agitation in the tank, it produces intense mixing between water, mud and air. Considering the way in which the air suctionis is made, mechanical aeration systems are the following:

- aspirated mechanical aerators;
- mechanical rotor aerators;
- mechanical aerators with blades or brushes.

Mechanical aeration tanks with aspiration are rarely used. These aerators are actually vertical tubes through which the air is sucked with water through pipes, knowk as the „Venturi" effect and water + air mixture is pushed to the bottom.

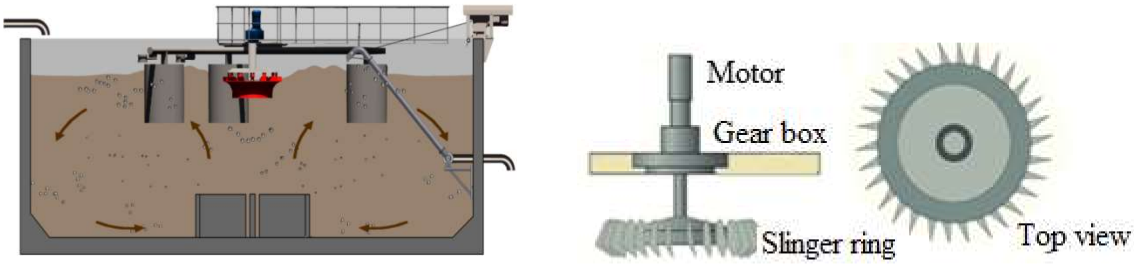

Figure 7: Mechanical aerator surface [15]

In the case of mixed aeration methods (Figure 8), the two schemes mentioned above are used which achieves the dispersion of air into the water table (pneumatic) and forcing convection by mechanical system (system recommended in waters heavily organic loaded).

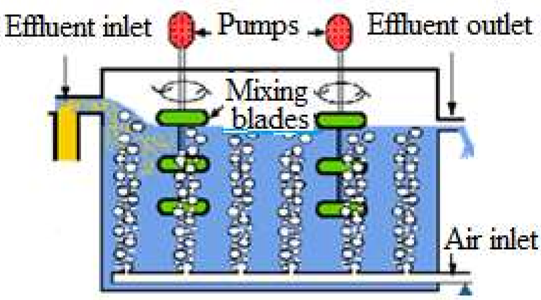

Figure 8: Mixed aeration tank [15]

Regardless the aeration system, there must be taken into consideration the amount of air circulated and how the transfer of oxygen from air to water is achieved. Using oxygen from the air for biological wastewater treatment depends on the variation of physical quantities (pressure, temperature, etc.) and the characteristics of wastewater (biodegradability of organic materials, their amount in the water, the oxygen content initially).

4. CONCLUSIONS

In wastewater treatment, for certain specific treatments, the processes of transfer in/of water of gaseous components are important. Among these, the most representative treatment, widely used in practice is the introduction of gaseous oxygen in the effluent, in order to remove organic impurities under the action of a biomass of aerobic bacteria. The oxygen comes most often from the atmosphere, and in this case the process is called water aeration.

To protect the environment, and especially the emissary, the soil and the air, the process of wastewater treatment should provide favorable conditions for further use of treated water in domestic, industrial or agricultural activities. Untreated wastewater discharged into rivers has a devastating impact.

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DESIGN AND SIMULATION OF A PHOTOVOLTAIC WATER PUMPING SYSTEM IN A WASTEWATER TREATMENT PLANT

Andreea BIRLOG[1] , Andreya BONDREA[1] , Razvan TUDOR[1]

ABSTRACT

Water resources are esential for human needs, health protection, provision of food, energy generation, for ecosistems reconstruction, and of course for economic development and sustainable development. Water is the main source of life for human, animal and plant world. We define water as a colourless, odorless, tasteless liquid, Water is esential for life, no matter its form, water is one of the most common solvents. From chemical point of view water is an hydrogen compound. The increase of worldwide human population and several other factors have led to a decrease of the number of people that benefit of dinkable water. This problem can be solved by increasing the production and optimizing the distribuion without wasteing the existing resources. Any working water pumping system has as main component a power generating source.

1. INTRODUCTION

Usually the water pumping system is conected to the power grid because this power source requires a minimum of maintenance. But there are many rural areas where the water sources are located far away from the power grid, sometimes there are many kilometers in between.Extending the grid, installing transformers if there are required is very expensive. Some water pomps use combustion engines because this are easy to install and are portable. The main disadvantage in this case is the frequent intervention because the system has to be loaded with fuell, also the fuell is expensive and hard to find or to transport in those rural areas.

2. CHOOSING THE PUMPING SYSTEM

As a solution to the problems above we sugest installing photovoltaic panels, because of their reliability and because they are cost efficient reported to their life expectancy, especially for the applications that require less then 10 kW. If the water source is located at a 1/3 mile distance, approximately 0,53 km, or more, form a power grid, photovoltaic panes become the best economical choice. In the table below are shown the advantages and disadvantages of different power sources that can be used in a pumping system.

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System type	Advantage	Disadvantage
Photovoltaic system	– Low maintenance cost – Function unattended – Reliable and long life expectancy – No need for fuel and do not pollute – Easy to install – The system is modular and is suited for the needs	– Big investment – Low power generation in bad weather
Diesel system (or gas system)	– Average installing costs – Easy to install – Portable	– Frequent maintenance intervention and replacement – Supervision required – Noise, dirt, pollution – Fuel is usually expensive and hard to provide
Wind system	– No fuel required – Doen't pollute – Long term investment – Work in areas with wind potential	– High maintenance costs – Discontinous energy generation because of wind speed variation – Expensive repairs – Hard to install and require for installing spacial tools

We sugest in this article a system without batterys. The system is made of simple photovoltaic panel, a maximum power point tracker (MPPT) and a solar water pump that works in discountinuous current. This water pumping system it is intended to be small.

The purpose of this research is to investigate the use of power electronics in renewable energy field, focusing on photovoltaic systems. The maximum power point tracker (MPPT) is used mainly on photovoltaic systems to automaticaly adjut the electric load in such a way that the system obtaines the biggest power production possible. MPPT is made form a convertor (DC – DC), that transforms voltage value to other voltage value, and from an analogic controller. This controller type is the most used. Photovoltaic systems use to type of pumps: volumetric pumps and centrifugal pumps. For this paper we have used the Kyocera SD 12-30 pump. This is a volumetric pump, equiped with permanent magent, DC engineand is conceived to supply water to comsumers that are remotely situated. The flow of this type of pump can reach 17 l/min, the daily capacity of water is between 2700 and 5000 liters and the rated power is 150 W. The required working voltage is small and the power demand is of 35 W. We will talk next of the Cuk convertor design. After we establish the system components, Pspice simulation will validate our design and corect choosing of MPPT. We will determine which of the two types of photovoltaic systems, equiped with MPPT or without MPPT, is more efficient. The Cuk convertor is made based on the specifications in the table below.

Table 2.Design specifications of Cuk convertor

Specifications	Value
Input voltage (Vs)	20-48V
Input current (Is)	0-5A
Output voltage (Vo)	12-30V
Output current (Io)	0-5A
Maximum Power output (Pmax)	150W
Frequency (f)	50 kHz
Cicle (D)	0.1<=D<=0.6

The inductor characteristics are chosen so that the current pulsation doesn't exceed 5% and we presume that the biggest current difference happends when maximum power conditions are met. In these conditions the average current (IL1) shown by the input indicator is 4,35A and the current pulsation in IL1 is 5%.

$$\Delta iL1 = 0.05 \cdot IL1 = (0.05)(4.35) = 0.2175A \quad (1)$$

$$L1 = \frac{Vs \cdot D}{\Delta iL1 \cdot f} = \frac{(34.5)(0.465)}{(0.2175)(50X103)} = 1.475mH \quad (2)$$

On the market we found a 1,5mH inductor that meets the system requirements. The condenser has been choosen so that the pulasation are smaller then 5%. The average voltage in the condenser (C1) is $V_{c1}= V_s+V_0=34.5+30=64.5V$, so the maximum voltage pulsation is $\Delta V_{C1} = 0.05X64.5=3.225V$.

The load resistance is: $R = \frac{V0^2}{P0} = \frac{(30.0)^2}{(150)} = 6\Omega$ (3)

The C_1value is calculated with the following equation:

$$C1 = \frac{V0 \cdot D}{R \cdot f \cdot \Delta Vc1} = \frac{(30)(0.465)}{(6)(50X103)(3.225)} = 14.42\mu F \quad (4)$$

The closest condesner from the value obtained is the 22µF condenser.
The output value of the condenser (C_2) is calculated using the voltage pulsation.

$$\frac{\Delta V0}{V0} = \frac{1-D}{8 \cdot L2 \cdot C2 \cdot f^2} \quad (5)$$

From this equation, C_2 is:

$$C2 = \frac{1-D}{8 \cdot (\Delta V0 / V0) \cdot L2 \cdot f^2} = \frac{1-0.465}{8(0.05)(1.5X10-3)(50X103)} = 0.3567\mu F \quad (6)$$

The suitable condenser is 0,47 μF.

3. MODELING OF THE WATER PUMP

The pumped water flow is directly proportional with the water pump engine speed, the engine speed is voltage dependent. The value is selected to reach the maximum rated power of 150 W at maximum voltage of 30 V. The water pump parameters are unknown, so are choosed by varying of the implicit values and thier estimation from other references. The voltage source si varied from 0 to 30V at a 1V persecond rate.$R_{load} = 9.5x10^{-5} \cdot V_0^3 - 8.7x10^{-3} \cdot V_0^2 + 0.37 \cdot V_0 + 0.2$, where $V_0$is the output voltage of the convertor. This equation is a characteristic of the dc water pump engine, and it is used for simulations in MATLAB.The next figures show the convertor output voltage and output current relation that is equal to the DC engine load. The output current is increasing fast with the increase in voltage, until the current reaches a value big enough to create suffincient torque to start the engine.

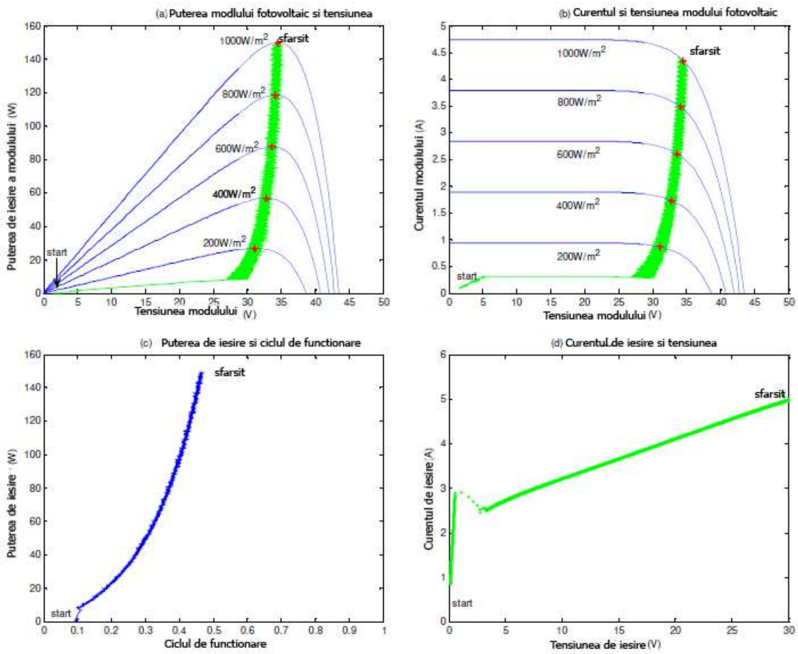

Figure1: MPPT simulations with water pump DC engine load (from 20 to 1000W/m^2, 25°C)

The water pumping photovoltaic system simulated in the previous section is compared with the photovoltaic system that is directly connected to the water pump, without MPPT. The irradiation data used is measured on a sunny day. The total energy produced in a 12 hour period is calculated and presented in table 3.

Table 3: Photovoltaic system energy generationand efficency, with and without MPPT

	With MPPT	Without MPPT
Total energy (Simulated)	1.057 kWh	0.577 kWh
Total energy(Theoretical value)	1.060 kWh	1.060 kWh
Efficiency	99.75%	54.42%

4. RESULTS

The results show that the photovoltaic water pump system witout MPPT has low efficiency because of the noncompliance between photovoltaic system energy productio and water pump DC engine load. It is also shown that the MPPT system could use more than 99% of the photovoltaic capacity. Assuming that a DC – DC convertor has more than 99% efficiency, the system could increase the global efficiency with more than 35% compared to the no MPPT system. Another simulation set shows a comparison between the flow and total pumped water volume by the two systems. The results show that MPPT can significantly increase the system performance, the water flow of the Kyocera SD 12 – 30 is directly proportional with the supplied power. When the dynamic pressure is 30 m, the flow rate on Watt is aproximately 86.7 cm^3 / W $\cdot min$. The minimum power demand of the water pump engine is 35 W, so as long as the power output is bigger then 35W, the pump is delivering water at the flow mentioned above. Using the same testing conditions the pump water flow are obtained from MATLAB simulations and are shown in figure 2.

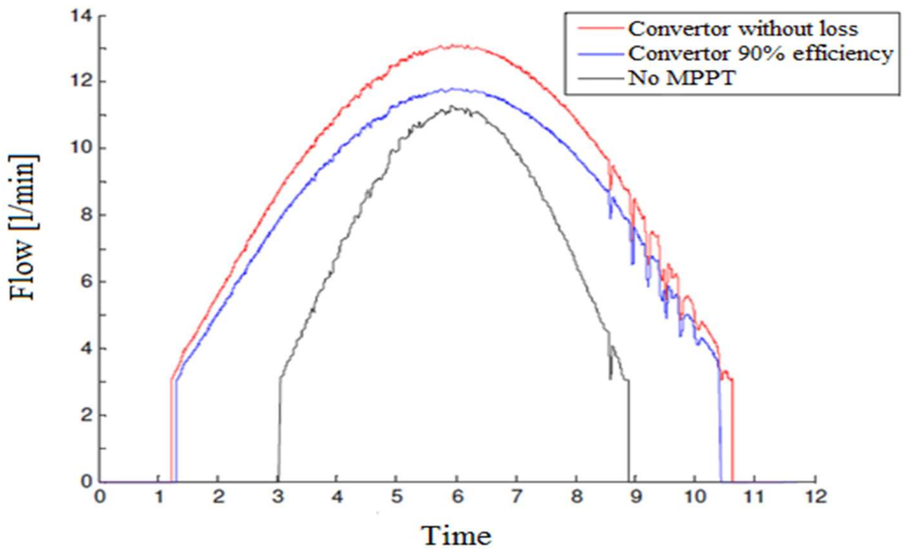

Figure 2: Water pump flow for a 12 hour period simulated with data irradiation for a sunny day
(total dynamic pressure= 30m)

The results show that the photovoltaic system without MPPT has a severe disadvantage due to the fact that the pump remains inactive for more than two hours in the morning, the system with MPPT starts with two hours earlier than the system witout MPPT. In a similar way, in the afternoon the system with no MPPT stops pumping water with two hours earlier than the system with MPPT. The water flow is smaller during the whole tested period. The total volume of pumped water for a 12 hours period is calculated for both systems and showed in the table below.

Table 4: Total volume of pumped water for a 12 hours period simulated with data irradiation for a sunny day (total dynamic pressure = 30m)

	With MPPT		Without MPPT
	Convertor with low loss	Convertor with 90% efficiency	
Total volume of pumped water for a 12 hours period (simulated)	5,.302m^3	4.719m^3	2.831 m^3

The results show that MMPT offers a significant increase in performance. This allows the water pump to increase its performace with up to 87%. Even if the convertor efficiency is set to 90 % the pump still has a water flow bigger with 67 % than the system without MPPT. The present study sugest a simple but very efficient photovoltaic system to pump water.
Every component is mathematical modeled and simulated using MATLAB. The results show that the mathematical modeled photovoltaic system is close to the real system, a small increase in the system efficiency can lead to a significant increase in the energy economy if the system is bigger. Also, the results show that the MPPT can increase significantly the performance of the system, including energy production and water pump performance.

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ANALYSIS OF WIND-PHOTOVOLTAIC HYBRID SYSTEM SUPPLYING REMOTE LOADS

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ABSTRACT

In order to restrain the global warming, to provide power to isolated consumers and to cover the growing consumption, renewable energy investments are growing worldwide. The major disadvantage of renewable resources is their discontinuous character. Wind turbine-photovoltaic hybrid power systems represent an answer to this problem. To increase the performance of the overall hybrid system it is necessary to use high efficiency wind turbine and photovoltaic panels. The few existing studies related to helical wind turbines report high performances compared to other types of small power wind turbines. This makes the helical Savonius an interesting and feasible option. The present study analyzes the opportunity to install a helical wind turbine-photovoltaic hybrid system that will power an isolated consumer that has a total installed capacity of 3 kW. The research was made based on meteorological data thus energy generated by each component and by the whole system was simulated and reviewed.

1. INTRODUCTION

Wind turbine (WT) - photovoltaic (PV) hybrid systems are widely spread because of the availability of the renewable resources needed to operate. They are also a feasible way for power remote areas, isolated consumers or, if used in parallel with the power grid, they can lead to big economies due to the fact that the consumer will pay less to the energy supplier. To increase the hybrid systems performance, in the present paper different wind turbines types where proposed and simulated. In this paper a helical wind turbine-photovoltaic hybrid system is analyzed.

Helical wind turbine, also known as the Twisted Savonius, is a vertical axis wind turbine that combines the blade design of the helical Darrieus, which has a better performance, with the advantages of the Savonius wind turbine, which is self-starting and is more stable in operation.

According to the scientific literature, at lower installed capacity the performance of Twisted Savonius is one of the highest, even higher than the horizontal axis wind turbines. The 50% performance of the 3 bladed horizontal axis wind turbines is recorded for installed capacities higher than 10 kW. For horizontal axis wind turbines smaller than 10 kW installed capacities, the efficiency is about 30%. None of the wind turbines yet designed has reached the maximum theoretical performance, 59%, known as the Betz Limit. [1]

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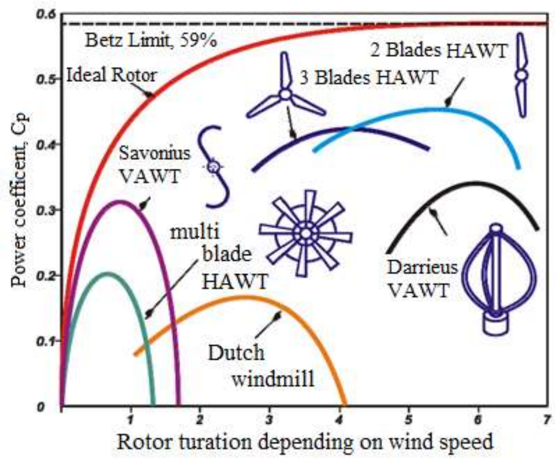

Figure 1: Different wind turbines performance [1]

In table 1 maximum efficiencies for different turbine designs are reported [2]. The helical rotor theoretical performances reported are between 30 – 50%, in practice the efficiency being approximately 35%.

Table 1: Efficiency of different rotor designs

<table>
<tr><th>Rotor type</th><th>Peak efficiency [%]</th></tr>
<tr><td colspan="2">Vertical axis wind turbines (VAWT)</td></tr>
<tr><td>Savonius</td><td>16</td></tr>
<tr><td>Darrieus</td><td>40</td></tr>
<tr><td>Helical</td><td>35</td></tr>
<tr><td colspan="2">Horizontal axis wind turbines (HAWT)</td></tr>
<tr><td>American farm windmill</td><td>31</td></tr>
<tr><td>Dutch windmill</td><td>27</td></tr>
<tr><td>Modern wind turbine for power higher than 10 kW</td><td><table><tr><th>Blade number</th><th>Efficiency</th></tr><tr><td>1</td><td>43</td></tr><tr><td>2</td><td>47</td></tr><tr><td>3</td><td>50</td></tr></table></td></tr>
</table>

Computational Fluid Dynamic studies were conducted for different twist angles to see the variation of power coefficient (Cp) with tip speed ratio (TSR). TSR represents the ratio between the speed at the tip of the wind turbine blade and the real velocity of the wind. For Helical Savonius Rotor with shaft at a 45° rotor angle the maximum Cp obtained is 0.4742 at a TSR of 1.636 [3]. Similar Cp results for Helical Savonius Rotor without shaft were reported in [4].

The advantages of the vertical axis wind turbine are many, they produce energy regardless of the wind direction, the required starting speed is smaller than the one of the horizontal axis wind turbine. In addition, the maintenance costs reported are smaller, they are installed at smaller heights so they don't affect the wildlife, especially birds and bats, also they can be installed on rooftops and are suited for urban scape. Another advantage is the fact that they can be placed in arrays to build small twisted Savonius wind parks [5]. In Oklahoma City is installed the world's biggest rooftop wind farm and is made of 18 helical wind turbines [6]. All this advantages corroborated with a high performance make the helical wind turbine a good choice for small renewable power applications.

2. ANALYSIS OF TWISTED SAVONIUS WIND TURBINE-PHOTOVOLTAIC HYBRID SYSTEM

Based on historical meteorological data, the possibility of installing a stand-alone Twisted Savonius wind turbine-photovoltaic hybrid system in a remote area situated in Eastern Romania was analyzed [7]-[10].

This system supplies a consumer that demands about 22000 kWh annually. The hybrid system was sized according to our consumer's energy demand and for redundancy was presumed that both the wind component and the photovoltaic component have to be able to fully cover all the load. Table 2 reports the characteristics of the system proposed.

Table 2: System characteristics

Photovoltaic panel		Wind turbine		Batteries	
System uses 60 PV pannels				The system has 8 12 V – 150 Ah batteries	
Rated capacity	300 W	Rated power	10 kW	Battery type	Valve Regulated Lead-Acid
Maximum power point voltage	32.5 V	Cut-in wind speed	2.5 m/s	Nominal voltage	12 V
Open circuit voltage	39.7 V	Rated wind speed	12 m/s	Nominal capacity	150 Ah (20 hour rate)
Maximum power point current	9.26 A	Survival wind speed	55 m/s	Sizes	532x183x214 mm
Module efficiency	18%	Efficiency	35%	Life expectancy	10 – 12 years at 20 °C

The analysis of the data for the wind turbine was hourly. In table 3, the energy generated monthly by the WT is reported. In figure 2 the energy generated by each component and by the whole system during the studied period are illustrated.

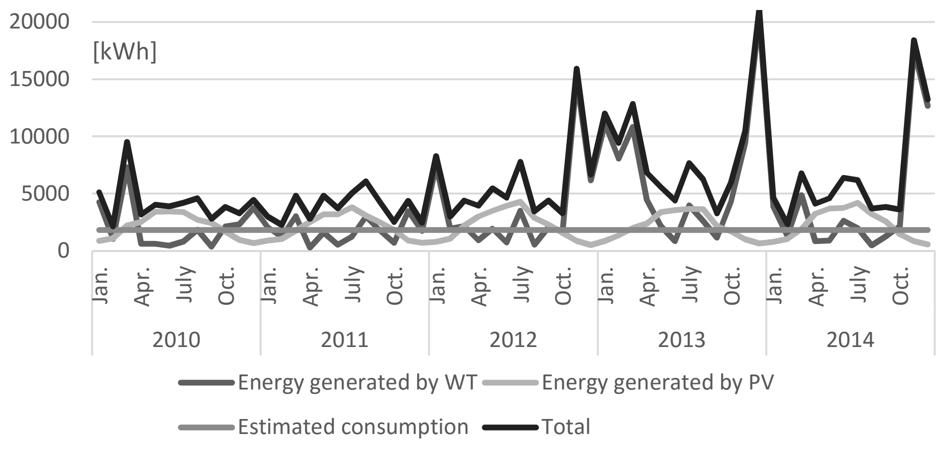

Figure 2: Energy generated daily by the system during the studied period

Table 3:Energy generated by the wind turbine [kWh]

Year / Month	**Energy generated by WT**				
	2010	**2011**	**2012**	**2013**	**2014**
January	4247	2507	7489	11134	3856
February	1041	1215	1925	8056	1296
March	7313	3036	2167	10837	4875

April	624	293	927	4447	852
May	663	1613	1934	2162	896
June	447	536	724	837	2630
July	807	1233	3502	3986	1990
August	1863	2993	550	2612	486
September	361	1755	2084	1142	1271
October	2128	710	1714	4319	2158
November	2320	3479	15035	9.413	17571
December	3764	1748	6168	20472	12666

In figures 3 – 7 we can observe the power generated hourly by the WT in each year analyzed.

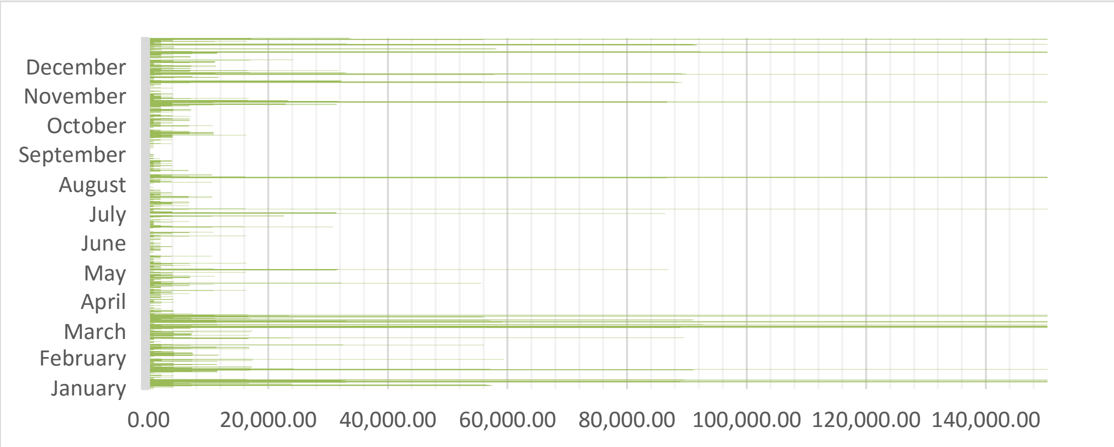

Figure 3: Hourly power variation [W] during 2010

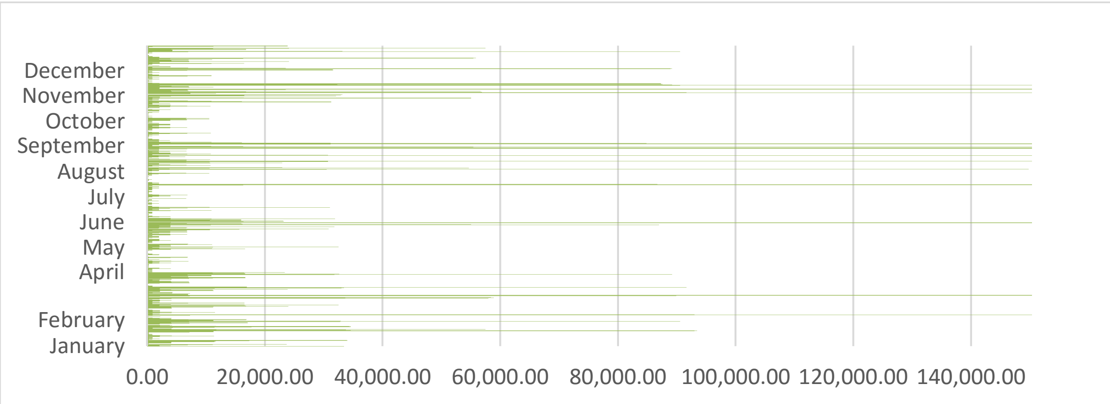

Figure 4: Hourly power variation [W] during 2011

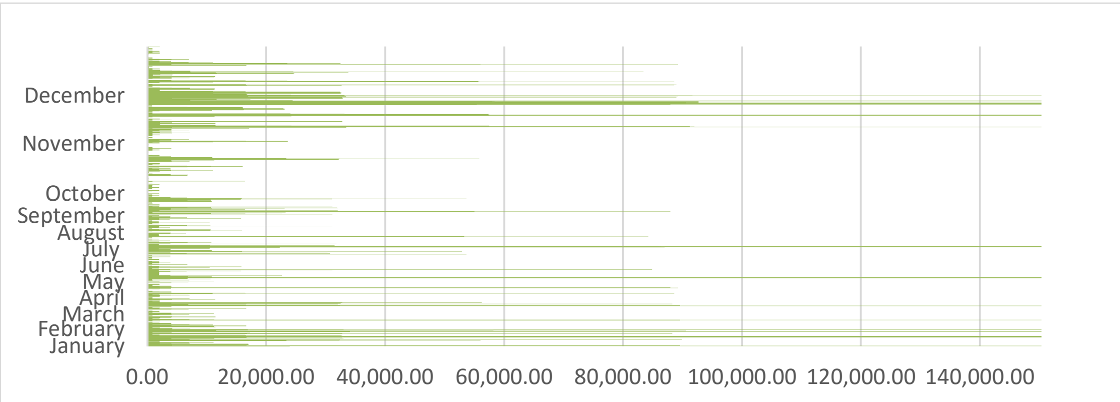

Figure 5: Hourly power variation [W] during 2012

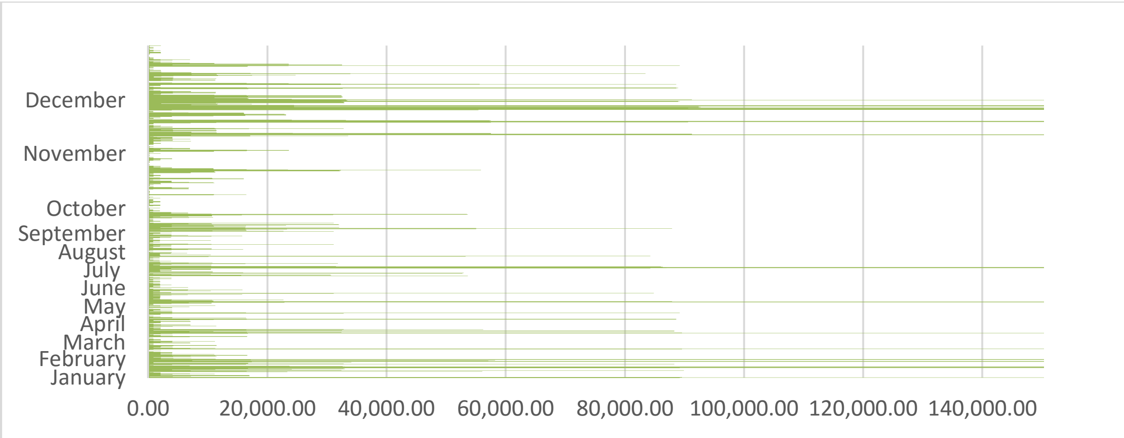

Figure 6: Hourly power variation [W] during 2013

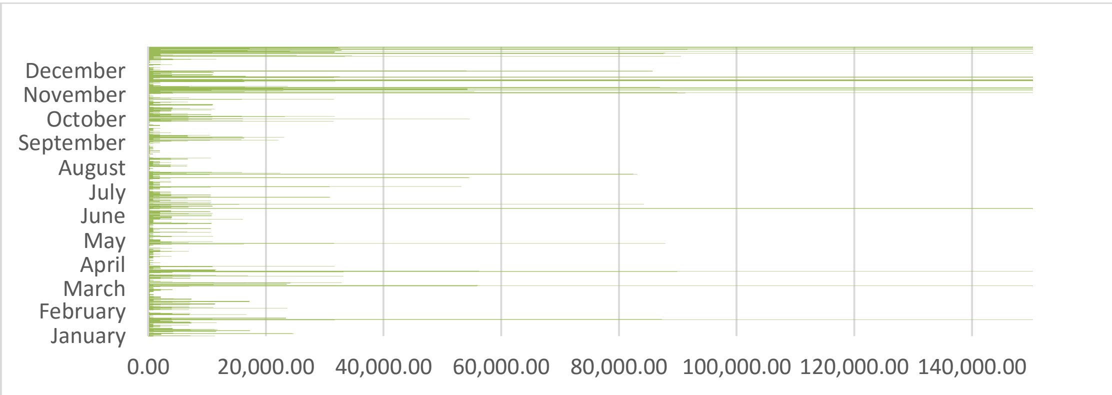

Figure 7: Hourly power variation [W] during 2013

Based on this research, the twisted Savonius wind turbine-photovoltaic hybrid system can be installed in the analyzed location. This system can operate off grid in a remote mountain area where the wind direction changes rapidly, and this represents one of the reasons helical wind turbine is fitted for this application.

3. CONCLUSIONS

In order global warming to be limited, an even greater development of renewable power resources usage is imperative to be done. Hybrid systems represent a solution to these problems, but their efficiency has to be improved. Twisted Savonius wind turbines have many advantages and can increase the total performance of a wind turbine-photovoltaic hybrid system.

In this paper, a twisted Savonius WT-PV hybrid system was sized and the feasibility of implementing such a solution in a remote isolated area in Romania, where the classical grid connection investment can be exceed the hybrid system costs, was analyzed. Acording to our study the total energy demand is supplied 30 % by the wind source, 50% by the PV panels and 20% by the batteries. The 20 % gap in the energy production, supplied by the batteries, is mostly distributed in winter periods when the PV panels generate less energy. The helical wind turbine can operate without any risk of damage because from the data analyzed we observed that the survival wind speed of the WT is never reached. So, the system can supply the consumer with the energy needed without any blackouts.

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THE IMPACT OF THE LEATHER INDUSTRY LEFT ON THE ENVIRONMENT

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ABSTRACT

Production of the leather industry has been positioned, from a historical point of view at the top of the market, seeking to improve the quality and to launch innovative offers on the market. All the efforts of the tanneries along the years have resulted in improving the sustainability of their production. The excellent results obtained deserve to be appreciated more by the interested parties and be better stimulated by measures to encourage new investment. In Romania, the leather industry is developed in almost all towns and is mixed through hard work with tradition and technique. The leather sector constitutes an important source of material for various industries and domains, some of them are listed as top areas. Waste from leather and leather clothing industry can be harnessed by using several processing methods in different domains.

1. INTRODUCTION

The european leather industry has been a world leader in the field, but recently has fallen to the level of turnover being topped by China but still has a growth potential through the innovation level achieved through quality and commitment towards the environment, creating a recycling rate of over 90% of waste results. Environmental pollution represents material contamination wich is harmful to ecosystems, people and the quality of life. There are cases in which pollution is a result of natural causes, for example volcanic eruptions but most polluting substances come from human and industrial activities.

There are biodegradable pollutants that are more friendly with environment but become a problem if they accumulate faster than there is time to break them down. The skin of the animal suffers during the course of its proceessing over 75 chemical and mechanical operations turning in semifabricated leather. The process entirely includes complex chemical reactions, physical and mechanical processes. Leather processing operations involve transforming belly skin into a brute stable material that can be used in the further manufacture of leather. All these operations have lesser or greater importance in skin processing technology. Some operations change much of the character of the skin and because of this is called the main operation of processing of hides and skins.

These operations are unhairing, tanning, lubrication, dyeing and finishing. Unhairing is the process which removes the hair from the dermis. Tanning is the key operation of the entire technological process by which skin in a state o putrefaction is transformed into a material non-putrescibil. Lubrication gives softness to the skin. Dyeing turns the skin in the desired

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color painting and finishing print functional and aesthetic properties of the skin. Nationally, the vectors pollutants are derived from industrial activities, municipal waste or waste storage. There are some waste that may have potential energy thus stand at the basis of a sustainable ecology. We can say that some waste that can be recovered is a real treasure. This is way, there is a national preocupation and concern of the EU directives for a clean and ecological environmental. After the acceptance into the EU, the new member countries from Eastern Europe must use these technologies for the recovery of waste. It has been considerd the variant of incinerating the sludge, but this technology besides the technical and economical requirements that must be respected, emits a series of pollutent gasses in the air and the population does not agree to this.

It is known that the incineration of sludge is an expensive process if we take into account the criteria related to the life, economic and environmental cycle. There is still no information about the quantities of sludge that thermal power plants or cement factories use as a supplement in the industrial processes. This article aims to reduce the impact of the industry on the environment and the main leather waste generated by this industry.

2. THE WASTES WHICH COMES FROM THE LEATHER INDUSTRY

From municipal waste which Romania produces, approximately 64% represent domestic waste, while waste street are approximately 10% and construction waste are 9%. During the year 2013 the amount of waste generated by mining, energy and manufacturing was 190 milion tons, of which the better part (90%) of the waste resulting from the extraction activities (mining) and 15 milion tons of the waste was generated by the energy and manufacturing industry.

During the year 2013, were put into service the following installations for the incineration for hazardous waste:

- 8 installations of incineration plants / co-incineration plants
- 10 installations for the incineration of hazardous waste
- 7 installation of co-incineration plants in cement kilns

During the year 2013, there were operating 40 industrial landfills for hazardous or non-hazardous industrial waste, as follows:

- 8 landfills for industrial hazardous waste from which
    - 6 landfills by economic operations which they stored their own waste;
    - 2 regional landfills in accordance with legal requirements ;
- 32 landfills for industrial non-hazardous waste from which
    - 17 landfills in accordance with legal requirements;
    - 15 landfills that storing waste în liquid form.

If we consider ecological leather processing, their distribution on the various processing phase can be represented in the next figure.

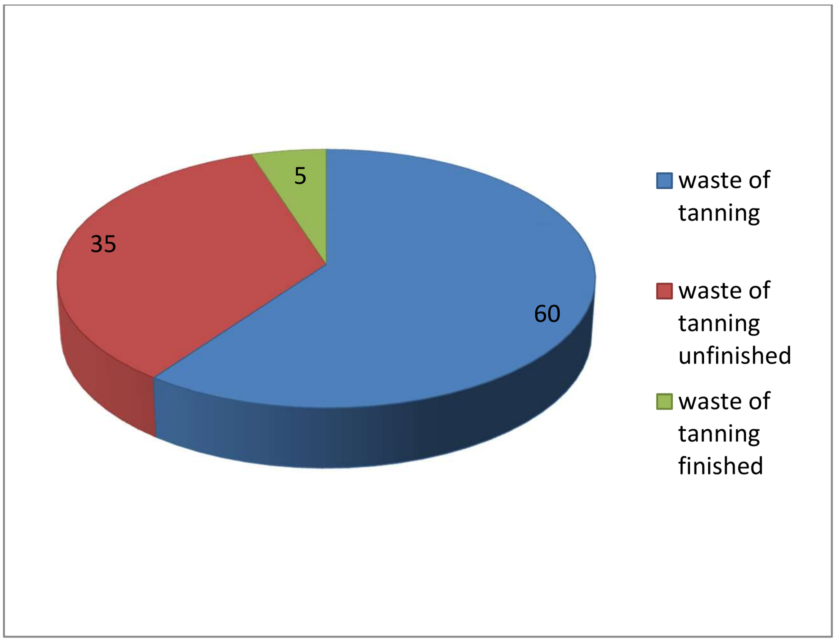

Figure1: Distribution of the 3 major phases of waste processing

Waste generation sources include the place where they get the skin, which are slaughterhouse, then follows the tanning of the skin which goes through several phases and finally the leather apparel sector. The first source of generating skin waste is the slaughterhouse, in which the operations are performed as: skinning, trimming and sprinkling, the resulting of raw waste with hair. In the case that applies to the operation of conservation of the skin, waste comes fromthe trimming operation of the salty skin purchased from private individuals and is therefore salty hair waste.

In the tannery waste sector we can fiindwaste both as a result of the processing operations in the wake of the pelts, differentiated between them both by the degree of hairiness on the skin and through the tanning and/or finishing process. In the leather sector, the skin is the basic material but we can find other materials such as polymers, wood, metals. We can mention that there is a big quantity of material processed in this sector and the amount of waste is important.

3. CONCLUSIONS

The leather industry although it has made considerable progress in its relationship with the environment, it still constitutes a factor of aggressive pollution due to the waste protein in nature, in special those resulting from tanneries and footwear factories. A part of the sustainable development of the industry is due to skin products, manufactured in terms of protecting the environment and in harmony with the ecosystem. Harnessing waste of the skin are a necessity to clean techonologies, eco-friendly, since only 25% of raw skin is found as a finished product. Reducing pollution caused by waste tanneries and the processing of finished products in the skin can be done by finding alternatives to chromium solutions or recycling solid waste.

Acknowledgment

This work was supported by a grant of the Romanian National Authority for Scientific Research CNCS – UEFISCDI, project ID PN-II-PT-PCCA-2013-4-1017, “Green Tannery – Methods for energetic recovery of biodegradable wastes”

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RECOVERY OF TRIVALENT CHROMIUM FROM THE WASTE WATER USED FOR TANNING OF HIDES

Dana Andreya BONDREA [1], Gheorghe COARĂ[3]

ABSTRACT

The leather industry has developed in most cities in Romania and consists of intense work combined with technique. Although it made progress in its relationship with the environment, the leather industry is a factor of pollution due to the aggressive nature of the protein waste. Through a complex process, we obtain the finished skin that has natural character and structural properties. Leather processing industry is characterized by an important volume of waste water. Chromium is the main source of pollution in wastewater from tanners. One of the best solutions is the separation of chromium through precipitation of fleets from tanning. In this paper we studied the method of recovery of chromium through precipitation with calcium hydroxide. After this treatment by means of precipitation with calcium hydroxide solution Cr_2O_3 the content is about 5% lower than the initial one.

1. Introduction

The leather industry in Romania has developed rapidly in recent years. Most cities have a tannery located on the outskirts. Daily work in a tannery is intense and complex. Proffesional training, modern equipment, automation, environmental protection and social responsibility are part of the sustainable development for thetannery . Raw materials from a tannery are raw skin, over 98% of which comes from animals raised initially for the production wool, milk or meat. We can say that tanneries harness a secondary product, which in the absence of the specialized industry would be thrown. The leather industry has built factories in countries with high numbers of sheep,pigs and of course cattle. We can enumerate India, Argentine, Brazil, Ukraine, China and Mongolia, which are the main manufacturers of leather on the entire globe. Countries such as France, Italy and Japan have developed a tanning industry but they use both their own material and imported leather.

From the economic point of view, the skin is a key material, generating jobs in the whole value chain starting with the animal growing up and ending with the consumer. The usage of manufactured leather is found in different industries, from instance footwear, boats, furniture, clothing, car seat, aircraft and many articles of daily use. The leather industry in the EU is approaching 40.000 companies, with over 500.000 employees and a total turnover of approximately 50 bilion euros.

The european leather sector remains the global leader with a turnover of 25% of the total worldwide. The skin is a valuable material, its a renewable material. The manufactors want to create a more eco-friendly processes, which consumes less energy, water and fewer chemicals. The official data shows an average of 1,7 kg of chemicals consumed for $1m^2$of

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finished leather. Trying constantly to reduce this quantity of chemicals used in the processing of leather.

Harnessing the skin waste is a necessity for clean technologies, eco-friendly, since only 25% found in the finished product is raw skin.

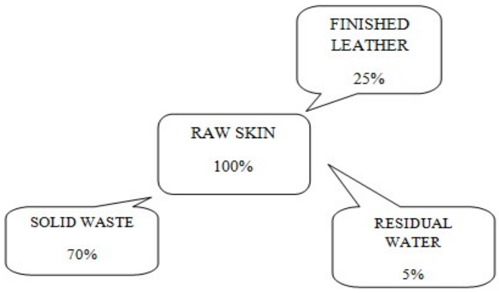

Figure 1. From raw leather to finished leather

2. THE MAIN TECHNOLOGICAL OPERATIONS OF PROCESSING HIDES

The processing of tanning operations involve turning the skin, a brute organic material easily degradable in the finished product, a stable material that can be used in further manufacturing of leather products. The entireprocess includesa complex chemical reactions, physical and mechanical processes. Among them, tanning is the fundamental step, which gives the skin its durability.

The tanning industry depends on the animal population and the rate of scarification for the consumption. This industry is a potential source of pollution because of the chemicals used and residual waste, the environmental impact is generated by emission of gaseous liquids or solids, but also through the consumption of raw materials (skin), energy and water.

3. THE TANNING PROCESS

The waste water from leather tanning are loaded with different substances, for instance we have basic chromium salts, sodium chloride,lime, sodium, proteins, chemicals, solvents. In Romania the decontamination process for tanneries are based on a classicalchemical treatment process with high consumption of reagents, resulting in large amounts of mud which cannot be used in agriculture as a fertilizer. Of all the substances listed above, alkaline salts of chromium present the biggest danger from the point of view of environmental impact. Because the wastewater generated from the stage of tanning with chromium salts are getting rich with use in neutral salts, raised the issue of recovery of chromium from these waters, with his subsequent reuse. Chromium (III) salt are among the most familiar tanning agent. The chromium tanning method is the most common technique used with a share of 90% of skins, it involves using chromium salts. The chromium tanning is done in fleets where pickling was carried out at temperatures between 30^0C and 50^0C, stirring, for 10 to 25 hours, the duration of the tanning extends overnight , leaving skins at rest in the same fleet, while chrome continues to be absorbed. The pH in the fleet is between 3 to 3,6. The final pH of the fleet can have values between 3,4 to 4 being influenced by agents of basification: sodium carbonate, sodium bicarbonate.

4. REMOVAL OF CHROMIUM FROM WASTE WATERS

Eliminating or reducing the amount of chromium from waste water has been divided in different methods: precipitation tanning agent chromium from waste water, direct recycling waste water or partial replacement of chrome tanning agent with another material. The main methods of recovery of chromium from waste waters were:

- wastewater reuse from chrome tanning
- the use of waste water to dissolve the sodium dichromate in order to reduce its basic chromium salt
- the precipitation with chromium from wastewater in the form of chromium hydroxide solutions

In this paper we studied the method of recovery chromium through precipitation with calcium hydroxide. The liquid obtained is analyzed and stored and basicity is corrected with sodium carbonate before being used in tanning. Recovery efficiency is 98% and the effluent pollution load is practically zero. To remove the chromium salts from waste fleets resulted from the leather tanning process, in the first phase it causes the precipitation of these basic salts of chromium at 8,3 to 8,5 as chromium hydroxide. We use the precipitating agent for calcium hydroxide because calcium sulphate is insoluble in water and we can be reused.The calcium hydroxide has the role of adjusting the pH but is also a good coagulant and it is effectively technically and economically. In this case the use of polyelectrolyte with high molecular mass, for instance Praestol 2515. The Praestol solution added to the effluent in the required amount, will cause agglomeration of colloids and suspended solids Destabilization and coagulation of a very large number of simple particles lead to the formation of flocs, which are easily separated from suspension. It produces the phenomenon of coagulation and flocculation, decantation occurs in a secondary settling basin. From the settling secondary basin the purified water goes to the sewerage installation and the mud will go to the filter press where it can be used as fertilizer in agriculture.

5. CONCLUSIONS

For a less environmental impact, each tannery must be retrofitted or at least some parts of them. But few Romanian economic agents can afford such additional expenses.
For recycling and reusing organic waste there are currently many methods:

- fat can be recycled and used
- the waste non-tanned can produce gelatin and glue
- recovery of protein

- recovery of collagen

In the case of chromium recovery the result will be an active component that can be reused in leather tanning (reducing chromium) and in other industries (building, rubber, oil) simultaneous with ensuring recirculation of large quantities of water thanks to advanced purification. We can say that polyelectrolyte Praestol 2515 (the one used here) is the best, because a small amount is used for content Cr_2O_3 and the efficiency of removal of chromium oxide is high and forms a small volume of sludge. Physical and chemical analyses show that samples of wastewater from leather with the initial content $Cr_2O_3$of between 5,2 and 5,5 g/l , after treatmentby precipitation through calcium hydroxide solutionCr_2O_3content result between 0 and 25 mg/l mg/l.

Acknowledgment

This work was supported by a grant of the Romanian National Authority for Scientific Research CNCS – UEFISCDI, project ID PN-II-PT-PCCA-2013-4-1017, "Green Tannery – Methods for energetic recovery of biodegradable wastes"

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GREEN TANNERY – THE LEATHER PROCESSING UNIT

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ABSTRACT

The paper aims to present the concept of tannery wastes utilization in order to minimized the impact over the environment. Raw hide is turned into tanned leather by means of technological processes where chemical and biochemical operations alternate in an aqueous medium. Animals whose skin serves as raw material for the leather industry are not bred for their skin, but for meat, milk, wool, etc. except for animals with highly valuable fur that until recently have only been found in the wilderness.

1. INTRODUCTION

In the context of the current technological evolution of sustainable development of various industries and climatic change at global scale, the concept of green tannery as leather processing unit involves solving the problem of the processing efficiency and environmental pollution control, given that the leather industry affects all three environmental factors: water, air, soil. It is also known that only 25% of raw hide becomes a finished product and the remaining 75% is the solid waste from processing operations.

2. METHODOLOGY

Leather processing yields significant amounts of solid waste depending on the type of processed leather, their source or origin and applied technologies.

The types of waste resulting from technological operations are schematically presented below:

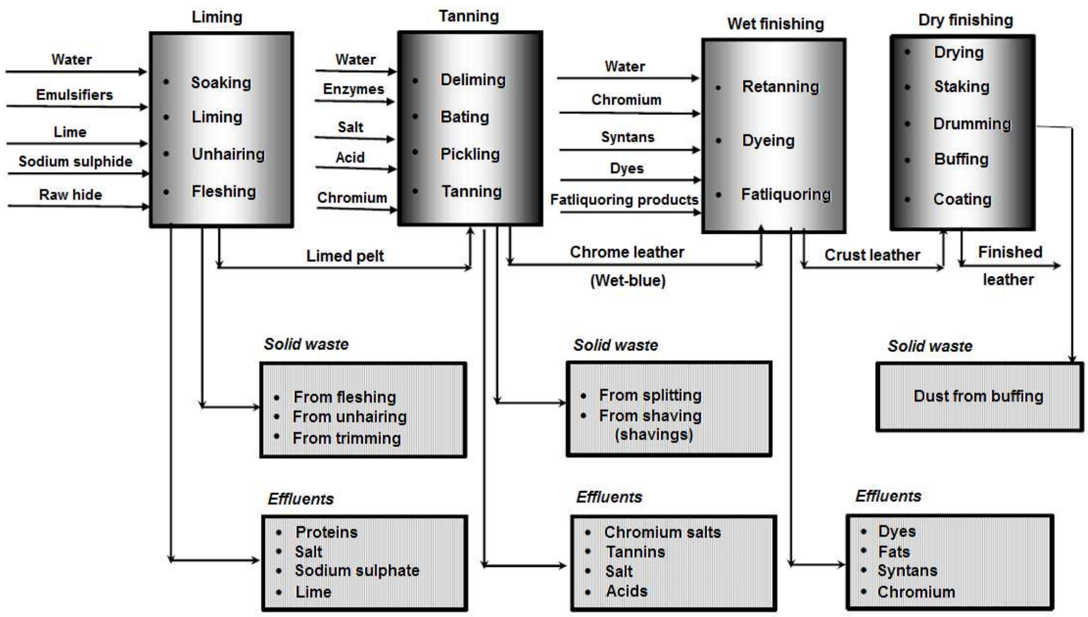

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Figure 1: Polluting waste resulting from various phases of cattle hide processing

The leather sector is an important source of materials for various industries and areas of activity, some of them considered top areas. Waste from the leather and leather goods industry may be recovered using several processing methods in various areas.

Given the existing leather availability at global scale, the amount of related waste can be easily inferred, reflecting the interest manifested by the waste processing and superior recovery industry.

Interests related to the possibility to recover leather waste have emerged since the 1970s, and have grown more intense with the change in legislation on environmental protection and emergence of econanotechnologies, leading to a quantitative reduction of waste and its pollution content. If we consider ecologic leather processing, the distribution of waste per processing phase is the following:

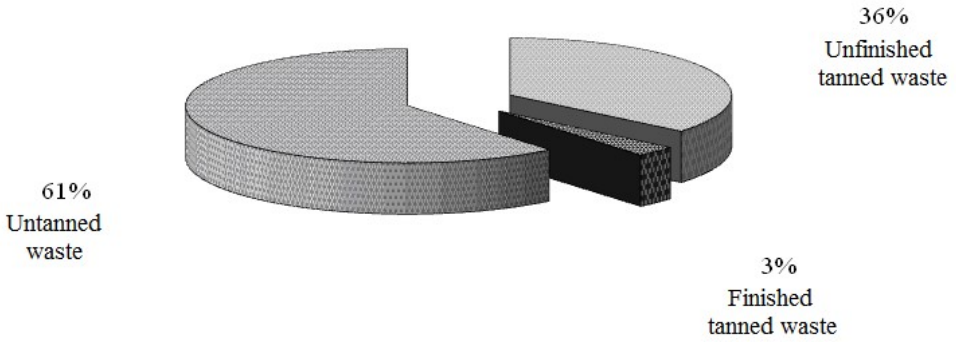

Figure 2: Distribution of waste per processing phase

Tannery production is closely related to the presence of a large amount of waste, particularly organic waste. Both organic waste and other residues may be largely prevented and reduced using the best available technical procedures in processing units. Recycling options are numerous and are carried out both on and off site. Recycling potential should be exploited by separating waste. Of equal importance is the commercialisation of waste as by-products and cooperation among tanneries so that recycling and reuse options would be economically feasible.

Table 1: Amounts of solid waste resulting from cattle hide processing

Waste type	Percentage of raw hide weight (%)
Raw hide trimmings	2 - 5
Lime fleshing	10 - 40
Limed splits	10 - 20
Chrome shavings	20 - 30
Chrome splits	
Chrome trimmings	
Buffing dust	0.2 – 1.0
Pigments and other chemicals	0.5
Sludge from wastewater treatment	40 - 50
Packaging	1.5

<u>Management of water used in the tannery</u>

The first step in the management of tannery wastewater involves optimisation of water consumption as well as reduced consumption of chemicals used in wastewater and waste treatment; this will implicitly lead to reduction of both wastewater treatment plant size and energy consumption. Although a decrease in water consumption does not reduce pollution loading, physical-chemical treatment of concentrated effluents is more effective. As a consequence, efficiency of water consumption leads to cost reduction. Efficiency of water use may be improved by: increased control of processing water volume; the use of low floats and an effective maintenance program that prevents ineffective use of water and involves a user-defined program, thorough training, clear communication, practice for operators, including information on cleaning cycles and basic technical equipment installation, such as relatively simple flow meters and valves.

The technique of low floats reduces water consumption, processing time, saves chemicals, due to a higher, efficient concentration and improves absorption of chemicals in leather. Low floats may be used, 40 – 80% float instead of 100 – 250% for certain process stages.

Combining washings and low floats saves up to 70% compared to a conventional process. A water consumption of approximately 12 – 25m^3/t (for cattle hides) may be obtained if the tannery has an effective technical control and good water management.

Techniques with particular importance in treating tannery effluents are:

- ✓ oxidation of effluents containing sulphide before mixing them with other effluents (particularly with acid effluents), as hydrogen sulphide may form at a pH lower than 9.5. Effluents containing sulphide must be mixed before total oxidation, in a closed tank, allowing for air extraction.
- ✓ Where chromium (III) is precipitated, the chromium-containing effluent is usually separated from other effluents. Precipitated chromium may be recovered and recycled. Where effluent separation is not possible, mixing them increases the efficiency of treatment as chromium tends to precipitate in the presence of protein during pre-treatment.
- ✓ Tanneries generate effluents that may differ significantly in terms of composition. To handle this high rate of fluctuation in volume and composition, treatment plants must be carefully monitored and constantly checked to optimise the efficiency of the treatment process, and a high retention capacity is recommended.

Up to 30-40% of suspended solids (including hair, non-emulsified fat) from the raw effluent may be removed by appropriate mechanical filtration. A preliminary decantation of the raw effluent may reduce COD up to 30%, decreasing the required amount of flocculation chemicals and reducing the amount of resulting sludge, in general.

After mechanical and physical-mechanical treatment, tannery effluent is generally easily biodegradable in biological treatment plants. Tannery effluent may be treated with or without the addition of water from other sources. It may be necessary to add small amounts of phosphate to maintain biological activity. Standard aerobic biological treatment stations are used routinely, their size and capacity depending on local conditions, for example inside or outside the tannery. Extended aeration is important in the case of tannery effluent.

The bacteria that reduce sulphates grow in anaerobic conditions. Measures to prevent the formation and release of hydrogen sulphide are required, either by treating released gas or by removal of sulphur compounds before anaerobic treatment. The anaerobic process results in less sludge than the aerobic one. For anaerobic treatment of effluent from liming, a COD reduction of 40-62% can be reported. The biological treatment combined with the physical-chemical one may reach a COD removal rate of up to 95%. Currently, biological treatment is employed without the physical-chemical one in certain treatment plants, as a measure of reducing the sludge produced in the process.

Most biological treatment plants use the "activated sludge" method (bio-aeration). It makes use of the metabolic activity of suspended microorganisms.

They convert (change) convertible biological content into carbon dioxide and activated sludge. Other substances, like metals, are adsorbed in the sludge. Oxidation occurs in continuously aerated tanks. A treatment time of 6-12 hours is generally sufficient. The energy consumed by a conventional activated sludge plant is about 1.08-1.8MJ per eliminated Kg of BOD. An extended, modified system for aeration / low activated sludge loading uses a longer retention time and provides greater protection against loading shock. A period of 1-3 days may be necessary, with an energy consumption higher than 3.6 MJ per eliminated Kg of BOD.

Sustainable techniques for reducing air emissions

- Odours

Odours may arise from decomposition of improperly preserved or stored hides, from the accumulation of waste, from wet technological processes (soaking ÷ tanning) and from wastewater treatment processes, carelessly or superficially controlled. Odours are not necessarily toxic but they are a problem and a cause for complaints from neighbours.
Besides the natural distinct smell of hides, bacteria that degrade organic matter may lead to the appearance of putrid odours. It is in the interest of tanners to prevent any degradation of the raw hide (capital invested in raw materials is high). Odours from raw hides can be effectively avoided by appropriate storage and preservation, and preventing the occurrence of odours from the accumulation of waste products, from wet operations or wastewater treatment plant can be avoided through strict control of these operations. Waste must be removed thoroughly, before their decomposition starts. Some toxic substances also release unpleasant odours such as hydrogen sulphide, ammonia, amines, aldehydes, ketones, alcohols or organic acids. These emissions are harmful and may require exhaustion. Emissions from different technological stages can be reduced by measures integrated into the technological process.

- Organic solvents

Because of limited applicability and effects of contaminated air extraction techniques, the best option for reducing VOC emissions is the use of water-based systems, and optimisation of techniques. Solvent removal techniques (exhaustion) are important for environmental protection, but they shift the problem from air to water and solid waste. Recovery of organic solvents must be a priority; it is actually the final solution of the problem. Recovery and reuse of organic solvents may be feasible only if a limited number of solvents are used.

Available techniques for VOC emission reduction:

- Wet washing is the standard technique for treating gaseous waste and it is especially effective in the case of dust and aerosols. Water-soluble solvents dissolve in washing water. Increasing use of finishing materials dispersible in water, based on glycols and alcohols, has led to a more efficient technique. Approximately 50% of solvents emitted can be removed by wet washing.
- Adsorption techniques using activated carbon, for example, are effective only if the concentration / volume of emissions is within a certain range and remains relatively stable while the adsorption unit is loaded. Activated carbon adsorption is the standard technique for eliminating halogenated hydrocarbons. Some organic solvents may be removed by desorption from the adsorbent material. After reaching the recycle limit, the adsorbent material should be disposed. In the case of halogenated hydrocarbons, activated carbon filters are the only method to reach the treatment parameters required by the legislation.
- Bio-filters can also be used. Besides removing odours, they can oxidize soluble organic solvents such as alcohols, ketones, esters and ethers. For safe operation, bio-filters require

careful control of process parameters. But they cannot be used at high concentrations of solvent.
- Incineration (catalytic or thermal) is a safe but expensive method for reduction / elimination of emissions of organic solvents and odours.

- Ammonia and hydrogen sulphide

Normally, the first measures to reduce emissions of ammonia and hydrogen sulphide consist of the ventilation system. Only if mitigation of emissions thus obtained is still not below the limits, will air treatment be required. Decreased concentration of these substances can be obtained through bio-filters, but it must be known that at high concentrations of these substances, filtering microorganisms are poisoned. In this case, a wet washing may precede or even replace bio-filtration. Wet washing of ammonia is performed using an acid solution, and of hydrogen sulphide with an alkaline solution, such as hydrogen peroxide or a mixture of hydroxide and sodium hypochlorite.

- Dust and other fine particles

Particulate matter may occur from mechanical operations, such as drumming, grinding or staking. Particulate matter evaluation parameters are concentration, chemical content and particle size. Particulate matter is removed to ensure safety in the workplace. Extracted air filtering is needed to protect the environment. After a good filtration, air can be recirculated to the workplace. For very good control of dust and to prevent accidental releases, the following considerations must be applied:

- ✓ Dust should be controlled at the source, for example a tannery uses soluble packaging for chemical powders;
- ✓ Operations and machines that produce dust should be grouped in the same area to facilitate collection.

3. CONCLUSIONS

The concept of green tannery as a leather processing unit involves the following objectives in the current context:

- ✓ The use of unpreserved or short-term preserved raw materials near the source to avoid or reduce salt pollution;
- ✓ Low water consumption in the technological process;
- ✓ Low energy consumption to reduce carbon dioxide emissions;
- ✓ Separation of wastewater flows to optimize water recycling and recovery;
- ✓ Air purification;
- ✓ Sludge with 0 chromium or heavy metal content;

The focus is on conducting activities in clusters to enable optimisation of operation (production, supply, research, ecology, waste recovery outsourcing) with an optimisation of costs and benefits to the environment and consumers.
All these objectives lead to a unique product, genuine leather, a useful product that allows an easy trade without major restrictions, obtained from a renewable natural raw material with the ability to reproduce through biological processes.

Acknowledgment

This work was supported by a grant of the Romanian National Authority for Scientific Research CNCS – UEFISCDI, project ID PN-II-PT-PCCA-2013-4-1017, "Green Tannery – Methods for energetic recovery of biodegradable wastes"

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CHARACTERISATION, MANAGEMENT AND RECOVERY OF TANNERY WASTE

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ABSTRACT

The paper aims to present the main waste used, processing methods used to separate valuable components and possibilities of recovering these components. Over the last decade, the leather industry has become a decisive factor due to its unprecedented remarkable development. Although it has made considerable progress in its relationship to the environment, the leather industry remains an aggressive pollution factor, due to protein waste, particularly those resulting from tanneries and footwear manufacturing companies.

1. INTRODUCTION

Anatomically, skin is a conjunctive-epithelial membranous sheath, and physiologically it may be seen as a real organ with multiple functions: protection, secretion, perception, etc.
In terms of histology, skin consists of a superficial epithelial layer called epidermis, a deeper conjunctive layer called dermis, an even deeper layer, the hypodermis or the subcutaneous adipose tissue that binds the tegument with existing tissue. These three layers differ by their degree of development, histological structure, chemical composition and physiological purposes. Animal skin undergoes processing consisting of over 70 chemical and mechanical operations in order to become leather. All these operations are more or less important in leather processing technology. Some of these deeply alter the nature of the hide, which is why they are considered main operations. These are: unhairing, tanning, fatliquoring, dyeing and finishing. Unhairing is the removal of animal hair or wool from the dermis, tanning makes the hide imputrescible, fatliquoring softens the leather and gives it a pleasant handle, dyeing provides colour to the semi-processed material, and finishing provides leather with functional and aesthetic properties..

2. METHODOLOGY

Part of the sustainable development of the leather industry is due to clean products, manufactured under environmental protection conditions and in harmony with the ecosystem.

Leather waste recovery is a necessity of clean, environmental technologies, as only 25% of the raw hide becomes a finished product.

Pollution resulting from tannery waste and finished leather product processing may be reduced in several ways:

- ✓ optimization and reduction of toxic chemicals up to replacement;
- ✓ finding alternatives to chromium tanning agents;
- ✓ recovering and recycling solid waste.

Untanned waste is a by-product consisting of hair, soluble protein and fat; this waste is commonly treated with sulphites and ammonium salts. As it is biodegradable, they are quickly processed or preserved. Waste treated with tanning agents contains 40% water, 45%

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tanned protein, 3% trivalent chromium and other mineral salts. Finished leather waste contains 15% water, 70% protein, 5% chromium, 8% fat derivatives, 2% organic or inorganic auxiliaries.

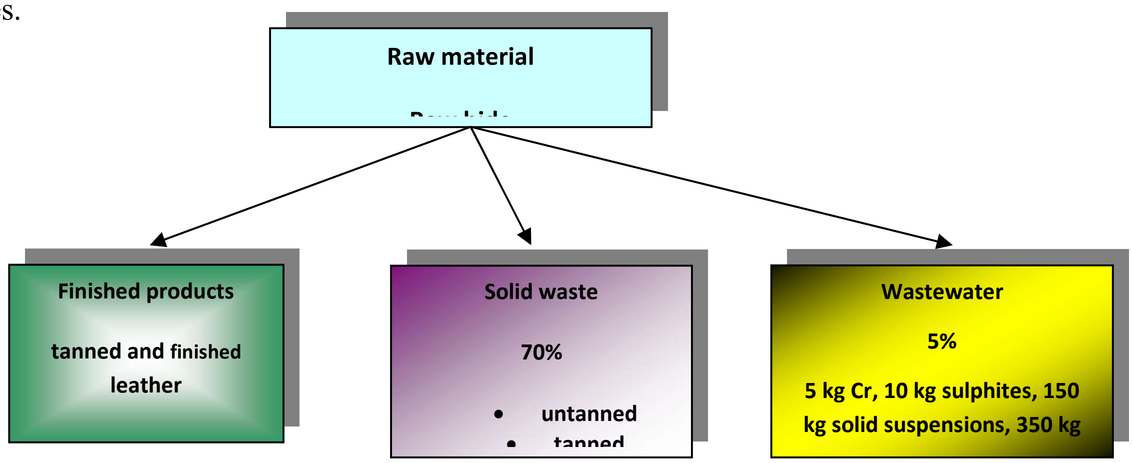

Figure 1 : Material balance in a tannery

Hide waste sources

Animal hide is used as raw material to obtain tanned leather in various assortments to make footwear uppers, soles, clothing, leather goods, upholstery, technical items etc. In addition to finished products, leather processing also results in a large amount of by-products that sometimes reach approx. 30% - 40% of raw hide weight. The initial form of the hide and technological operations for processing it into finished leather leads to loss of both constitutive proteins, by their solubilisation and discharge into wastewater, and solid by-products, waste those results in various phases of the manufacturing process. The highest amount of waste is that of material residues, resulting from leather processing, from preserved raw hide to cutting finished leather to manufacture goods. The leather processing industry yields many types of waste (approx. 25 – 30 types) with different physical and chemical characteristics, depending on:

Animal origin: cattle hide; pig skins; sheep-goat hide; game skins.Tanning method:

- ✓ mineral and vegetable tanned cattle leather;
- ✓ mineral and vegetable tanned pig skins;
- ✓ sheep-goat leather without fur;
- ✓ sheep-goat furskins;
- ✓ game furskins.

Processing phase: limed hides; tanned leather; finished and unfinished leather;

Waste from soft cattle hides

No.	**Material (waste)**	**Technological phase it results from**	**Form**	**Suppliers**
1.	Fleshing	Removal of subcutaneous layer of hide	Paste	Tanneries Fur processors
2	Trimmings	Pelt trimming	Small sized pelt scraps	Tanneries Fur processors
3	Chrome shavings	Equalization of hide thickness	Wet shavings	Tanneries Fur processors
4	Chrome trimmings	Trimming chrome leather and splits	Edges and small pieces of chrome leather	Tanneries Fur processors
5	Unfinished leather trimmings	Trimming dry leather and splits	Small-sized pieces	Tanneries Fur processors
6	Finished leather patches	Trimming finished leather	Pieces of different sizes and shapes	Tanneries Fur processors

Waste from hard cattle hides (leather for soles)

No.	Material (waste)	Technological phase it results from	Form	Suppliers
1	Fleshing	Removal of subcutaneous layer of pelt	Paste	Tanneries
2	Pelt trimmings	Pelt trimming	Pelt scraps	Tanneries
3	Vegetable trimmings and shavings	Tanned leather trimming	Vegetable tanned leather pieces	Tanneries
4	Dry leather trimmings	Final trimming	Small vegetable tanned leather pieces	Leather goods manufacturers

Waste from pig skin processing

No.	Material (waste)	Technological phase it results from	Form	Suppliers
1	Pre-fleshing	Removal of fat and flesh residues	Paste	Tanneries
2	Fleshing	Removal of subcutaneous layer	Paste	Tanneries
3	Chrome trimmings and shavings	Equalization of thickness and scraping the edge of chrome leather	Small hide pieces and wet shavings	Tanneries
4	Unfinished hide and split trimmings	Trimming edges of hides and splits	Pieces of small size and different shapes	Tanneries
5	Finished leather patches and trimmings	Finished leather trimming	Pieces of different sizes and shapes	Footwear and leather goods manufacturers

Waste from sheep and goat skins

No.	Material (waste)	Technological phase it results from	Form	Suppliers
1	Fleshing	Skin fleshing	Paste	Tanneries Fur processors
2	Chrome shavings	Equalization of hide thickness	Wet shavings	Tanneries Fur processors
3	Chrome trimmings	Trimming chrome skins	Edges and small pieces of chrome skins	Tanneries Fur processors
4	Unfinished skin trimmings	Trimming dry skins	Pieces of different sizes	Tanneries Fur processors

Waste from furskins

No.	Material (waste)	Technological phase it results from	Form	Suppliers
1	Trimmings and fur patches	Furskin trimming	Fur edges and pieces of different sizes	Tanneries Fur processors
2	Wool	Fur shearing	Short-stapled wool < 0.5 cm	Tanneries Fur processors
3	Lint and hair	Fur shearing	Short-stapled wool > 0.5 cm	Tanneries Fur processors

Waste from footwear and leather goods manufacturing

No.	Material (waste)	Technological phase it results from	Form	Suppliers
1	Soft leather scraps	Cutting pieces for footwear uppers	Irregular pieces with $S = 10\ dm^2$	Footwear and leather goods manufacturers
2	Hard leather scraps	Punching components for	Pieces of different	

		leather	sizes and shapes	
3	Waste from sole cutting	Punching pieces	Residues from cutting patterns	

Chemical composition of hide waste

Waste from raw hides has the same composition as that of animal hides. Preliminary leather processing operations alter this composition depending on the type of operation, therefore, after each processing stage; the resulting waste will have different chemical compositions.

Chemical composition of raw cattle hide

Class of components		**Protein components**	
Component	%	**Component**	%
Fat	1 – 10	**Keratin**	0,5 – 1
Water	60 – 65	**Albumin + globulin**	4 – 6
Protein	30 – 35	**Muscle protein**	< 1
Carbon hydrates	1	**Collagen**	90 – 95
Mucopolysaccharides	0,5 – 1	**Elastin**	2,5
		Reticulin	1 – 2
		Other categories	0,6

Depending on various hide selection criteria (breed, age, sex, nutrition, group, etc), the chemical composition of hides is highly varied, first of all given the relationship between protein, water and fats. Thus, for sheepskins, fat content reaches approx. 15-20%, while for pig skins, it may reach up to 30-35%. Collagen is of the highest economic interest in the waste recovery process, followed by keratins from sheep and goat, with a share of up to 10% of total protein. Also, mucopolysaccharides are of economic interest due to their exceptional properties. Muscle protein, elastin, reticulin and other categories of substances, found in much smaller amounts, have also drawn the attention of researchers. The general chemical composition of leather waste includes: water, fats, minerals, protein and small amounts of synthetic polymer used in retanning and/or finishing with coating films.

Strategic directions regarding recovery of waste from the leather and footwear industry

Technologies for untanned waste recovery to obtain soap, glue, auxiliaries for leather processing (pigment pastes and fatliquoring products), pharmaceutical and medicine products, are currently applied in manufacturing companies.

Waste from chrome cattle leather are mostly (70%) used in combination with defibred soft and hard leather waste to obtain artificial soles, a technology that is currently employed.

To completely and effectively recover solid waste from leather processing and manufacturing, the following are considered:

- ✓ extending existing capacities or building new production capacities to obtain artificial soles in or nearby large tanneries, to eliminate transport fees;
- ✓ finding new areas of recovering this waste, both by physical-mechanical processing (as construction materials or in mixtures with synthetic polymers used for various purposes), as well as by physical-chemical processing in order to obtain chemical auxiliaries;
- ✓ incineration, gasification and biomechanisation while recovering released heat from unrecovered waste is a more effective method in terms of environmental protection than landfill storage.

In Romania, problems created by large amounts of waste resulting from the leather and footwear industry are well known, but so are the possibilities of its reduction and reuse.

Given the high costs of treatment and recovery of this waste, so as to minimize its environmental impact, very few Romanian companies can afford investments or additional expenditure in this regard. It is known that all costs related to measures of environmental protection and health of workers are incurred by the company and are part and parcel of the technological process. Upgrading leather processing technologies in order to fall within the limit values of standardised emissions is an additional financial effort, which affects the economic efficiency of the process. Wishing to maintain efficiency parameters, companies cannot fully provide the required investment resources to comply with regulations in force in Romania and the EU. Therefore, financial incentives are necessary to promote investment in modern environmental protection systems. These incentives, given by means of certain facilities, not directly, may be:

- ✓ the possibility of deduction of costs related to investment in greening and human health protection (in the fiscal year when they were incurred) up to 5% of the turnover (this is the average amount of expenses for environmental protection and health in EU countries)
- ✓ elimination of duty for equipment for upgrading technologies that directly impact environmental protection and health
- ✓ granting government guarantees for companies participating in European projects on environmental issues
- ✓ delaying payment of taxes and dues to local and state budget for 1-3 years, in equivalent amounts invested in greening and health protection projects
- ✓ making a priority of financing projects developed within the national research and development institute, with the goal of creating an infrastructure for monitoring and evaluating environmental and health factors operating in the leather, footwear leather goods, rubber and plastics industries
- ✓ forcing companies to submit data on emissions to monitoring agents.

In the last years, companies have been searching for the most technically and economically viable solutions to apply nationally and internationally known and accepted methods and technologies as possibilities of waste recovery and reduction. The priority is setting up wastewater treatment plants.

A more intense collaboration with chemical industry companies is required to jointly recover useful components from the leather industry (obtaining glue, gelatin, fertilizers, biodiesel and biogas etc.). A future solution, already implemented in developed countries such as Italy, is that of setting up industrial parks that possess and jointly make use of wastewater treatment plants and pilot waste recovery plants. For the leather and footwear industry, pilot waste recovery plants, wastewater treatment plants and incinerators for unrecyclable waste may be set up in geographical areas where there are clusters of similar companies. Thus, investment costs are lower and easier to bear by companies.

4. CONCLUSIONS

The large amount and variety of waste from the leather and footwear industry imposes a technical, economic and environmental solution to the problem of its recovery. The current record of materials is superficial, and therefore a joint framework is required for all companies, addressing all problems in this area:

- ✓ waste management should be carried out by companies according to the material balance of the source process, for each type of waste
- ✓ data centralization and dialogue with other source factors of the economy are required for a good coordination of the disposal and recovery effort
- ✓ collection and storage (until recovery) must be carried out by a specialised company, preferably on relatively narrow geographical areas, so as not to augment the cost of waste

- ✓ introducing a computerised monitoring system that dynamically highlights sources, amounts, existing and implemented recovery technologies, recovered amounts per source, stored amounts available, as well as other useful information

In Romania there is interest in recovering waste resulting from processing various types of raw materials, among which leather industry waste plays an important part. Scientific and practical interest in this industrial area was generated by several causes:

- ✓ Reducing the amount of solid technological waste resulting from the leather and footwear industry;
- ✓ Leather, even as waste, is a valuable protein source for various areas: leather industry, automotive industry, agriculture, zootechnics, cosmetics, pharmacy, medicine, etc.
- ✓ As a result of research and achievements at national scale in the area of leather waste recovery, it was established that up to now the highest recovery rate is that of unfinished tanned leather waste mechanically wet processed as microfibrils embedded in synthetic polymers for artificial soles. The lowest recovery rate is that of tanned and finished leather waste resulting from manufacturing garments, leather goods and footwear because the extraction of active components from finished leather requires high energy consumption.

Acknowledgment

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ANAEROBIC DIGESTION OF TANNERIES WASTES

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ABSTRACT

Anaerobic digestion of solid wastes is a practical solution for reducing pollution and encouraging the energy recovering in the form of biogas. Another big advantage is are the residues that can be used to improve soils. Organic wastes products, such the ones from tanneries, contain a sufficient amount of nutrients necessary for the growth and metabolism of the anaerobic bacterias involved in the production of biogas. The process of digestion with production of biogas fermentation depends on the composition of the tannery waste products. Type of waste generated varies significantly in amount and composition. Degradation of secondary solid wastes from tanneries in anaerobic conditions was addressed with the aim of evaluating the digestion rate depending on the organic proportion, biogas yield, time inhibition process or the operational problems by evaluating also the feasibility widely. The studies were conducted at both laboratory and pilot scale.

1. INTRODUCTION

There are many types of wastes that come from leather factories, but two of them distinguish by the option to be used for energy production: animal fat and biogas resulted from wastewater treatment and sludge discharged. Large quantity and variety of waste from the leather footwear industry requires that the problem be resolved with their recovery technically, economically and environmentally.

The process of digestion for biogas production depends on the composition of raw materials and products of fermentation. Tannery wastes are animal products with a high nitrogen content, because their composition is dominated by protein peptides and amino acids.

The use of these products in the process of anaerobic digestion is limited due to high ammonia concentrations formed during the fermentation. The ammonia is derived from protein degradation in biological material by anaerobic metabolism of the bacterial cells and result in a change in intracellular pH, inhibiting specific enzymatic activity and increase the need for maintenance of cell energy. Therefore, a large amount of ammonia causes severe inhibition of anaerobic digestion, resulting in reduced productivity.

The experiments of solid wastes from tanneries digestion were carried out in a 75 litre pilot plant, which operates at a hydraulic residence time of 45 days and mesophilic temperature (37°... 38°C). The aim was to assess the feasibility of implementing this process in industrial units. The initiation of the process was done with thickened sludge from a wastewater treatment plant. In the process were monitored the following parameters: pH and temperature in the acidogenic and methanogenic reactors, sludge loading parameters COD, ammonia nitrogen, total nitrogen and phosphorus. Raw material used was made of leather scraps from which it was removed grease and hair.

The maximum rate of biogas production was of 22 litre/day and the biogas production was of 833 litre/kg of volatile substance loaded. The methane content in the biogas was approximately 63%. The average yield of biogas in the reactor was of 0.3 litre/day.

Chopping was done originally to 0.5 … 1.0 cm to 0.5 additional shredding.

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METHODOLOGY

Wastes were collected from a leather factory in Bucharest. The waste was analysed through standard methods, substrates were collected and frozen at -4°C before analysis and other experiments. The material chosen as a substrate for biogas production are solid leather scraps separated from fats and hair.

The substrate was graded less than 6 mm in diameter, using an electric chipper. To this material was added water as a diluent to keep the solids in suspension and to achieve the desired level of flow in the feed. Industrial alcohol and acetic acid was used as a substrate in varying proportions to maintain the C / N ratio and pH.

The material of predigesting was formed in the hydrolysis reactor and fermentation acidogenic by placing substrate base and acid in order to stabilize the pH to a value ≤ 4 and reactors methane was introduced activated sludge waste, thickened to 4 ... 6%. This sludge contains all types of anaerobic microorganisms, including methanogenic bacteria.

In the laboratory were determined the basic physical characteristics of the substrate, resulting in a dry matter content of 19% and 1.4% of mineral substance.

The purpose of developing appropriate technology for solid waste management in leather and tannery, anaerobic digestion has been studied using a pilot plant.

For feeding the digester was used an amount of 0.15 kg substrate/day in a volume of 1.5 l of water. The whole test was carried out at a temperature of 37±3 ° C for a period of 5 weeks. Daily were recorded data regarding variation of pH, temperature enclosures thermostats, temperature and CO_2 concentration in the environment and electricity consumption in order to maintain a constant temperature. Periodically the pH of the hydrolysis with phosphoric acid, acetic acid or hydrochloric acid was adjusted by adding carbon contribution of industrial ethyl alcohol in the first reactor methane. Samples were taken weekly from the reactor outlet to determine the concentrations of COD, ammonia nitrogen and phosphorus. The produced biogas determinations were made for measuring the concentration of CH_4, CO_2, CO, O_2 and H_2S, to determine the quality and efficiency of anaerobic digestion process.

The results of the experiments are shown in the following figures:

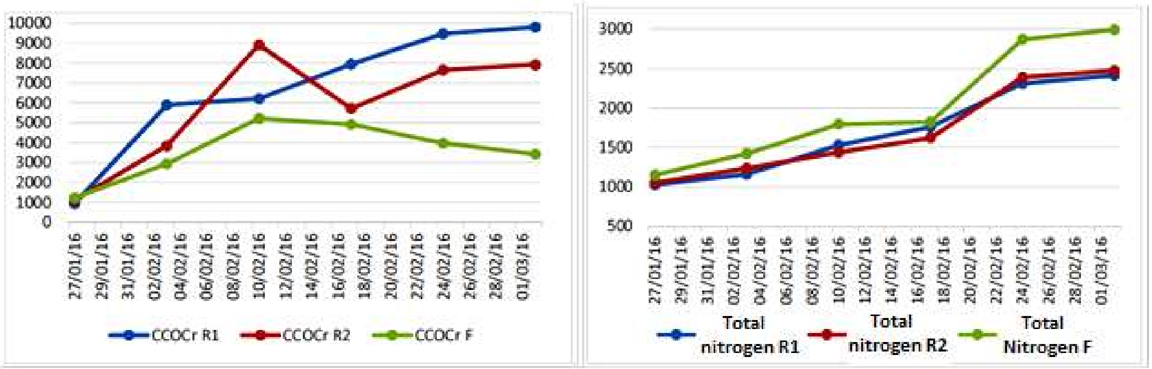

Figure 1: COD variation over time (mg/l) and Total nitrogen variation over time (mg/l)

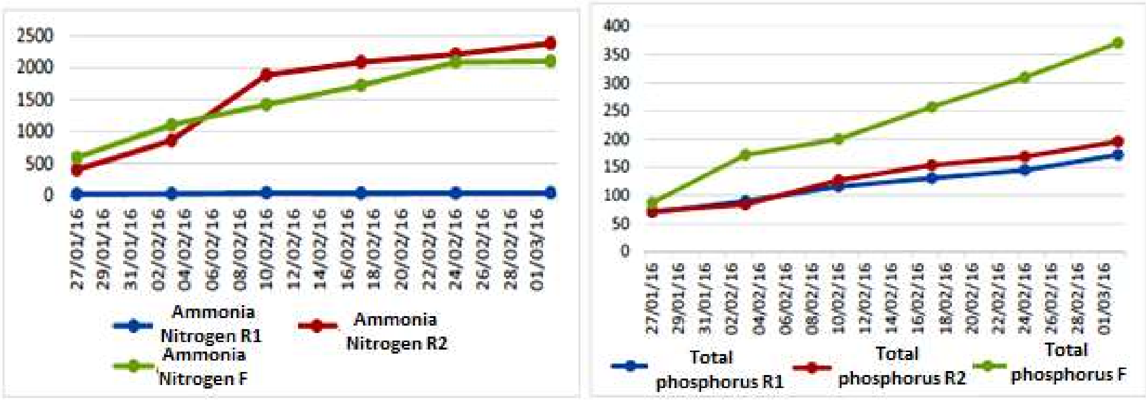

Figure 2: NH_4^+ variation over time (mg/l) and Total phosphorus variation over time (mg/l)

In Figure 1, it was represented variation of the concentration of dissolved organic substance chemical oxidant (COD) crossing the reactor 1 of reactorul2 and evacuation function of time. Time was found to increase in dissolved organic carbon in the reactor 1 by hydrolysing the raw material introduced partial reduction in reactor 2 and continue through the formation of biogas output. In Figure 1 there was also presented the variation in the concentration of total nitrogen (N_t) crossing the reactor 1 of reactorul2 and evacuation function of time. It was found to increase the accumulation of time.

In Figure 2 was presented the variation in the concentration of ammonia nitrogen (NH_4^+) in the transition from reactor 1 and reactor 2 from the exhaust function of time. It was found the formation of an anaerobic conversion of the total organic nitrogen, in a relatively constant concentration in the reactor 1, by the accumulation in reactors 2 and 3.

In Figure 2 there was also presented the variation in the concentration of total phosphorus crossing the reactor 1 of reactor 2 and evacuation function of time. It was found to increase the accumulation of time.

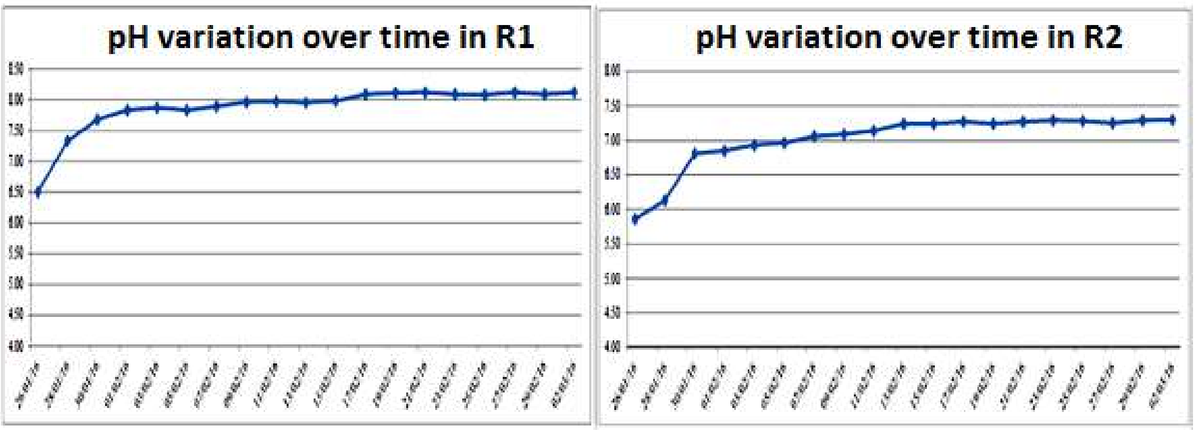

Figure 3: pH variation in methanogenic reactor 1 and reactor 2

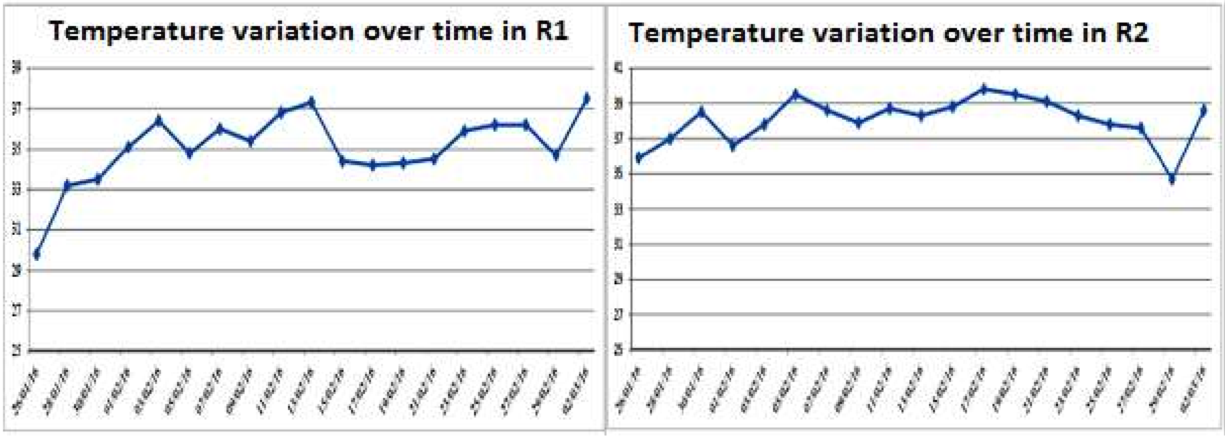

Figure 4: Temperature variation in methanogenic reactor 1 and reactor 2

By hydrolysing the raw material decomposes organic carbon, protein and phosphorus dissolved in passing as COD, total nitrogen and phosphorus. They are subsequently converted into biogas containing partially dominant methane CH_4 and carbon dioxide CO_2. Residues represent other compounds - ammonia nitrogen and phosphorous, and unassimilable in the digestion process unconverted organic carbon in methane.

It is noticed that after the first week of operation stabilizes the pH to slightly alkaline value between 7 and 8 without the need for chemical regulation. The temperature averaged 36°C in the first reactor methanogenic vs. 38ºC in the second methanogenic reactor. Although the temperature is lower in the first reactor methane biogas quantity was higher than in the second methanogenic reactor. In fact 70% by weight was generated in the first reactor.

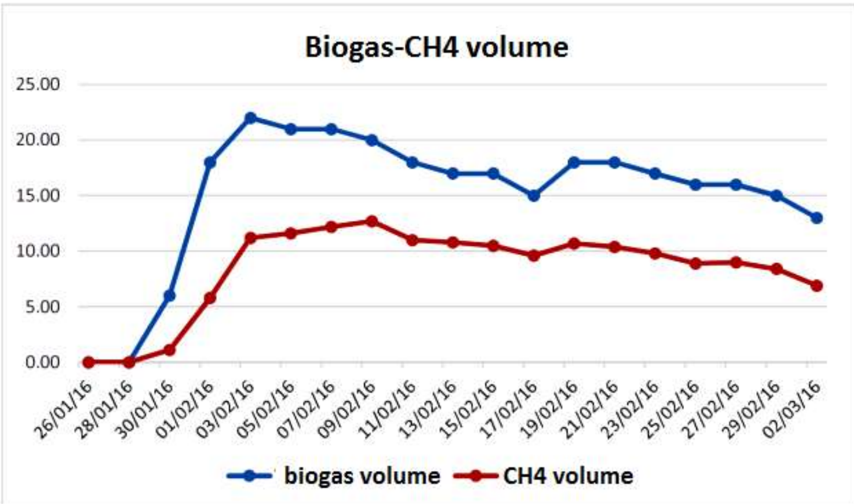

Figure 5: Biogas total variation (l/day)

After priming the process of anaerobic digestion biogas finds a peak in the first 10 days of operation, after which reveals a gradual decrease in the yield of biogas formation due to accumulation of ammonia nitrogen and phosphorus. These compounds are toxic to anaerobic microorganisms.

3. CONCLUSIONS

From the experimental results that the process of forming anaerobic digestion biogas using waste leather industry is feasible, the intended purpose of obtaining biogas with a high concentration of methane is practically possible. The experiments were conducted in the mesophilic for temperatures of 36 ... 38°C, an area where the pH was maintained in optimum operating area, 7.5 ... 8 without requiring corrections from the outside, except acidogenic reactor, where on average once a week was necessary to reduce the pH to 5-4.

Gradually reducing the efficiency of biogas production was due mainly ammonia products accumulation which gradually decreased C / N ratio of 5-2 or less at which the process was disrupted, especially methanogenic reactor 2. By adjusting process so that the ratio to keep or increase (by removing ammonia nitrogen) will be able to achieve a constant operation of the digester.

Acknowledgment

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MANAGEMENT OF CRITICAL INFRASTRUCTURE

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ABSTRACT

The paper presents the concept of critical infrastructure and a scatch of a risk analisys in water sector.

The growth as never in the history, in the last decades, of the risks, danger and threats to the vital objectives of the states and international organizations, together with the increase of their number and vulnerabilities lead to sedimentation and defining the new concept generically called critical infrastructure.

1. INTRODUCTION

The notion of critical infrastructure has been developed in recent years as a as a crucial element in the design framework for understanding and preventing new security threats, national and international.

Critical infrastructures are analyzed in primarily relation to national security, taking into account the impact these by a malfunction may have on the national economy and people's lives.

Considering the critical infrastructure as an area of national security has begun to have an increasingly acceptable level, being conceptualized and analyzed from the perspective of measures to ensure the security and resilience by more and more countries, especially the developed ones. Thus, critical infrastructures in Romania are defined as a system or part thereof located on national territory, which is essential for maintaining vital functions of society, health, safety, security, social welfare economic times of people and whose disruption or destruction would have a significant impact nationally as a result of the failure to maintain those functions.

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2. EUROPEAN APPROACH IN CRITICAL INFRASTRUCTURE

Members of the European area have started the process of resizing policy and finalizing the strategy on security and securing critical infrastructure especially after the dramatic events of 11 September 2001 in the United States, and of 11 March 2004 in Madrid and the 2005 to London.

Identification, optimization and security of critical infrastructures represents an unquestionable priority into managing of systems and processes.

By this reason, the quoted European Directive give a special attention for defining, identifying and its security.

The Directive considers that ICE owners/operators should be granted access, especially through specialized authorities from member states, to best practices and methodologies regarding the protection of critical infrastructures.

The EU's aim was to achieve a common policy on critical infrastructure protection. The primary responsibility for protecting and final European Critical Infrastructures (ECI) for the Member States and the owners / operators of such infrastructures. The Commission supports, through the competent authority of the Member State, the owners / operators ICE designated by ensuring their access to information on best practices and methods available, as well as support in terms of training and exchange of information on new technical developments in the field of critical infrastructure protection. In order to improve the protection of ECI, common methodologies may be developed for the identification and classification of risks, threats and vulnerabilities related infrastructure elements.

3. Critical Infrastructure Protection

Understanding the process of securing critical infrastructure requires knowledge of the concepts of **threat**, **vulnerability** and **risk**.

• Threat is defined by any action that can exploit a vulnerability, intentional or unintentional, which can damage or destroy the object reference. From the perspective of the critical infrastructure, threats represent capabilities, strategies, intentions, plans that enhances a threat to critical infrastructure, evidenced by attitudes, gestures, acts, acts that create unbalanced or unstable and generates state of danger, with impact on security national (national strategy for critical infrastructure protection).

• The vulnerability is defined by the impossibility of assurance, through project and effective accomplishment, by their own protection and also through the growth of scheduled pressures, direct or indirect, intentional or random over them.

• Risk **-** *"... Uncertainty that affects the possibility of achieving the objectives" (British Standards Institute (BSI), standard 6079-3/2000).*

4. A short example of a risk assessment

In our living world risk cannot be eliminated, but it can be controlled and reduced to acceptable levels. In order to handle and reduce the risks, we must know it and be aware of what influence it, so we can take the necessary measures to prevent and protect ourselves.

A risk analysis means significant threats scenario analyzing, for vulnerability evaluation and potential impact of perturbation or of critical infrastructures destruction.

An example of this is the scenarios for the dam failure by internal erosion.

The causes that may lead to the scenario are:

• Making the wrong foundation injections at depths below those foreseen for sealing veil;

• Failure dosage of cement binder-water slurry;

• Spacing between injection wells greater than that provided in the project;

• Failure to regular technical inspections and occasional;
• Failure program performance monitoring construction activity

Establish probability for risk factors as a critical infrastructure target in the water sector

For determining the probability was adopted following scale:

Table 1

Establish probability

Level/ Associate score	Probability determination	**Periods**
☐ 1 - Very low	It has a very low probability of happening. Normal measures are necessary to monitor the evolution of the event	More than 13 years
☑ 2 - Low	The event has a low probability of occurring. Further efforts to reduce the probability and / or impact mitigation.	10 – 12 years
☐ 3 - Medium	The event has a significant probability of happening. Significant efforts are needed to reduce the probability and / or impact mitigation.	7 – 9 years
☐ 4 - High	The event has a probability of happening. Priority efforts are needed to reduce the likelihood and mitigate the impact.	4 – 6 years
☐ 5 - Very high	The event is considered imminent. Immediate and extreme measures are needed to protect the lens to an alternate location evacuation / safe area where impact requires.	1– 3 years

Setting the severity of the consequences the proposed scenario.
Given the gravity of the consequences is the worst levels of vulnerability and impact.

Table 2

Vulnerability analysis

	Vulnerabilities	Level
1.	ICN placement in terms of road traffic or pedestrian areas	Very low Low Medium High Very high
2.	The recovery degree of injections regarding the recovery of the sealing veil	Very low Low Medium High Very high
3.	The degree of specialization of dam staff	Very low Low Medium High

		Very high
4.	Dam facilities with specialized equipment	Very low
		Low
		Medium
		High
		Very high
5.	Controlled access to the galleries, evacuated and technical spaces	Very low
		Low
		Medium
		High
		Very high
6.	The worn degree of the dam	Very low
		Low
		Medium
		High
		Very high
7.	The condition of the technological equipment and of the facilities	Very low
		Low
		Medium
		High
		Very high

Table 3

Calculating risk level

PROBABILITY	Very high 5					
	High 4					
	Medium 3					
	Low 2					**The dam failure**
	Very low 1					
	0	Very low 1	Low 2	Medium 3	High 4	Very high 5

Risk level calculated	Level	Score
	V. low	1-3
	Low	4-6
	Medium	7-12
	High	13-16
	V. high	17-25

GRAVITY CONSEQUENCES

Note: The risk is given by the product of the probability of a hazard / threat and severity of its consequences

Calculated Risk has **value 10** (Severity 5 x Probability 2) therefore there is a risk of producing medium chosen scenario. **The dam failure by internal erosion** seriousness of the consequences has "very high" (value 5) while the probability of the scenario chosen is "Low" (value 2).

To reduce the risk reduction measures to be taken following vulnerabilities:

Table 4

Measures to reduce the risk

Vulnerability	**Proposed measures**
The degree of recovery in the recovery injections sealing veil	- drilling into the sealing veil of the dam to verify its integrity
	- the design of new injections for the sealing veil
	- the execution of injections to restore the sealing veil
Dam facilities with specialized equipment	- verification of existent equipment and it's degree of severe disrepair
	- installation of reliable and resistant to corrosive media
Condition of technological equipment	- verification of equipment condition and technological system condition - new equipment and technological systems setting

CONCLUSIONS

Critical infrastructures contributes to supporting fundamental strategic components of national security and requires adequate protection.

Considering products and services vital that critical infrastructures are offering to support the normal functioning of society, the protection of critical infrastructure becomes an integral part of the mechanism of national security and a means of potentiating the capacity of government line ensuring necessary conditions development.

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INTEGRATED DRYING, PELLETISING AND INCINERATION TECHNOLOGY FOR SEWAGE SLUDGE TREATMENT

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Abstract:

The continuous degradation of the environment caused by the increasing anthropogenic pressures raised some issues as headlines for public agenda all around the world: ozone depletion, greenhouse effect, land use and scarcity of raw materials, acidification, eutrophication, summer smog, winter smog, heavy metals, carcinogenic substances, waste, respiratory effects, ionising radiation, eco-toxic substances. The current global environmental challenges drive societies to implement new sustainable ways of using resources and managing waste. Treatment and disposal of the sewage sludge represent a growing problem world-wide since sludge production will continue to increase the following years. The current challenge for the WWTPs managers is to find cost-effective and innovative techniques and solutions while addressing the environmental, regulatory and public concerns.

1. INTRODUCTION

Sewage sludge is a product of municipal waste water treatment. Although, sludge treatment issues are often neglected in comparison with water-related parameters - such as the outgoing load and the degree of removal of different waste water compounds – the sludge resulted after the water treatment process represents a potential threat for the environment.

The Romanian National Policy for Sewage Sludge Management, states that our country faces a fourfold increase in sewage sludge in the following decade. [1] Currently, most of the sludge produced by the Romanian wastewater sector is disposed by landfilling or applied directly to agricultural land, but considering the fact that sewage sludge represents a source of energy and nutrients, it is possible to utilise it as raw material for industrial processes and energy production.

According to EU negotiations, by December 31, 2018, Romania has the obligation to enter into full compliance with EC Directive 91/271/ EEC. All cities with more than 2000 inhabitants should be served by wastewater treatment plants and so the sludge production will increase.

The available data on the current situation regarding the sludge management in our country are synthesized in the National Wastewater Sludge Management Plan. There is a general lack of sludge treatment facilities; where treatment facilities do exist they are generally combined with sewage treatment. Often sludge is simply dumped into an existing wastewater treatment plant, which may negatively impact on the treatment of the waterborne sewage.

Recycling and use of the sludge in order to eliminate it, but also to recover energy are the preferred options for sustainable development, rather than incineration or landfilling. This

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study presents, a treatment scenario for sewage sludge using integrated drying, pelletizing and incineration techniques.

Sludge incineration is considered nowadays as the most radical solution for neutralising the pollutants from the sludge, allowing in the same time energy recovery and mineral substances recovery or storage. In principle, sludge incinerations enables the possibility to reduce the sludge volume that could be stored in the landfills, destruction of the pathogenic loads and last but not least, sludge incineration permits the neutralizing of toxic organic compounds that do not allow agricultural use or recovery processes of useful substances .

At the same time, the combustion processes may be considered as an emission source for the different pollutants, including the most dangerous dioxins, but also dust, NOx, SOx. For this reasons there are investigations for developing alternative technologies as gasification, wet oxidation, plasma pyrolysis and others that are in different stages of development. [3]

For a practical evaluation of such principles, an international research team has been involved in a package of activities under the project "The development of innovative solutions for products and services that could contribute to the competitivity enhancement of the companies associated in the Medgreen Cluster", that was financed under POS-CCE, Priority Axis I, "An innovative and eco-efficient manufacturing system", Main field D1.3, "Sustainable development of entrepreneurship", Operation "Support for the integration of companies in value chains and clusters", co-financed by European Fond for Regional Development.

2. METHODOLOGY

Wastewater sludge can be submitted to a drying process in order to minimize its mass and to save the disposal costs. Handling and storage of dried sludge is easy and all further disposal and utilization methods are possible. The dried product can be used as fertilizer and as well as fuel - its caloric value is similar to that of brown coal. During thermal sludge drying almost all water is evaporated, including surface, capillary and cell water, but this can only be done with an important amount of heat. A great portion of the drying heat is recovered from the exhaust and re-circulated systems. After an appropriate pre-treatment, the solid content of the sewage sludge is between 60 and 95%.

The drying-pelletizing-incinerating technology involves in the first stage of the processing an advanced drying of the sludge to a low water content (10 -20 %). After the sludge is brought to a low water content, using the proper technology, it can be pelletized in order to make the incineration process suitable for small and medium size pellet boilers. The next step is the thermal energy generation by incinerating the pellets in boilers and the energy recovery using appropriate conversion methods. For the thermal process, there are taken into account three technologies that can be custom-tailored for each type of application: belt dryers – for small to medium evaporation capacities, fluidized bed dryers – for medium to large evaporation capacities and drum dryers (the dried sludge obtained from this technology can also be used for agricultural application as fertilizer).

Dewatered sludge is processed further by pelletizing it. The heat resulted during the pelletizing process dries the sludge to a water content of about 5%, also slightly reducing its volume. The resulting product can be stored and distributed as a fertilizer or as a solid fuel. Pellets are a highly marketable product and have a low enough water content to be easy to transport. Figure 1 presents a concept of an integrated sludge drying – pelletizing – incineration technology.

Heat drying and pelletizing technologies solve most of problems associated with the beneficial reuse of sludge: there is a minimal volume of sludge product, the processing odors are easily contained for treatment, there is a little land area required for processing site and the product is easier accepted by the end-users. For pelletized sludge to meet the highest standards, the moisture content of the pellets must be 10% or lower. [4].

The incineration of the sludge pellets can be done in several ways: mono-combustion, co-combustion or other alternative processes, using different systems – fluidized bed and smelting furnaces for the mono-incineration, co-combustion with wood pellets or coal combustors, as well as co-incineration with municipal solid wastes in various furnaces.

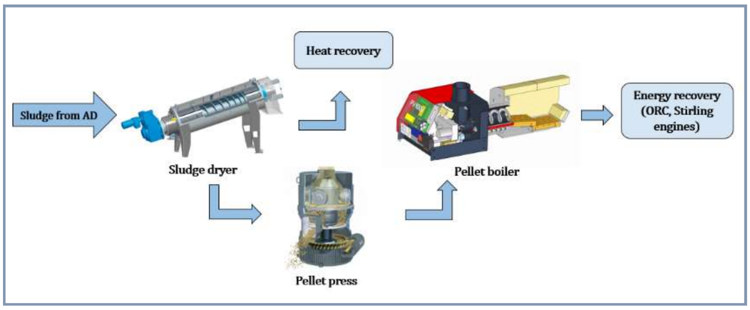


Figure 1. Integrated sludge drying – pelletizing – incineration technology

There have been numerous research activities carried out for setting the optimal parameters for the pelletizing of sludge. (Figure 2) The best results have been obtained for a humidity of 12-14%. There were also tested the humidity and the ash quantity resulted after the incineration process.

Figure 2. Drying sludge and turning it into pellets

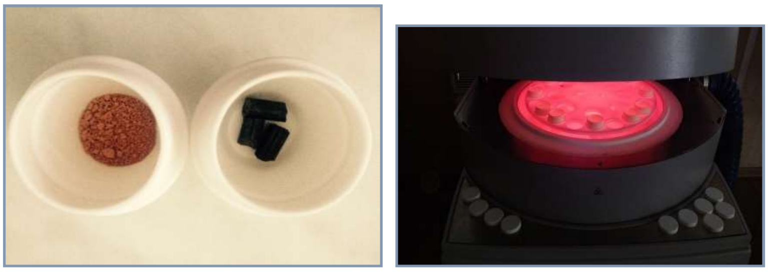
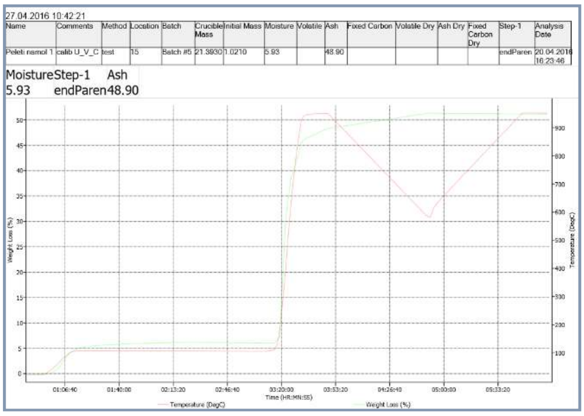


Figure 3. Analysing humidity and ash content for pellets sludge using Leco TGA701

The test regarding the pellets characteristics were conducted for two sludge pellets sample, using a LECO thermogravimeter TGA701, that allows us to determine mass loss as total moisture ash, volatile content, loss-on-ignition in various samples. The TGA701, can operate in a selectable atmosphere: N_2, O_2 or air, allows simultaneous sample analysis (up to 19 samples), at a temperature up to 1000°C.

Figure 4 and figure 5 show the variation of the samples weight with the temperature increase, the ash content and the samples' water content. After incineration the total volume of the samples, decreases up to almost 50% - a very important outcome, taking into account the fact that experts estimate the quantity of sludge resulted from WWTP will increase in the following decade.



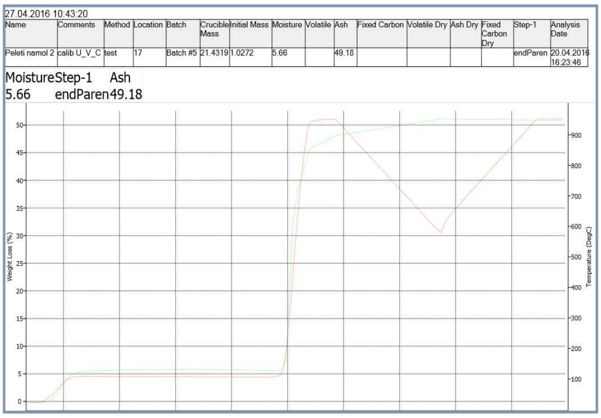


Figure 4. Sample 1. Material weight loss as a function of temperatureFigure 5. Sample 2. Material weight loss as a function of temperature

3. CONCLUSIONS

The research activities conducted have shown that incineration is not an easy process, due to the high content of water that has to be released and the low combustion characteristics of the sludge. The drying technology represents a key factor, from an economical point of view, considering the fact that a fast process requires a high level of energy consumption. However, taking into account that after combustion, the sludge volume reduction can reach an average of almost 50%, this can be presented as one as the main advantages of incinerating wastewater sludge. Also, if the energy content of the sludge is considered, in order to reach sustainability from an economical point of view, this can also be considered a good argument for the technology, although the energy recovery process is a very complex one, with many factors to be taken into account for further research activities.

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THE COMBUSTION CHARACTERISTICS OF THE BIOGAS OBTAINED BY ANAEROBIC DIGESTION OF PROTEINS FROM LEATHER INDUSTRY

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ABSTRACT

This research involves to project a biogas installation obtained by anaerobic digestion. Anaerobic digestion (AD) used represents a biochemical process, during which the organic matter type protein is decomposed by various kinds of microorganisms in the absence of oxygen. The efficient operation of a process of anaerobic digestion is to use a continuous process reactor with continuous extraction of the digested effluents, followed by the addition of the same amount of fresh substrates.

1. INTRODUCTION

Anaerobic digestion (AD) used represents a biochemical process, during which the organic matter type protein is decomposed by various kinds of microorganisms in the absence of oxygen. There was thus obtained the biogas, which is a mixture of methane, water vapor and hydrogen sulphide, the remainder being carbon dioxide.

There are two possible modes of temperature to which the anaerobic digestion process can be operated: mesophilic regime (around 37°C) and thermophilic regime (around 55°C), but thermophilic operation offers several advantages in the processing of waste from tanneries [1]. The rate of degradation of organic matter is significantly faster in this case, requires a retention time of about half of the necessary for mesophile operation; therefore digestion vessel volume required is approximately two times lower, resulting in lower investment costs. Thermophilic operating conditions, also ensures a higher degree of ecology.

2. ANAEROBIC BIOGAS PRODUCTION PLANT

The efficient operation of a process of anaerobic digestion is to use a continuous process reactor with continuous extraction of the digested effluents, followed by the addition of the same amount of fresh substrates. AMS (Aerated Mobile Support) is a medium retaining biofluid microorganisms that cause biodegradation of waste water [2].

AMS biofilm carrier elements are small pieces of circular shape with regular extrusion cross-shaped center for better strength and fine wrincles on the outside. These parts are made of special plastic material with a density close to that of water. This enables AMS to float freely "between the waters". Introduction of aerated mobile support (AMS) is a solution that ultimately lead to increased energy efficiency of the installation.

It is necessary to install in series the following reactors: hydrolysis reactor, the reactor acidogenic and methanogenic reactor.

The reactors are placed in a temperature-controlled bath, thermal insulation, with 1.2 m x 0.5m dimensions. The acidity, characterized by pH indicator, is maintained at 4.7 to 7.2 in acetogenic reactor to 7.2 in methanogenic reactor through the dosing solution of hydrochloric acid and sodium hydroxide from the solution tanks, according to the indications of the pH sensor. Linking is accomplished by a programmable automaton.

For an average composition can be considered: CH_4 = 50-60%; CO_2 = 30-42%; H_2S = 1-2%, H_2 = 1-2%. Average calorific value will be $20{,}080\, kJ/m_N^3$.

The plant for biogas production performed has the role of research and a production of around 20 l / day. The gas obtained was stored on determining power characteristics.

3. CHARACTERISTICS OF BIOGAS COMBUSTION

The combustion rate is a maximum in the right stoichiometric concentration of air, and tends to zero at low concentrations and high, respectively. Table 1 shows the influence of fuel gas concentration on the normal rate combustion for the biogas components [3].

Table 1

Normal rate of combustion

Characteristic	Gas fuel		
	H_2	CO	CH_4
Stoichiometric concentration x_{st} [%]	29,5	29,5	9,5
Normal rate of flame at x_{st} [m/s]	16	3	2,8
Concentration in the mixture with air for maximum combustion speed $\left(S_u^{max}\right)$, [m/s]	42	43	10,5
Maximum speed of flame propagation $\left(S_u^{max}\right)$, [m/s]	26,7	4,2	3,7
Fuel concentration in the mixture with air for $\left(S_u^{max}\right)$, [%]	38,5	45	9,8

In the case of burning a mixture of fuel gas, the normal combustion rate is determined by the equation:

$$S_u = \frac{\sum r_i S_{ui}}{\sum r_i} \quad [m/s] \qquad (1)$$

Where r_i are volume participations of gaseous components in the mixture are and S_{ui} are speeds and normal rates combustion of *i* components.

The presence of N_2 and CO_2 inert gases leads to reduced the combustion rate. This reduction is presented analytically by relationship:

$$S'_u = S_u\left(1-0{,}01\ N_2 - 0{,}012\ CO_2\right) \quad [m/s] \qquad (2)$$

In which N_2 and CO_2 represents the gas concentrations in volume percent.

For an average composition of the biogas, the combustion rate will be:

CH_4 = 58%, CO_2 = 39%, H_2 = 2%, CO = 1%,

$$S'_u = \frac{58\cdot 3{,}7 + 2\cdot 26{,}7 + 1\cdot 4{,}2}{(58+2+1)}\left(1-0{,}012\cdot 39\right) = 2{,}08\, m/s$$

The massive presence of the CO_2 as inert gas, significantly reduced the normal combustion rate, from the 3.7 m / s value to 2.08 m / s for CH_4 (dominant gas). This rate will be used in the construction of the burners, by considering the Wobbe number:

$$\left(W_0 = Q_i^{um}\cdot\sqrt{\frac{\Delta p}{\rho}} \right), \qquad (3)$$

Where Q_i^{um} is the calorific value of the fuel gas and ρ its the density.

To the turbulent rate combustion the relationship Williams - Bollinger will become:

$$S'_t = 0{,}000167\cdot S'_u \cdot d^{0,256}\,\mathrm{Re}^{0,238},\ m/s \qquad (4)$$

The linear dependence between the turbulent burning velocity and the normal rate, it is noted. So that, for a burner with the nozzle d in m, the sizing relationship will becomes:

$$S_t' = 0{,}00035\, d^{0{,}256}\, \mathrm{Re}^{0{,}238},\ m/s \tag{5}$$

If notes u_m speed in jet axis, the stability condition flame in turbulent flow regime, will be:

$$u_m < S_t',\ m/s \tag{6}$$

The relationship allows the determination of the burner nozzle diameter d, depending on the initial velocity of the air:

$$\left(u_m = 0{,}96 u_0 / \left(\frac{2a \cdot x}{d} + 0{,}29 \right) \right) \tag{7}$$

Where x is the length along the axis of the flow.

Table 2 shows the upper x_l^s and lower x_l^i limit values of concentration which is no longer possible the propagation of the flame front [4].

Table 2 **Limit concentration of flame propagation**

Gas fuel	$x_l^i, [\%]$	$x_l^s, [\%]$
Hydrogen	4,1	74
Carbon monoxide	12,5	74
Methane	5,3	13,9
Ethane	3,1	12,5
Propane	2,4	9,5
Butane	1,7	8,4
Ethylene	3,0	28,6

If a combustible gas mixture of n with r volume of participation, lower and upper limits of concentration of the existence of flame spread are given by relationship:

$$\lambda_l^{i,s} = \frac{\sum_l^n r_n}{\sum_l^n \frac{r_n}{\left(x_l^{i,s}\right)n}} \quad [\%] \tag{8}$$

If in the mixture are inert gases, this requires a combination between each one inert components and combustibile one. Applying relationship for calculating limits flame propagation for the biogas average composition, resulted:

$x_l^i = 15{,}9\%$, $S_l^s = 42{,}85\%$.

The influence of combustion temperature, T_f, is given by:

$$S_u^2 / a = \left(\frac{T}{T_{fl}} \right)^5 \cdot k_0 \cdot 5{,}35 \cdot 10^{-2} \cdot e^{-1{,}5 \cdot E / \left(R \cdot T_f\right)} \tag{9}$$

In which: $a = \frac{\lambda}{\rho \cdot c_p}$.

Kinetic combustion relations are as follows:

$$\frac{dC}{d\tau} = 2{,}137 \cdot 10^{14} C_{H_2} \cdot e^{-130/(RT)}$$
$$\frac{dC}{d\tau} = 7{,}05 \cdot 10^{6} C_{CO} \cdot e^{-96{,}4/(RT)} \qquad (10)$$
$$\frac{dC}{d\tau} = 5{,}6 \cdot 10^{12} C_{CH_4} \cdot e^{-100/(RT)}$$

Where R is the constant gas, expressed $kJ/(mol \cdot K)$.

4. CONCLUSIONS

- An average composition of biogas can be considered: CH_4 = 50-60%; CO_2 = 30-42%; H_2S = 1-2%, H_2 = 1-2%. Average calorific value will be $20{,}080\, kJ/m_N^3$.
- The massive presence of the CO_2 as inert gas, significantly reduced the normal combustion rate, from the 3.7 m / s value to 2.08 m / s for CH_4 (dominant gas).
- By analyzing the characteristics of the flame for the average biogas composition it resulted the possibility to successful use of the types of burners and furnaces for natural gas.

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BIOGAS MODERN TECHNOLOGY BY USING BIODEGRADABLE WASTE FROM TANNERIES

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ABSTRACT

In this paper was pursued the energy recovery by biogas production obtained through decomposing the waste from leather industry. Applied technology is a multi-phase anaerobic digestion process, characterized by a C/N ratio under 5. We used two-phase anaerobic digestion - acidogenic and methanogenic because acidogenic and methanogenic microorganisms present different growth rates and pH range 4.0-6.0 and 6.5-8.0 respectively. Phase separation allows optimization of hydraulic retention time and organic loading rate. For this a pilot plant was build and which is formed of three digesters were hydrolysis processes and methanogenesis, as well as acidogenesis are being conducted

1. INTRODUCTION

Leather industry produces large quantities of organic waste in the form of fleshing, trimmings, cuttings and chips from hides and mud as a result of sewage treatment. Biodegradation of organic waste emit greenhouse gases, especially methane and nitrous oxide. In addition, potential smell and land contamination issues. Adoption of eco-technology recycling of this waste is a necessity for the tannery industry. The technology is adopted by anaerobic digestion waste treatment in aqueous medium with obtaining biogas.

Before introducing the wastes into the process a fluidization of the materials must be assured by water addition, crushing and homogenization, before pumping into the facility. For hydrolysis, wastes are cut to 2-5 mm (to improve digestibility matter) in a shredding machine, mixed with water in a ratio of 1 to 10 and placed in a digestion reactor acidogenic to accelerate the decomposition process.

Anaerobic digestion is a biochemical process during which complex organic matter is decomposed by various kinds of microorganisms in the absence of oxygen. By carrying out these processes in controlled conditions, the organic material is stabilized in the form of sludge fermentation and is produced biogas, which is a mixture of methane (50 ... 65%), water vapour (5%), hydrogen sulphide (up to 1%) and carbon dioxide.

The process is conditioned by ensuring an optimal environment for the development of methanogenic microorganisms. This requires a neutral pH, a constant temperature and homogenization of content digester. There are two possible arrangements of temperature in the process of anaerobic digestion that can be carried out: mesophilic, about 37°C and thermophilic, about 55°C. Although the efficiency of degradation substrates is similar at both temperatures, functioning thermophilic offers the advantage of high rates of degradation of organic matter, requiring a retention time of about 15 days, half of that necessary to discharge mesophilic, so volume and digests needed is twice lower, resulting in lower investment costs. Thermophilic conditions also ensure the health of the waste. On the other hand, thermophilic operating conditions are less robust and more sensitive to variations in operating conditions. Fluctuations in temperature and increased levels of ammonia have a negative effect on the rate of methane production. High temperatures require additional energy consumption.

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2. METHODOLOGY

When designing the plant was taken into account the technology with two-phase anaerobic digestion, acidogeic and methanogenic microorganisms present as different growth rates and optimum pH (range 4.0 - 6.0 and 6.5 - 8.0 respectively). This technology stabilizes the operation and ensure precise control of phases.

It follows a multistage anaerobic treatment plant configuration, as shown below, in which are contained hydrolysis reactor acetogenic, methanogenic reactor 1 and reactor methanogenic 2.

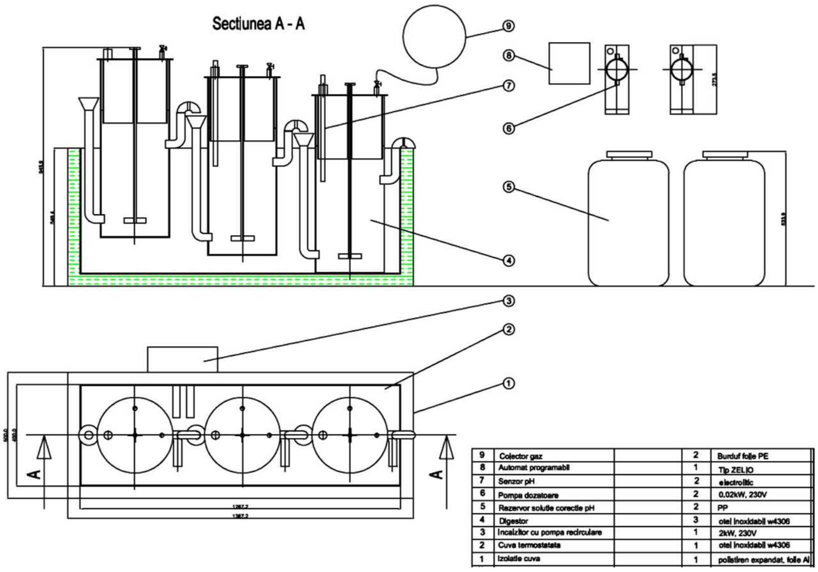

Figure 2 : Multiphase anaerobic digester

From Figure 1, for practical reasons, we introduced the reactors in a thermostatic bath, isolated dimensions 1.2m x 0.5m. The internal environment is maintained at a pH in reactor 4 ... 5 ... 8.0 7.0 acidogenic and methanogenic reactors, by dosing hydrochloric acid and sodium hydroxide solution, the choice of the pH sensor, if necessary. The correlation is performed by the PLC. Results of fermentation gases are collected in plastic inflatable balloons. Subsequently these gases will be analysed in the laboratory for determination of CH_4, CO_2, H_2S, O_2, H_2, N_2.

The installation is composed of a bowl (1) made of stainless steel insulated and thermostated, which are placed in reactors (4), (5) and (6) of stainless steel, fitted with bell shaped covers for biogas collection. Reactor (4) is acidogenic and methanogenic reactors (5) and (6).

The temperature is provided and maintained by hot water produced by the boiler (3) and recirculating pump (2). The reactors are equipped with vertical mixing system and sensors for pH and temperature (15) and (16). The stabilization process is performed with the programmer (14) which controls the dosing control solutions pH (9) and (10) of the metering pumps.

To simplify installation reactors are identical but for the hydrolysis speed is double the speed of decomposition of methane were provided two reactors at a methanogenic reactor acidogenic. The mixture introduced into the first reactor by cascade effect determines reaction compounds evacuation, after reactor (6), resulting final residue.

The conventional mode of operation of an anaerobic digester is to use one anaerobic reactor in which a quantity of fresh material extraction followed by digested effluent. This occurs several times a day. There is a maximum organic loading rate at which the process is still operating in a stable manner; Biodegradable waste from tannery rate is between 3.5 and 4.0 kg org / m^3zi. However, the organic loading rate is not the only criteria for determining the volume of the digestion reactor. Decreases with the decrease in retention time, which decreases the removal of organic matter and, consequently, yield of methane. Ideally, a tank for digestion should be powered at regular intervals seven days a week in a buffer tank.

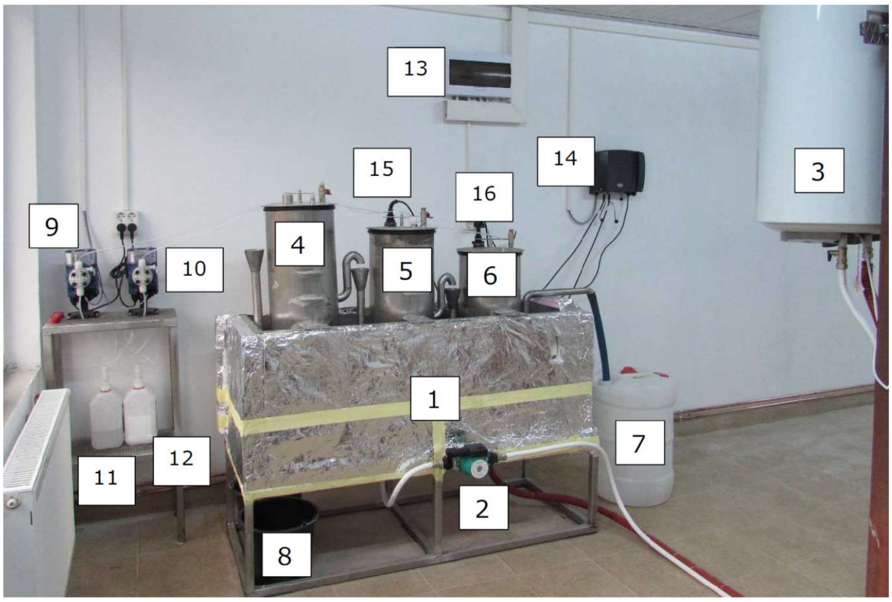

Figure 3: Pilot installation

As an alternative to the conventional system there is a batch process of anaerobic digestion, the digester can be fed directly to waste, thereby eliminating the need for a buffer tank. This process increases the yield of methane.

The plant project is based on a technology with a multi-phase anaerobic digestion process with discontinuous power, without circulation. This solution was adopted to separate phases acidogenic and methanogenic and more effective control of pH and temperature. Phase two methane digesters were provided to adjust during decomposition of methane compared with acidogenic phase and increase the yield of conversion into biogas.

The residues of tannery used in plant anaerobic are characterized by a C/N less than 5, so that the process requires a step of adjusting the anaerobic microorganisms due to high concentrations of ammonia (NH_4^+ / NH_3) over 1100 mg/l. The process by breaking down organic matter into methane, carbon dioxide and ammonia byproducts, reduce organic carbon (BOD) and increases the concentration of ammonia in the mixture produced in the reactor, further reducing the C / N ratio.

The ammonia is derived from biological degradation of protein material in an anaerobic environment. The ammonia absorbed in bacterial cells can induce changes of intracellular pH inhibits enzyme activity and increased energy demand increases for cell maintenance. A large amount of ammonia causes severe inhibition or failures anaerobic digestion, with important consequences both for process stability and productivity. Methanogenic reactor volume dividing into two smaller reactors makes loading in ammonia to be produced in the first reactor lower prolonging optimal methane biogas.

In order to methanogenic microorganisms to adapt to the environment containing ammonia produced at high concentration, priming process is done with concentrated waste sludge that is inserted into methanogenic reactors. By feeding gradual acidogenic reactor with tannery residues and initial pH adjustment to 3.5 ... 4, keeping the temperature constant at 37 ... 38°C in approximatively 12 days first reactor reaches full capacity methane biogas reactor at which the mixture is approximatively 1/1 waste from tannery sludge waste. The concentration of methane increases from 30% after 5 days, from about 60% to 12 days.

CONCLUSIONS

Digestion tannery waste in the pilot plant proved feasible given that priming is done with sludge waste. During the process of anaerobic digestion of protein residues organic carbon is converted into methane and carbon dioxide, and nitrogen and phosphorus builds up gradually to values that inhibit the biological process. The operation is effective until biogas production C / N ratio drops below 2, in which ammonia products represent more than 70% of total nitrogen. To optimize the carbon supply is required which can be achieved by the addition of waste with a high carbon content. Operation of the plant was stable, pH correction being made only periodically acidogenic phase, the pH remains constant in methanogenic phases neutral or slightly alkaline, in optimal limits.

Acknowledgment

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ON ANIMAL FAT USE AT DIESEL ENGINE

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ABSTRACT

Continuous reduction of non-renewable oil reserves, prices volatility, the more severe regulations of pollutant emissions and greenhouse gases and the raw materials availability leads to the intensification of the preoccupation for the use of alternative fuel obtained from renewable sources, animal fats having a high potential also due to their good combustion properties and also due to their offered large reserves. The general objective of the research is preheated gas oil-animal fat blends use analyzes at the experimental diesel engine, type CFR- IT9-3M. The engine was fuelled firstly with diesel fuel then with different diesel fuel-animal fats blends (5%, 10%, 15% animal fats content in mixture with diesel fuel). The main animal fat advantages - cetane number and calorific value very close to diesel, higher oxygen content it recommend a good alternative fuel for diesel engines.

1. INTRODUCTION

Continuous reduction of non-renewable oil reserves, prices volatility, the more severe regulations of pollutant emissions and greenhouse gases and the raw materials availability leads to the intensification of the preoccupation for the use of alternative fuel obtained from renewable sources, animal fats having a high potential also due to their good combustion properties and also due to their offered large reserves. Used oils and animal fats capitalization for biofuels production is also recommend it by their big energetically value, animal fats may represents an energetically source with large capitalization possibilities, either as raw material or even as oils obtained by transesterificantion with an alcohol (biodiesel) with large perspectives of use. Bio-diesel fuel is manufactured from plant oils, animal fats and recycled cooking oils and is an alternative to fossil fuel. The main advantages of biodiesel fuel are: it is renewable, it is energy efficient, can replace diesel fuel, it can be used as 20% blend in most diesel equipment with minor modifications, it can reduce global greenhouse gas emissions and it is not toxic being biodegradable. Biodiesel is an oxygenated fuel, non toxic, sulphur free and contain more oxygen compare to diesel petroleum and lower calorific power slightly lower than diesel [2]. In the paper are presented some results of raw animal fats use comparative to diesel fuel on different engines. The main problem associated with the use of animal fats and vegetable oils as fuel in diesel engines are their high viscosity and poor volatility. Methods used in the past that allow the use of vegetable oils and animal fats are:
transesterification; use of blends between diesel fuel and biodiesel fuel; use of blends between biodiesel fuel and alcohol; use of emulsion biodiesel with alcohol and water; fuel preheating [3]. Transesterification is an effective method to increase the energetic performance and pollutants emission reduction in a diesel engine, increase the cetane number and reduce the viscosity, but the method is a complex process itself with great energy consumption [3], [4]. Mixing animal fats with alcohols (methylesther or ethylesther) is a simple process but mixing with an increased amount leads to phase separation [3]. Emulsification of biodiesel with alcohol and water is a simple method of use animal fats as fuel in diesel engine without major modification of the engine and the results shows the reduction of smoke, NO_X emissions [3], [4]. Preheating animal fats and blending with diesel is a simple, cheap and does not require engine modifications [3], [4]. When animal fats are preheated and mixed to a temperature of about 38ºC and mixed with diesel they become a totally soluble blend which

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is completely homogeneous, with no limit of dissolution [5]. Raw animal fats can be use as single fuel or in addition with diesel fuel at diesel engines only when the animal fat is preheated at relative high temperatures so that their viscosity to be closer to the diesel fuel or by emulsification with alcohols (methanol, ethanol). The following table presents some of the physic-chemical properties of diesel fuel and animal fats:

Table 1: The physic-chemical properties of diesel fuel and animal fats

Specific properties of the fuels	Diesel *	MEGA	EEGA	Animal Fat
Density [g/ml]	0.8495	0.874	0.869	0.92
Viscozity at 40 ºC [mm^2/s]	2.96	4,814	5.036	45
Thick point [ºC]	-12	16	14	6
Congealing point [ºC]	-16	16	12	
Ignition point [ºC]	74	160	185	170
Boiling point [ºC]	191	313	327	344
Water and sediments [% v]	<0.005	<0.005	<0.005	<0.005
Coke number [% m]	0.16	0.056	0.052	
Ash [% m]	0.002	0.001	0	0
Sulphur [% m]	0.036	0.01	0.009	0
Iodine number [g/100g ,fuel]		49.1	47.2	54
Cetane number CN [-]	49.2	72.7	72.4	56
Caloric power Hi [MJ/kg]	42.9	37.25	37.63	39.77
Carbon [% m]	86.67	76.42	76.58	77.6
Hydrogen [% m]	12.96	12.59	11.57	12.3
Oxygen [% m]	0.33	10.98	11.84	12.5
Nitrogen [ppm]		9	10	
Oxygen for combustion O_t [kmol/kg cb]	0.1045	0.0917	0.0890	0.0915

*Diesel fuel for comparison produced by American company Philips 66, [6], [4]

MEGA – methyl ester of beef fat, EEGA – ethyl ester of beef fat

Animal fats and oils are lipid materials derived from animals. Physically, oils are liquid at room temperature (20…25ºC), and fats are solid. Chemically, both fats and oils are composed of triglycerides. Animal fats are in more parts constituted from tryglicerides of saturated monocarboxylic fat acids with even number or carbon atoms (C12-C18) in which palmitic and stearic acids are predominant [3]. Animal fats have a composition similar to that of diesel but with a lower content of carbon and hydrogen and higher oxygen content. The caloric power of fats is around 10% lower than that of diesel and that the density of fats is just under 10% higher than that of diesel. The most important difference between animal fats and diesel from animal fats is the viscosity value which is 20 times greater than diesel, at 40ºC. [5]. At lower temperatures the kinematics viscosity depends on the type of fats and their composition because fats are a mixture of fatty acids and glycerine esters, linolenic acid, stearic acid and other acids with different properties (ex :linolenic acid had a flow temperatures -14ºC and 70ºC for stearic acid) [6], [7]. By burning a 1 kg of fuel, considering the complete combustion of the combustible substances, results theoretical amount of oxygen required and combustion air as values that are highlighted in the table above, according to $O_t=c/12 + h/4 - o/32$ [kmol O_2/kg fuel] and the necessary air for theoretically combustion $L_t=(1/0.21)\cdot O_t$ [kmol air/kg fuel], [6]. Considering the fact that the composition of plant oils and animal fats oxygen content is between 4% and 12% depending on its origin, they fall into the category of oxygenated fuels [3]. After experimental tests on an engine with six cylinders in line, turbocharged, without intermediate cooling without EGR, 4-stroke model Volvo TD60 B, truck engine at speeds different from 1500 rev/min to

2500 rev/min and different torques 138, 277, respectively 415 Nm, corresponding to 27%, 54% and 81% of maximum torque, with animal fat preheated to 70°C are noted:

-maximum pressure in the cylinder is lower when using animal fats compared to diesel at different speeds and different loads. These results are characteristic of increased cetane number;

-the maximum rate of heat release has the same characteristic as the in-cylinder maximum pressure and it is lower at use of animal fats comparative to diesel [7]. According to other studies on another engine with a single cylinder, air cooled, model Lister Petter (LS1), direct injection, at the injection timing of β=20 CAD, fuelled with fuel diesel and animal fat at ambient temperature and the same animal fat, preheated to 70°C, and in blending with methanol and ethanol or in emulsions with water resulted in the following:

-maximum peak pressure in the cylinder has the highest values using diesel followed by emulsion methanol-animal fats and then animal fat;

-ignition delay is greater at use of animal fats compared to diesel because the physical component of ignition delay increases as a result of poor atomization and vaporization. Also, emulsions using animal fats with methanol and ethanol have an ignition delay higher than diesel. Ignition delay is due to the high value of the latent heat of vaporization of water and methanol / ethanol emulsion. Ignition delay reduces with preheating animal fats;

- combustion duration is higher when using animal fats comparative to diesel fuel. This longer duration is because of the injection of large quantities of fuel because heating value is higher at diesel comparative to animal fats while maintaining the same engine load;

- exhaust gas temperature is higher at use of animal fats because of a slow combustion. It is a reduction in exhaust gas temperature at use of emulsions with alcohols; emulsion with ethanol leads to a greater decrease in temperature due to the vaporization of ethanol. Also, using water in blends with an alcohol the decrease of the exhaust gas temperature is obtained.

-the smoke emission is almost half at animal fats use comparative to diesel fuelling, at (3.7) versus (6.1) for diesel fuel. Reducing of smoke emission is explain by the higher oxygen content of animal fats comparative to diesel which allows the complete combustion of the fuel and exhaust gases emission reduction. The greatest reduction in smoke emission is even seen at the use of ethanol - animal fat emulsion comparative to methanol and preheating fat use;

-exhaust gas temperature is much higher (about 20% higher) comparative to diesel fuel. When using an emulsion of ethanol-animal fat exhaust temperature drops to nearly the same temperature as when using diesel fuel as a result of ethanol vaporization (about 480°C for optimal emulsion);

-CO emissions are greater when using animal fats compared to diesel at all operating conditions at normal temperature. The CO emission level decreases when pre-heated the mixture to70Coran emulsion when used with ethanol/methanol and water; at the use of preheated animal fats results an increase in temperature of the fuel mixture and therefore a slight increase of, which is the disadvantage of using preheated fuel. However, the NO_X emission value is lower comparative to diesel fuelling;

-the use of animal fats at low temperatures leads to an increase in self-ignition delay and combustion duration greater than diesel when preheated is used. In animal fats decreases the length of delay and also to self-ignition and combustion duration [4]. At the use of preheated animal fats and mixed with diesel in various proportions in the University Politehnica of Bucharest laboratory was found:

-at the increase of the animal fats percent (from 0% to 15%) in blend with diesel fuel the indicated mean pressure, maximum pressure, NO_X emissions level, smoke emission level decreases [3]. From other researchers studies the main aspects are [5]:

-combustion performance are diminishes when the percentage of fat in the mixture is increased as a result of lower calorific value of animal fats;

-combustion performance are diminishes when pressure is increased, concurring with theoretical studies that indicate that over a certain injection pressure no longer see any improvement in the pulverization process.

-performance are diminishes when the combustion air increases, which it is true because the animal fats contain more oxygen than diesel fuel, requiring them excess combustion air for less [5]. Comparative to diesel fuelling, at animal fats use, auto delay ignition duration increases, maximum heat release decrease and maximum pressure decrease with the increasing of the fats percent in the blend with diesel fuel. Increase of autoignition delay when the fats content increases is a consequence of higher viscosity of animal fats which leads to the reduction of preformed mixture quantity, the diffusive combustion weight increase which leads to the decrease of maximum heat release rate at the beginning of combustion [7], [8]. Because of autoignition delay is increasing the combustion is moved in expansion and the in-cylinder maximum pressure is slightly decrease. At increase of the fats contents, the calorific power is smaller because the animal fats has a lower calorific power comparative to diesel fuel and the cycle heat release decrease, for the same injected fuel cycle dose. At increase of the fats contents the heat release is decreasing, the exhaust gases temperature is decreasing too, the mean effective pressure decreases and the energetically specific consumption increase [8], [9]. Exhaust gas temperature increase with increase of engine load. The specific fuel consumption is higher at use of diesel fuel-animal fats blends, at the increase of animal fats percent the specific fuel consumption is increases too. At engine full load, appears a slightly decrease of thermal efficiency at use of biodiesel and its blends, a decrease which is lower than diesel fuel–animal fats use [9], [10].

2. METHODOLOGY

The experimental investigation was carried on a type CFR- IT9-3M experimental diesel engine, firstly fuelled with diesel fuel first and then fuelled with blends of diesel fuel-animal fats (the quantity of animal fats in blend with diesel fuel being established by an energetic substitute ratio x_c which take into consideration the lower heating values of both fuels), for the same injection timing value (13 CAD) and for same compression ratio (□=13.74). The main animal fat advantages - cetane number and calorific value very close to diesel, higher oxygen content it recommend a good alternative fuel for diesel engines. But, the high viscosity and poor vaporization characteristics of animal fats need prior their heating and content limit in blend with diesel fuel. At the animal fats content in mixture with diesel fuel, for same engine adjustment's, were obtained the following results regarding some pollutant emissions: NO_X emissions level decreases with 30%; CO_2 emission level decreases with 3.5% and smoke emissions decreases with 65%.

In figure 1 the NO_X emission variation with the animal fats blend content is shown. The principal mechanism of NO_X formation is the oxidation of nitrogen from atmosphere. The specific chemical reactions of the NO_X formation are governed by high temperatures, availability of oxygen and availability time [10], [11].

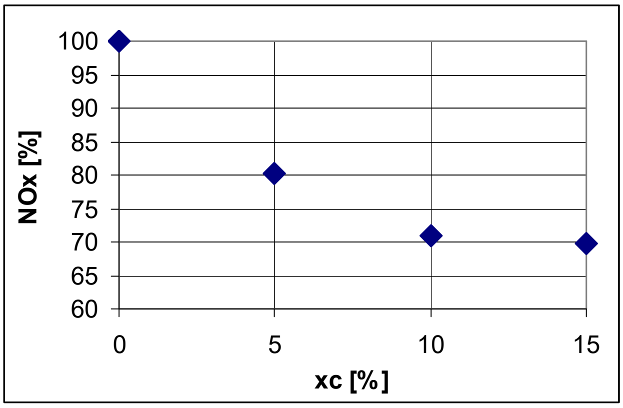

Figure 1: NO_X emissions level versus animal fats content

The NO_X formation is favoured into the high temperature zone associated to preformed mixture combustion. Decreasing of NO_X emission with 30% at the increasing of fats content, figure 1, is explained by reductions of the premixed mixture quantity because of the atomization aggravation, which leads to combustion temperature decreasing comparative to diesel engine fuelled with diesel fuel.

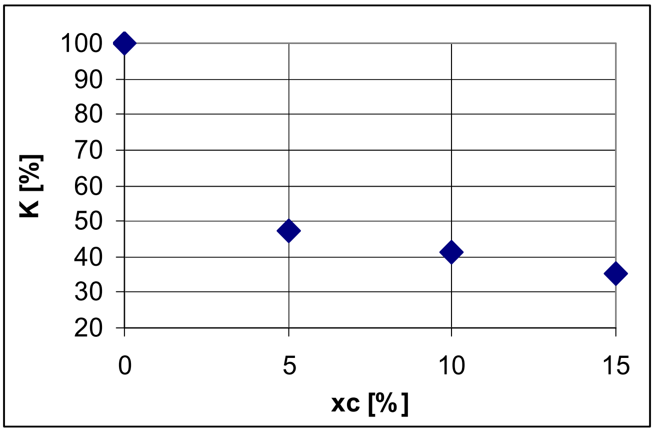

Figure 2: Smoke emissions level versus animal fats content

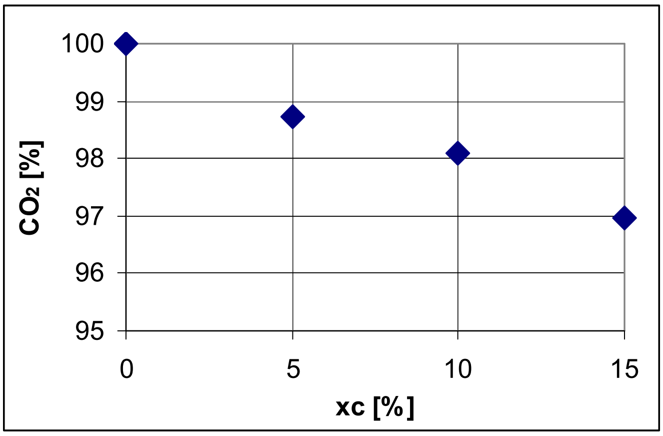

Figure 3: CO_2 emissions level versus animal fats content

In figure 2 and figure 3 the CO_2 emissions and smoke number variation versus the percent of animal fats in blend with diesel fuel are presented. Reduction of CO_2 emissions and smoke density may be explained by carbon content reduction and oxygen content increasing at blend molecular level (animal fats have a higher oxygen content in molecule). Thus the oxidation reactions are fostered. Thus, comparative to gas-oil fuelled engine, a reduction with 3.5% of CO_2 emission level and with 65% of smoke density for x_c=15% was obtained.

3. CONCLUSIONS

The use of animal fats at the diesel engine leads to the diesel engine pollutant emissions improvement. The NO_X, smoke and CO_2 emissions level decreases. Animal fats can be considered a good alternative fuel for diesel engine, assuring the replace of the fossil fuels and resolving the major problem of animal wastes. The animal fats are a biodegradable fuel and it go in intakes in CO_2 natural circuit. By achieving these specific objectives this paper brings an important contribution to solving pollution problems in large urban and agriculture areas, the solution can being easily implemented on diesel engines in running, even on the old design which can be converted to fit the current rules of pollution. In the same time is resolved and the animal wastes problem which will find an efficient use through replace of the fossil fuels. As a research originality is to establish a correlation between animal fats content in blend with gas-oil-injection timing-NO_X emissions level-smoke emission level.

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COSTS AND ALTERNATIVE METHODS FOR INTERVENTION IN OIL SPILL

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ABSTRACT

The main objective of the study is to compare the costs interventions for marine depollution, the harmful effects caused by the use of chemical dispersants and the marine environment bioremediation using oil-eating bacteria. The key to combating oil spills effectively and with minimal deleterious effects on marine life is to understand the differences between the methods of intervention.This paper present: 1) the costs analysis of interventions with normal disperesants and with bioremediation procedure in the Black Sea Basin; 2) a computer simulation for an oil pollution with estimating the risk of the scenario accident; 3) the need to reduce the use of dispersants with negative environmental effects and the necessity to throughly investigate the bioremediation method of intervention in an oil pollution.

1. INTRODUCTION

Maritime transport and port activities are amongst the major sources of oil pollution affecting coastal areas. Neighbouring Romania is advocating two proposals for a role in the Caspian oil business. One would involve the transport of oil from the Georgian port of Supsa to Constanta in Romania across the Black Sea for re-export to Slovenia, the Czech Republic, Croatia, Hungary, Austria and Germany through an existing pipeline network. The second envisages the processing of crude oil at Constanta and the distribution of finished oil products throughout the region. Romania also offers a substantial petrochemical capacity and access to the Danube-Black Sea Canal which provides an easy link between Central Europe and the North Sea via the Rhine-Main-Danube Canal. The Black Sea neighbours want to develop national and regional emergency response plans against pollution. They hope to assess the sources and levels of dangerous and potentially dangerous pollutants such as lead, synthetic materials, oils and radioactive fuels, and put in place a monitoring system for substances that have been identified as potentially damaging [1]. Oil spills affect coasts and marine life producing ecological as well as economic losses [**Error! Reference source not found.**]. Various techniques have been adopted for oil spillage restoration, for instance chemical dispersants, skimmers and booms, bioremediation, in situ burningand using sorbents. The dispersant use allowed is not exactly described in Romanian legislation [**Error! Reference source not found.**]. At that moment, the maine objective of romanian marine researchers is creating a methodology for the use of dispersants in the Black Sea, which could form the basis of developing a legal framework on the use of dispersants. In other countries of Europe where dispersant use is permitted, in practice, they have not been used for a decade or more [**Error! Reference source not found.**]. The use of dispersants is not recommended for the Black Sea (special area according to MARPOL 73/78), but with the recommendation of the Consultative Committee of the Operative Commandment for Marine Depollution, dispersants could be used as a secondary response under the conditions of requesting an international support, or

involving private partnership, but proving that the dispersants used are biodegradable and are on a list of approved dispersants [3]. All of this speaks to the critical need for cost-effective technologies, such as bioremediation, to help remove environmental contaminants.

A major aim of bioremediation must be the reduction of toxicity associated with the environmental contaminant, that is, the abatement of environmental impact [5]. This paper aims to collate and present data for dispersant use and bioremediation method and simulation for oil spill in Constanta harbour.

2. METHODOLOGY

For oil spill response Maritime Ports Administration of Constanta developed a local contingency plan, which is part of the National Contingency Plan and includes aspects related to oil pollution equipment and action teams (Table 1).

Table 1: Operational response capacities of Romanian Naval Authority [10]

Equipment	Type, quantity	Characteristics	Location	Cost
Multipurpose vessel "Nicolae Zeicu"	Technical vessels branch with system dispersant delivery	Length: 24.7 m Beam: 6.0 m Draught: 1.25-2.20 m Capacity of tank for dispersants : 1 m^3 Autonomy: 80 hours Deadweight:134 tdw. Cruising speed:7 knots	Constanta Harbour	351 euro/h
Skimmer Vikoma Komara 12K Disc System	Portable, lightweight oleophilic disc skimmer. Complete with Fastank, power pack and hoses	Rated at 12 Mt/h with crude oil. Through put: 70 GPM. Derated capacity: 68 m^3. Fastank temporary storage capacity is: 9 m^3. Dimensions (cm): 201x147x203 Weight:600/726	Constanta Harbour	41 euro/h
Boom Lamor HSW	200 ml	Height: 1350 mm; Section lenght: 25 m; Freeboard: 440 mm; Draft: 800 mm; Weight: 6 kg/m; Fabric tensile strenght: 4000 N/5 cm Deployment time: 20 min;	Constanta Harbour	In the inventory of multipurpose vessel "Nicolae Zeicu" additional cost free

- *The conditions for dispersant: Dispersant* use is usually considered by spill responders when other means of response, such as containment and removal, are not deemed to be adequate [**Error! Reference source not found.**].

When dispersants are applied during a spill, they act to break up the oil into droplets, moving it from the surface and moving downward into the water column. As a result, dispersants will increase oil exposure to some organisms while reducing it for others. When dispersants are applied, exposure to oil will typically decrease for surface-dwelling and intertidal resources, but increase for water column and bottom-dwelling resources [7]. Generally, dispersants are used to reduce immediate danger to environment and shorelines. The effect of oil spill dispersant used to handle offshore oil spill accident is influenced by many factors, such as oil type, oil spill dispersant type and environmental conditions [8]. In specific condition was demonstrate that the use of chemically dispersed crude oil is more toxic than crude oil alone [9].

- *Costs interventions for marine depollution*[10]*:* The pollution area is located along the western coast of Black Sea in Constanta.

In situation when the sea state is between 2° - 6° Beaufort scale and the water sea temperature has higher values than the point pour of pollutant, it can be used of successfully as a secondary method of intervention, discharge of dispersants. The pollutants features are: maximum thickness of the pollutant, 1 mm; maximum viscosity of the pollutant, 2000 cSt.

To estimate the amount of dispersant to be applied on the surface, we can use this formula:

$$C = 10000 \cdot t \cdot R\,, \tag{1}$$

where C is the amount of dispersant (l/100 m^2), t is thickness of pollutant from surface water in (mm) and R is ratio dilute dispersant/solvent (according to manufacturer's specifications - usually, dilution ratio is 10%, which means that 1 part solution disperses 3 parts of pollutant or 1 part undiluted dispersant to 30 parts of pollutant).

In a real situation using the dispersant Corexit 9500A, for an amount of 5.3 m^3 oil spilled over an area of about 50.000 m^2 with maximum thickness of 0.25 mm pollutant, a pollutant ration/dispersant 1:30, to disperse the pollutant is needed an amount of about 170 liters of dispersant undiluted or 1.7m^3 solution with 10% of dispersant concentration in sea water. Because the dispersant Corexit 9500A price is $ 17.078 for 1.317 kg, the cost of dispersant required to neutralize the pollutant is approximately $ 2.200/2.000 euro.

The total cost of depollution when we will intervene at the polluant dispersion from the seawater is determined by: a) the price is the amount of dispersant used to disperse the pollutant; b) the price resulting from the use of resources necessary for the discharge dispersant (tehnical branch vessels, aircrafts). For this situation, if we use the multipurpose vessel "Nicolae Zeicu", for a duration at 4 hours 10 minutes, the total cost of intervention for depollution is approximately $ 3.800/3.450 euro and if the intervention of marine depolluting would be made by mechanical oil spill response equipment (technical vessels, skimmers and booms) the total cost of intervention is $ 2.154/1.960 euro [10].

- *Exercise scenario* [11]

On the date of June 20, 2015, 12:00 hrs, the Master of the ship Kaptan M sent out a call on Ch. 16, and also a distress signal. The officer on watch from the SAR-Pollution Service (RNA/MRCC Coordination Centre), receives the distress signal on Ch. 16 (cruise ship KAPTAN_M , C/S YP3082, MMSI 264163082, Romanian Flag, length 30 m , width 8 m, draft 2.70 m, capacity 30 passengers) [11]. The cruise ship left the tourist port of Constanta-Tomis at 11:00 hours, having 20 passengers onboard and 15 crew members, all Romanian. The passengers on board were participating at a conference and were taking a cruise on the Black Sea. Around 11:40, sailing at cruise speed the passenger ship collided with the oil tanker EVIA PETROL FIVE, length 119,10 m, width 17 m, summer draft 6,75 m, holding 4200 mt of crude oil. At the time of the collision, the oil tanker was heading to the Midia Terminal to unload, having on board 22 crew members of different nationalities. Following the collision the passenger ship suffered a hull breach on starboard side. The ship started taking water and a fire broke out in the engine room. The tanker ship disengaged from the passenger ship, stopping at about 3 Mm from the collision site, to evaluate the damage taken and to avoid the cargo catching fire. Its position is latitude 44º 16’ 52 N and longitude 028º 56’ 00 E. With its main engine still on, the passenger ship reduced speed at minimum so that it’s bow was kept in the direction of the wind. Its coordinates at the moment of the accident were lat. 44º 16’ 75 N, long. 28º 50’ 69 E, cca 10 Mm from Mamaia Beach, weather conditions: wind from the E, Force 3 Bf, Sea degree 2/3, visibility 7 NM. At 12:30, the oil tankers captain announced that following the collision with the passenger ship, the no. 2 starboard cargo tank has been breached towards the bow, and crude oil was being spilled at a flow of about 80 t/h (Kirkuk crude oil, density 0.85 kg/m3, viscosity at 20 oC- 2,4/16,2 E /cSt, freezing point of 20oC). The quantity with held within the breached tank is 1000 t. A request is made by the captain to transfer the crude oil to another ship if possible, to reduce the spillage as it is not possible to transfer to another tank. They also ask for haven.

Entry data for the simulator [12]: east facing wind at a speed of about 5 m/s; after 30 h the wind speed increases to 10 m/s; air temperature 17 0C; sea water temperature 9 0C; state of the sea 0.5 m; sea water density 1026 kg/m3.

- *The course of the simulation:* The tanker’s position, at the moment of the crude oil leak is 25 km from the coast; due to the wind direction and currents, the oil slick will move towards the shore. The point of the simulation is to offer predictions on the movement of the oil slick and to check the efficiency of the response resources.

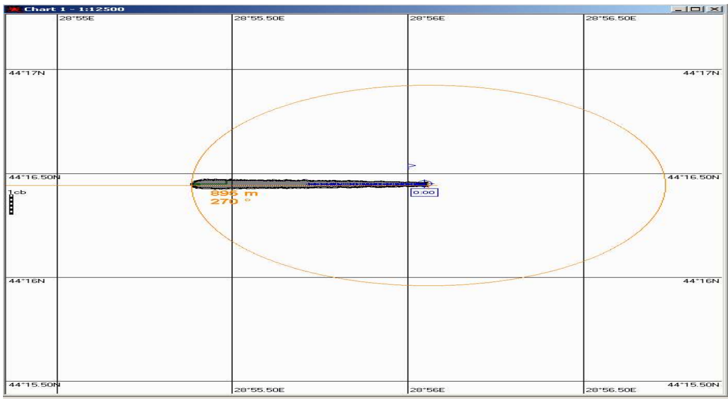
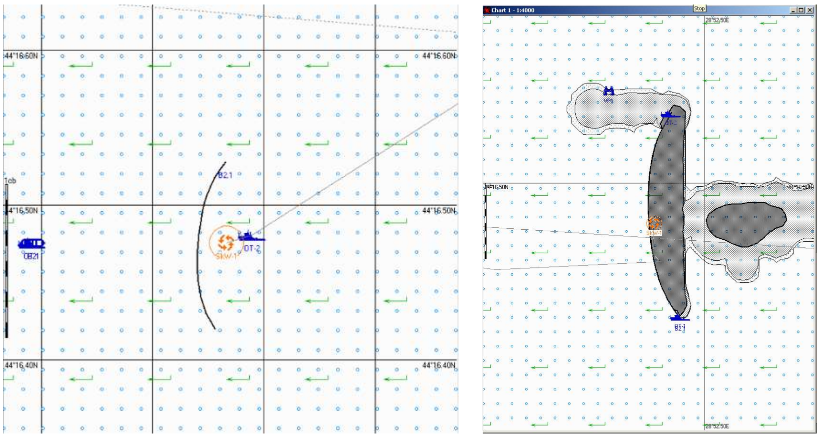


Figure 1: Oil spill shape and position at H 1 30 min

The 150HP fast boat, owned by ONACVA S.R.L. gets to the oil tanker and, on account of the divers intervention to reduce the hull breach, after 3 h the rate at which it spills oil is reduced from 80 t/h to 40 t/h [12]. After 30 min from the beginning of the scenario (H0 30 min), the PERSEU tugboat from PETROMAR S.A. loads up an air filled floating boom and an oil skimmer (with a capacity of 130 m3/h), from the ARSVOM base [12]. The ships carrying the booms sail towards the spill site after 45 min from the beginning of the scenario. Sailing speed is set at the maximum of 14 kt, thus the ships arrive at the spill site at H2 42 min [12]. At 4H 18 min the first boom is installed in front of the oil slick (Figure 2a).



a) b)

Figure 2: Complete deploy of inflatable boom length 550 m at 4H 18' (a) and at 19H 22'(b)

The oil recovey boom is unravelled to a length of 550 m; The deploying time is 1h 53 min. The two oil skimmers are ready to operate at H8 00 min. The recovey of crude oil continues at maximum capacity. At H19 22 min the oil slick goes past the booms at the northern part, due to the low recovery capacity of the skimmers (Figure 2b).

Final pollution report at H78 00 min: length of polluted shoreline 1510 m, crude oil quantity on shore 17,4 m3, recovered 353 m3, still at the boom 59,2 t, evaporated 297 m3, still floating near the shore 262 t (Figure 3).

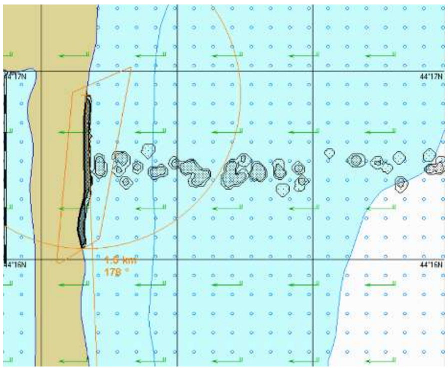


Figure 3: Final pollution report [12]

- *An alternative method of intervention:* The majority of molecules in crude oils and most refined products are biodegradable [**Error! Reference source not found.**]. Spraying areas of contamination with oil-eating bacteria accelerates the degradation of the oil. This process is known as bioremediation. Bioremediation is an attractive technology to decontaminate polluted environments (is not toxic)[13**Error! Reference source not found.**]. This process occurs when naturally occurring bacteria and fungi (microbes) use hydrocarbons as a food source and then ultimately excrete carbon dioxide and water as waste products [7]. Oil eating-bacterial are isolated from the hydrocarbon contaminated soils and aquatic environments. Many scientists was able to isolate potential hydrocarbon-degrading microorganisms. Through genetic engineering, scientists can enhances the ability of bacteria to metabolize petroleum. There are been attempts to develop an oil eating bacteria with quick action. However, even without this intake of bacteria, the ocean have a high capacity to natural biodegrade petroleum [**Error! Reference source not found.**]. When the oil is consumed, the oil-eating microbes, with less food available, stop dividing so rapidly and disappear. Bioremediation is still very much an evolving technology.

4. CONCLUSIONS

The informations presented in this paper demonstrate that low concentrations of dispersed crude oil are highly toxic to marine species and consequently, these pollutants may cause important impacts on marine life and natural bacterial community structure. The cost-benefit analysis of interventions shows that the use of chemical method of intervention is very expensive and has a negative effect on the aquatic environment. chapter containing the conclusions and the original contribution of the author is required. Following the simulation we can observe that the weather conditions permit de the evolution of the oil spill limitation resources [14]. The oil spills at the floating boom are attributed to the insufficient recovery capacity of the skimmers [3]. The oil spill reaches the shore; the shoreline subjected to pollution is 1510m long, and the oil quantity is 17,4 m3. If a second skimmer would have been used or a second floating boom, the oil pollution would have been stopped at sea, without polluting the shoreline.

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BIOMASS FOR ENERGY VERSUS FOOD AND FEED

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ABSTRACT

The use of biomass for energy and materials, as well as for food, feed and fiber is rising globally in parallel with increases in population, income, fossil energy prices, and concerns about energy security, and climate change.

A number of problems which have a direct impact on the fulfilment of policy objectives which are connected with its promotion. Primarily, the production of bioenergy has significant impacts on coupled biomass markets. Parallel to rising interests in bioenergy, concerns about its sustainability became more proeminent, with food security, greenhouse gas emission balances, and biodiversity impacts being discussed critically.

The objective of this study is to reveal the economic and ecological impacts of an increased biomass based energy production in the world.

1. INTRODUCTION

In the last 100 years, energy consumption has not directly affected people required food consumption or animal feed necessary. With the development concepts and technologies to achieve energy from biomass, the question of studying the impact of this trend on producing food and feed efficiency.

Biomass is one of the abundant renewable energy resources to switch fossil fuels to renewable and to mitigate emissions[1]. In relation to other renewable energy sources like wind, geothermal, hydro and solar power, biomass has specific features which have to be considered.

The global limitation of the availability of arable land. Biomass is not inexhaustible in the short term.

Biomass is not only an energy source, other usages like food, feed, or additional industrial compete with energy production for this resource. From these specific features a number of problems arise. Primarily, the production of bioenergy will have significant impacts on coupled biomass markets, like food or feed markets, including world prices, production, trade flows and land use. [2,3].

Existing studies estimate that compared to a situation with unchanged biofuel quantities at their level crop prices in 2014 increase by between 2% in the case of oilseeds and almost 60% in the case of sugar. [4]

The growing demand for bioenergy crops may create further competition for land and water between existing agricultural activities, energy production and the use of agricultural land for nature conservation and urbanisation needs. This could result in additional negative environmental pressure from cultivating bioenergy crops. [5]

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The bioenergy will be sustainable only when the feedstock biomass come after meeting the needs for the so called 6F applications namely food, fodder, fertilizer, fiber, feedstock, and further uses. These challenges can be overcome if feedstock are chosen from two ways-biomass that are produced in surplus land and biomass that are surplus after other applications. [6].

2. THE IMPACT OF BIOMASS IN THE FOOD INDUSTRY

The ecological evaluation of production of biomass for energy is complicated by the fact that this process can have both positive and negative environmental effects. Moreover, regional variations in the environmental impacts of biomass production are significant [7] However, the emphasis is often driven by a global perspective and disregards environmental impacts relevant on a regional level, for example such as eutrophication or acidification.[8] Water availability and pollution are the other examples of the scale issue, where only growing biomass using ill-advised species, or scale or design not appropriate to the site or region would pollute and potentially reduce local availability of water. The future of biomass energy is dependent on the complex interplay of a number of several potential environmental factors highly important to the sustainability of biomass-for-energy production such as soil, water, land, biodiversity, productivity, and energy/carbon balance. These factors must be effectively integrated to maximize the benefits and minimize the ecosystem and societal costs of biomass energy production.

The decision process in favor of or against comparable product alternatives often involves weighing different environmental impact categories within a sustainability framework.[9]

Weighing of different environmental impacts, therefore, always requires decisions regarding the priorities of impact assessment in order to evaluate the overall environmental performance of a particular product.[8] In particular, constraints owing to ecosystem characteristics, competition from alternative land use and offsite impacts can lead to practical or desirable level of biomass energy production that are much smaller than theoretical potential levels and a clear picture of these constraints can be an important asset in encouraging rational development of the biomass energy industry. [10]

Renewable energy systems such as wind, solar and biomass are significantly more land intensive than traditional fossil fuels. Thus, the overall potential yield of biomass energy depends on the land area allocated to producing it. Expanding the biomass energy industry involves the possibility that new production of biomass for energy will occupy land needed for growing food, feed and for conservation. Scenarios developed for the USA and the EU indicate that while short-term targets of up to a 13 percent displacement of petroleum-based fuels with liquid biofuels (bioethanol and biodiesel) appear feasible on available cropland, more ambitious targets will have to be fulfilled with imports.

One of the criteria for sustainable biomass is food security Food security is a key element of social sustainability, and is defined by FAO as follows: “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”. [11]

3. LAND

More than 99.7% of human food comes from the terrestrial environment, while lesst han 0.3% comes from oceans and other aquatic ecosystems. Most of suitable land for biomass production is already in use.

World wide, out of the total 13 billion hectares of land area on earth the percentages in use are: cropland,11%; pasture land, 27%; forestland 32%; urban 9; and other 21%. The remaining, 21%, is mostly unsuitable for crops, pasture or forest because the soil is too in fertile earth allow to support plant growth, or the climate and region are too cold, dry, steep, stony, or wet. Thus, most suitable land for production is already in use [12, 13]. Currently, the use of biomass covers about13% of the global primary energy demand Biomass supply potential is very dependent on the land availability, crop yields, population.

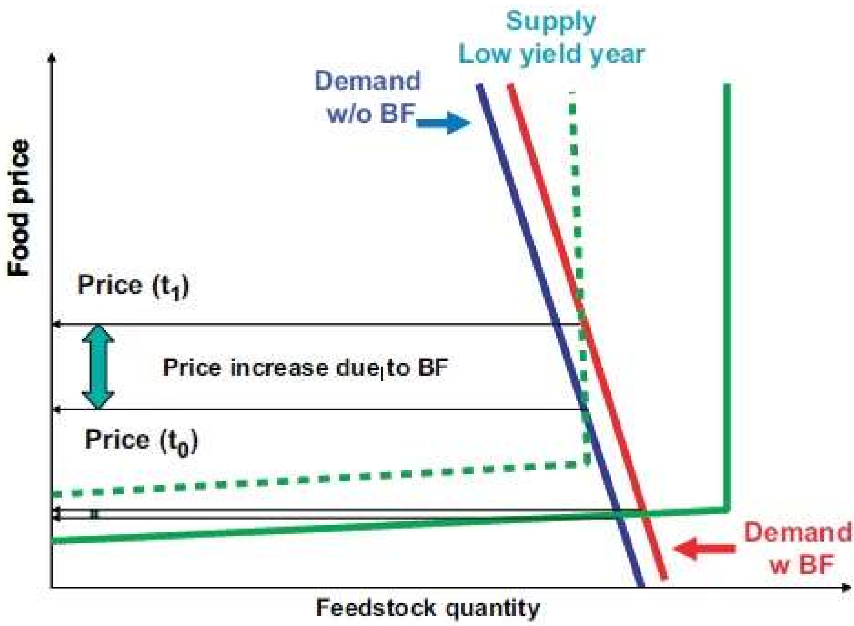

Figure 4 Short-term supply and demand for feed stocks from crop areas

Land used to cultivate biomass feed stocks for bioenergy in general, and for biofuels in particular, is a limited resource that may already be in use, so that increased competition for this land might affect food security both directly in crowding out food and feed production, and directly through food and feed price feedbacks. High levels of price variability (i.e. volatility) tend to have negative impacts on food, security, especially in net-food-importing countries and for net-food-purchasing (and in general vulnerable) households.

The prices of main staple crops determine together with the income levels the ability of households to ensure food security in terms of affordability.

Currently, the amount of land devoted to growing biofuels is only 0.025 Gha or 0.19% of the world's total land area of 13.2 Gha and 0.5-1.7% of global agricultural land of 1.53 Gha. Estimates of the total global bioenergy production potential in 2050 ranged from 33 to 1,135 EJ annually [15].

In individual bases, the minimum arable land required to sustainably support one person is 0.07 ha whereas per capita available arable land in 2050 is projected as 0.17 ha (Fig. 1)
[13]. Beyond arable land, 0.25 ha per capita is also available as permanent meadow and pasture land, which could be suitably upgraded to cropland (Fig. 2).

The role of agriculture as a source of energy resources is gaining in importance. As mentioned in Croezen [16] significant volumes of biofuels require significant areas of arable

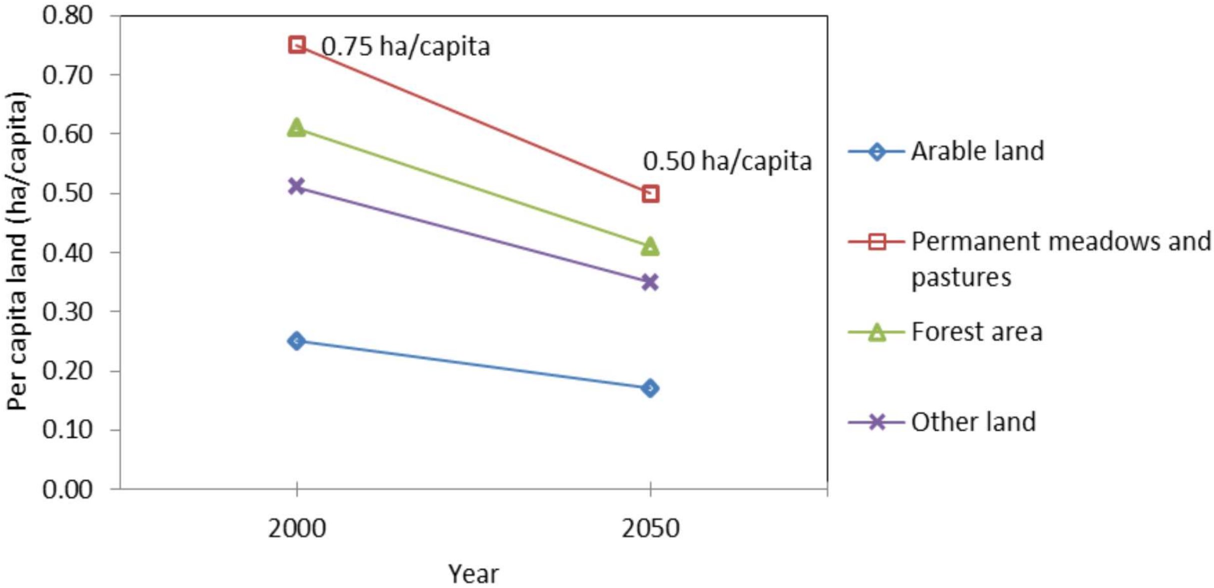

Figure 3. Per capita distribution of total meadow and pasture land in global scale: 2000-2050.

While bioenergy systems based on forest and agriculture residues require no additional land resources as the land is used for timber or food production regardless of how the residues are used, dedicated energy crops on the other hand require land which is often a limited resource. [19]

Moreover, degraded and marginal land could be rehabilitated by bioenergy plantations which could combat desertification and increase food production [20] However, the main factor for the large biomass potentials is the availability of surplus agricultural land, which could be made available through more intensive agriculture. [21] Thus, 32 biomass energy modeling studies project that additional areas beyond degraded, abandoned and marginal lands will become available as agricultural land is abandoned in response to surplus food supplies. [22]

4. PRODUCTION

Production of fuels from algae has been proven possible and is being carried out in multiple pilot-scale evaluation facilities [28, 29]. Unfortunately, at the moment, algal fuels are much more expensive compared with fossil fuels; algal fuels are expensive also relative to fuels
derived from crops such as soybean and oil palm. As a consequence, algae are not being used as commercial feedstocks for making biofuels.

Lignocellulose biomass is another nonedible feedstock for making liquid biofuels such as bioethanol and biobutanol. Fuel alcohols will eventually be derived from lignocellulose biomass and agro industrial waste instead of from corn and sugarcane. This may entirely displace the use of food crops for production of fuel alcohols, but will not necessarily remove competition for the resources needed for growing food. For example, if agricultural crop residues are removed from land for making fuels, the need for fertilizers for agriculture will increase. Similarly, growing dedicated lignocellulose crops for fuels will require land, water and fertilizers. In the long run, algal fuels may be superior to crop derived bioethanol [31], but commercializing them requires much more effort compared with commercialization of lignocellulose fuels.

Biogas produced by anaerobic digestion of organic waste is already being used to some extent, but is of limited value as a transport fuel. Also, the supply of readily useable organic waste for producing biogas is limited in comparison with the energy consumption of an industrial economy. For example, in the UK, if all the sewage sludge, animal waste, farm manure and domestic and commercial food waste is used to produce biogas, less than 3% of the of the annual national fossil energy demand could be met [33].

In short, nonedible feedstocks are either in short supply or too expensive to use for producing fuels because of technical limitations. Increasing the production of land-based nonedible crops as fuel feedstock is not desirable as it does not eliminate competition for the resources needed for food production.

Growing algae requires nitrogen and phosphorous fertilizers and it is possible to recycle much of the phosphorus and some nitrogen. On an equal mass basis, algae generally need much more nitrogen than land plants do.

Production of nitrogen fertilizers depends on fossil energy; although the atmosphere has a lot of freely available nitrogen, algae cannot use this. A capability for fixing this nitrogen exists in some microorganisms including in some algae-like cyanobacteria [40]. An ability to fix atmospheric nitrogen may have to be incorporated in the algae, to eliminate the need of providing nitrogen fertilizers at a substantial expense in fossil energy.

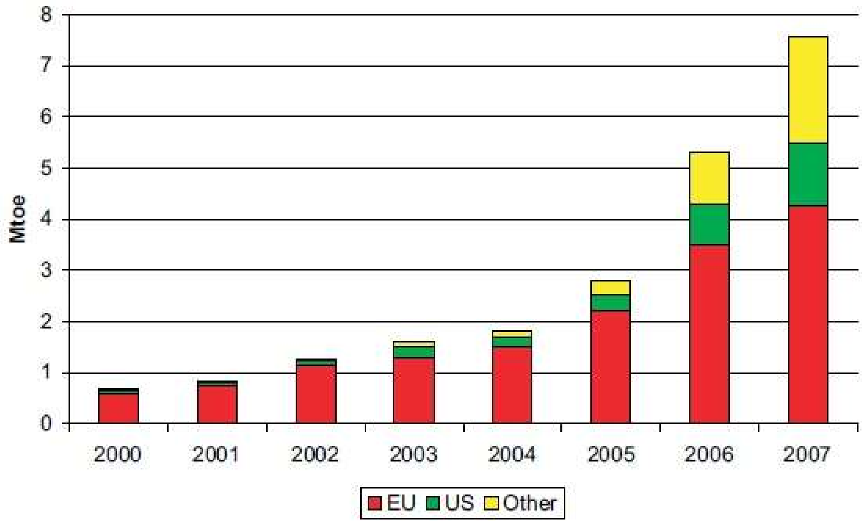

Figure 5 Recent trends in biodiesel

If fuels from marine algae can be commercialized, competition for agricultural land for fuels will be mostly eliminated, but competition for some of the other resources needed for agriculture will persist; for example, the competition for fertilizers. This competition may also be largely removed, but doing so will need a substantial and sustained effort over many years; for example, through biological nitrogen fixation.

Food and fuel are both essential for existence. Food is fuel for the body and biofuels have been an almost exclusive source of our energy for much of our existence – sustainable production of both food and fuels is vital. At the moment, unfortunately, production of neither food nor biofuels appears to be sustainable [43,44]. This is being increasingly recognized and is spurring in the development of sustainable production methods.

5. CONCLUSIONS

The major input for bioenergy are land and water resources, thus challenges lay in competition with these natural resources. Bioenergy can also be sources for many issues such as depletion of water resources, soil erosion and loss of biodiversity, however, rational bioenergy production could successfully address these issues.

Conversely, inappropriate bioenergy development could provoke further social and environmental damage. Bioenergy development could address fossil fuel depletion and environmental challenges or equally cause significant damages depending on the path taken.

Within the period 2000 to 2009 the increase and the volatility of feedstocks prices has not been only the consequence of continuously increasing biofuels production. Yet, by far the largest part of these volatilities was caused by other impact parameters such as oil price and speculation.

Agriculture, forestry and wood energy sectors are the leading sources of biomass for bioenergy. However, as an adequate bioenergy supply is closely linked to adequate food, water and land, the production of biomass for energy raises many environmental concerns.

To be acceptable, biomass feedstock must be produced sustainably. Bionergy from sustainably managed ecosystems could provide a renewable, carbon neutral source of energy through the world and there is a strong society need to evaluate the sustainability of bioenergy, especially because of the significant increases in production mandated by many countries.

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ENERGY EFFICIENCY IN A RENEWABLE BIOMASS RES PROJECT USING ANIMAL AND PLANT WASTE

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ABSTRACT

The article presents the investigation and analysis of the development of a biomass renewable energy sources (RES) project using animal and plant waste. It includes the estimated energy production and the CO_2 reduction, resulting from the use of ecological power in relation to electricity produced from conventional sources. The analysis of the biomass resource is developed on the basis of preliminary engineering studies for the possibility of burning methane gas produced from animal and plant waste. The produced electricity is sold to the National Electrical Distribution Company. The produced thermal energy is used both for the installation's own needs and for greenhouse heating.

1. INTRODUCTION – Expected benefits of the project.

The aforementioned RES biomass energy project will provide for thermal and electric production based on methane burning in a generator. The generated electricity will be sold to the National Electric Company (NEC), furthermore the heat energy will be used to recover heat losses, as well as for greenhouse heating during the winter season. The animal and plant waste is collected and transported to the site that is situated in the region of the town of Yambol, Yambol District. The system installation and its facilities are imported by Biogest Energie und Wassertechnik GmbH Ltd. The thermal power capacity of the generator is 810 kW and the electrical capacity is 800 kW. This system has an efficiency of approximately 85.5%.

The total project revenues are calculated based on the assumption that the gas used for burning in the generator is methane, generated through the decomposition process of animal and plant waste, carried out by mesophilic and thermofilic bacteria. VDC has explored the option of using light fuel oil (LFO) for thermal production, the price of which is 933 EUR/t. Annual LFO consumption would cost EUR 536,642.

During the biogas production process, the installation consumes electrical and heat energy. The annual electricity consumption for the equipment is 299.63 MWh/year. The annual heat consumption is 819.94 MWh/year which ensures a constant temperature in the basic fermenter is kept, as well as providing for recovery of all heat losses. The co-generators work hours are 8,760/year, the total annual electricity and heat production are respectively 6,400 MWh/year and 6,476 MWh/year.

Plant substratum consumption will be 17,971 tons per year. The animal substratum will be 5,500 tons per year. The animal and plant waste costs will be EUR 186,622 per year. In

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addition, the annual costs for operation and maintenance will be EUR 72,182. As a result of the project implementation, the annual gross profits are expected to be EUR 832,107.

The general fermenter where the fermentation of animal and plant waste will take place has a total volume of 2,593 m^3. The fuel consumption (corn and wheat silages, as well as cattle and pig fertilizers) is 17,971t/year. The annual methane (biogas) gas production is 1,505,882 Nm^3/year. The methane gas burns completely in the generator installation. The system efficiency is 85.5%, where 42.5% and 43% are the effective electrical and heat power efficiencies respectively.

It is accepted that the utilization of animal and plant waste does not generate emissions. However, for two years the CO_2 emissions will decrease by 11,959 tons in comparison to the methane gas combustion including electricity usage for the needs of the gas generator installation and the light fuel oil usage for heat loss recovery and greenhouses.
The CO_2 emissions reduction for the period 2010 - 2012 is presented in Table 1.

Table 1. Carbon Dioxide Emissions Reduction

Emission characteristics		2010	2011	2012	**Total**
Electricity savings	(MWh/yr)	1,537	6,099	6,099	**13,736**
LFO savings	(GJ/yr)	144	575	575	**1,294**
Carbon Emission Factors for Electricity	(tCO_2/MWh)	0.908	0.884	0.833	
Carbon Emission Factors for light fuel oil	(tCO_2/GJ)	0.0702	0.0702	0.0702	
CO_2 Emissions Reduction from electricity	(tCO_2/yr.)	1396	5392	5081	**11,868**
CO_2 Emissions Reduction from LFO	(tCO_2/yr.)	10	40	40	**91**
CO_2 Emissions Reduction total	**(tCO_2/yr.)**	**1,406**	**5,432**	**5,121**	**11,959**

2. PROJECT BASELINE

The preliminary engineering studies of burning methane gas produced from animal and plant waste project installation includes: storage for fermenting waste, general and additional fermenters for biogas generation, gas generator, a separator and its facilities, and assembly.

The animal and plant waste is delivered to the main fermenter as solid (silages) and liquid (cattle and pig fertilizer) substances. Through a discharge pipe, the substratum is transported to the additional fermenter. Produced by aqueous fermentation, the biogas is burned in the generator. Electricity and heat are produced. The substratum from the fermenting remains is separated by the separator into a liquid and solid phase. The former is stored in open temporary depositories for liquid fertilizers, whilst the latter phase is used as an asphalt mixture. The goals of the project are: the production of electric energy for own needs and for selling to the NEC; the production of thermal energy for covering the heat loses and technological needs of a greenhouse nearby the site.

The complete technical equipment of the installation using animal and plant waste consists of the following:

- Generator and additional equipment:
- Gas generator;
- Lubrication system;

- Installation for supplying and exhausting air;
- System for emergency cooling;
- Electrical distribution device;
- Three phase self-controlling synchronous generator;
- Catalyst;
- Mixtures cooling system;
- Water-cooling engine system; preliminary heat-exchanger;
- Exhausting gas system;
- Gas analyser;
- Low pressure gas meter;
- Substratum loading system;
- Main and additional fermentors;
- Central pump station;
- Smoke jet;
- Separator;
- Sulphur purification fan;
- Stationary compressor;
- Condenser.

The cash flow of the project is based on the use of waste animal and plant products instead of light fuel oil and the sale of electricity to the National Electrical Company.
The annual consumption of animal and plant waste is 17,971 t/year. The annual plant substratum consumption amounts to 12,471 t/year. The plant substratum represents the silage mixture of corn and wheat waste. The methane gas production is 1,423,942 Nm^3/year. The water content in the substratum, as well as the annual methane production are presented in Table 2.1.

Table 2.1 Substrate amount and biogas (methane) production from plant waste

	Raw material			Dry material					Methane production	
	[t/a]	[t/m³]	[m³/d]	TS [% d. FM]	oTS [% d. FM]	TS [t/a]	oTS [t/a]	oTS [t/d]	[Nm³ CH4 / kg oTS]	[Nm³ CH4/a]
corn silage	9,471	0.65	39.92	33.00%	31.35%	3,125	2,969	8.13	0.38	1,128,262
wheat silage	3,000	0.50	16.44	35.00%	30.80%	1,050	924	2.53	0.32	295,680
sum/average value	12,471	0.61	**56.36**	-	-	4,175	3,893	**10.67**	**0.37**	**1,423,942**

The annual animal (cattle and pig) waste consumption and methane gas generation is presented in Table 2.2. As evident, the biogas production is 81,940 Nm^3/year.

Table 2.2. Substrate amount and biogas (methane) production from animal waste

Fertilizer										
	Raw material			Dry material					Methane production	
	[t/a]	[t/m³]	[m³/d]	TS [% d. FM]	oTS [% d. FM]	TS [t/a]	oTS [t/a]	oTS [t/d]	[Nm³ CH4 / kg oTS]	[Nm³ CH4/a]
cattle fertilizer	2,500	1.10	6.23	10.00%	8.50%	250	213	0.58	0.22	46,750
pig fertilizer	3,000	1.02	8.09	6.00%	5.10%	180	153	0.42	0.23	35,190
sum/average/t liquid	5,500	1.05	**14.32**	-	-	430	366	**1.00**	**0.22**	**81,940**

The annual biogas and energy production from both animal and plant waste is presented in Table 2.3.

Table 2.3 Total biogas production

Substratum	Methane	Energy	Power
	1	2	3
	Nm³ CH_4/a	[kWh/a]	[kWel]
plant substratum	1,423,942	14,239,420	757
animal substratum	81,940	819,400	44
total	**1,505,882**	**15,058,820**	**801**

Waste production (animal and plant) is mixed in the mixing tank by means of a conveyor worm. The mixing tank is fed by a screw elevator. After passing through that tank, the substratum mixture is transported to the fermenter where the methane gas is discharged. The methane production process requires a constant temperature in both fermenters. Additional heat energy has to be supplied in order to cover the heat losses through the fermenters cover. The annual required heat energy for the fermenter is presented in Table 2.4. i.e., 819.94 MWh/year.

Table 2.4 Main fermenter own heat energy consumption

Necessary heat energy for the fermentor							
	Power [kW]						[kWh/month]
	Heating	Losses				General	General
	Necessary heat	Necessary heat addit. Fermentor	bottom	Fermentor lead	Fermentor jacket	Total	Total
January	88,0	0,0	5,6	6,5	13,4	113,5	84,472
February	85,7	0,0	5,5	6,1	12,7	110,0	73,907
March	80,9	0,0	5,2	5,5	11,4	103,0	76,601
April	76,2	0,0	4,9	4,8	9,9	95,7	68,906
May	71,4	0,0	4,6	4,1	8,5	88,5	65,840
June	64,3	0,0	4,1	3,6	7,5	79,5	57,206
July	59,5	0,0	3,8	3,3	6,9	73,5	54,687
August	59,5	0,0	3,8	3,4	7,0	73,7	54,826
September	66,6	0,0	4,3	3,9	8,2	83,0	59,768
October	71,4	0,0	4,6	4,8	9,9	90,6	67,401
November	80,9	0,0	5,2	5,6	11,6	103,3	74,365
December	85,7	0,0	5,5	6,2	12,8	110,2	81,964
min Temp	**88,0**	**0,0**	**5,6**	**9,4**	**19,5**	**122,6**	**-**
Max. Temp	88,0	0,0	5,6	6,5	13,4	113,5	84,472
Average	74,2	0,0	4,7	4,8	10,0	93,7	69,711
Minimum	59,5	0,0	3,8	3,3	6,9	73,5	54,687
						Total	**819,943**

The annual electricity consumption for own needs is 820 kWh/day, or 299.63 MWh/year, and is presented in Table 2.5.

Table 2.5 Daily electricity consumption own needs

Unit	**Nominal Capacity [kW]**	**Installed capacity [kW]**	**working period [h/d]**	**Electricity consumption [kWh/d]**
Co-generator 716kW	740.0	9.0	22.0	198.0
Low pressure gas compressor	4.5	4.5	23.0	103.5
Substratum loading system	105.0	60.0	2.0	120.0
Main pump station	9.8	9.8	2.0	19.6
Mixer 1,Basic fermentor with FU	11.0	4.0	18.0	72.0
Mixer 2, basic fermentor with FU	11.0	4.0	18.0	72.0
Mixer 2, basic fermentor with FU	15.0	4.0	18.0	72.0
Mixer 1 , Addit. Fermentor	18.5	18.5	4.0	74.0
Mixer , Addit. Fermentor	18.5	18.5	4.0	74.0
Separation	5.5	5.5	2.0	11.0
Desulphurization fan	0.2	0.2	24.0	4.8
Total	**939.0**	**138.0**		**820.9**

Net electricity and heat production for the installation are presented in Table 2.6. The net annual electricity and heat production are respectively 6,099 MWh/yr. and 5,656 MWh/yr. According to the manufacturer's data, the losses are expected to be 2,184 MWh/yr.

Table 2.6 Net monthly electricity and heat production

Net electricity production				1	2	3	4	5	6	7	8	9	10
Month	Day in the	T	T	energy	Losses	electricity	heat	electricity consumption		net production		power	
	month	Outer	Bottom	gross	14.5%	42.5%	43.0%	electricity	heat	electricity	heat	electricity	heat
	[day/month]	[°C]	[°C]	[MWh]	[MWh]	[MWh]	[MWh]	[MWh]	[MWh]	[MWh]	[MWh]	[kW]	[kW]
January	31	-0.60	5.00	1,279	185	544	550	26	84.4	518	466	696	626
February	28	1.60	6.00	1,155	168	491	497	23	73.9	468	423	696	629
March	31	5.80	8.00	1,279	185	544	550	26	76.6	518	473	696	636
April	30	10.50	10.00	1,238	179	526	532	25	68.9	501	463	696	644
May	31	15.10	12.00	1,279	185	544	550	26	65.8	518	484	696	651
June	30	18.20	15.00	1,238	179	526	532	25	57.2	501	475	696	660
July	31	20.10	17.00	1,279	185	544	550	26	54.7	518	495	696	666
August	31	19.70	17.00	1,279	185	544	550	26	54.8	518	495	696	666
September	30	16.00	14.00	1,238	179	526	532	25	59.7	501	473	696	656
October	31	10.60	12.00	1,279	185	544	550	26	67.4	518	483	696	649
November	30	5.10	8.00	1,238	179	526	532	25	74.3	501	458	696	636
December	31	1.20	6.00	1,279	185	544	550	26	82.0	518	468	696	629
Total	**365**			**15,059**	**2,184**	**6,400**	**6,476**	**301**	**820**	**6,099**	**5,656**		

Table 2.7 shows the annual quantities of the produced thermal energy, electricity sold to the NEC, light fuel oil replaced by biomass energy production, as well as the operational and maintenance costs of the system installation.

Table 2.7 Heat energy productions, Electricity sold to NEK, Light Fuel Oil Consumption, and O & M Costs

Co-generator facilities	Heat Energy Production by CHP	Electricity sold to NEC	Replaced LFO by heat energy production	O&M Cost
	(MWh/yr.)	(MWh/yr.)	(t/yr.)	(EUR/yr.)
Implementation of combined heat/power production installation working with animal and plant waste	5,656	6,099	575	56,712
Total	**5,656**	**6,099**	**575**	**56,712**

3. CONCLUSIONS

The assessment of impact of the project is based on the energy balance of the overall energy balance of Bulgaria using the data of the Statistical Yearbook of the National Statistical Institute. The system installation has an installed total thermal output of 810 kW and will generate net thermal energy of 5,656 MWh/yr. The electricity output is 800 kW and will generate net electricity of 6,099 MWh/yr.

According to the published energy balance, the total annual final energy consumption in the country is 8,520 K tons of crude oil equivalent, of which 639 K tons are attributed to biomass.

The allocation of electricity production, light fuel oil savings, O&M costs and methane consumption are in Figure 3.1.

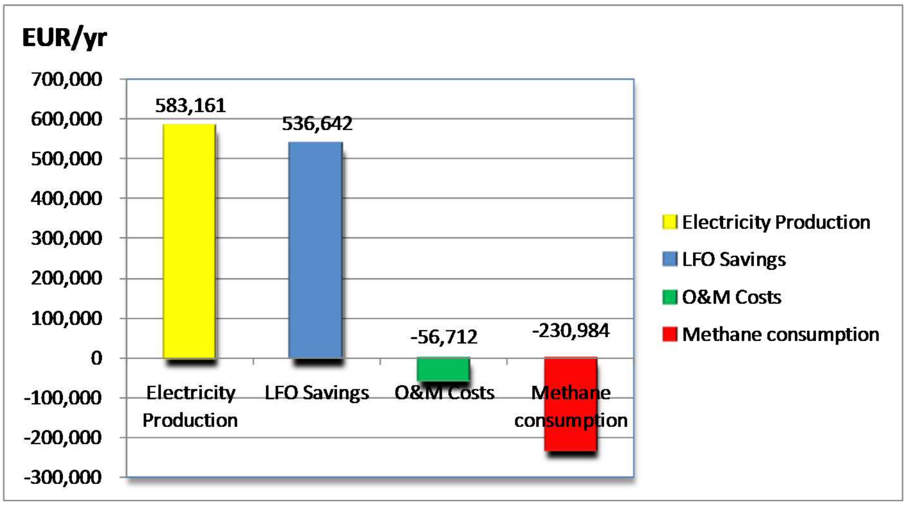

Figure 3.1 Savings Resulting from Project Implementation

The estimated produced electricity from the biomass co-generator is equivalent to 0.0048% of the total annual final energy consumption in the country.

Revenues such as energy and other savings, revenues from electricity sales, Carbon Credits and Tradable Green Certificates

In defining the project results, the annual quantity of electric energy and thermal energy used for own needs, as well as for the heating installation and for greenhouses, were calculated. A balance of the animal and plant waste quantities is made and the quantity of electrical and thermal energy produced by the biomass co-generator is defined. The influence of the co-generators efficiency on the combustion process is also taken into consideration.

The revenues are calculated based on the produced electricity with the respective purchase price of the NEC, and also the savings from the replacement of LFO. The waste heat from the processes will be used for heating the system and to heat the greenhouse.

A detailed calculation model of the proposed energy conservation opportunity is given in Table 3.2, which summarizes the output of the biomass energy project implementation at VDC Ltd for the overall project implementation period up to 2029 in cash equivalent.

Table 3.2 Project Savings for the Different Measures

Sources of Cash Flow			2010	2011	2012	2013	2014	2028	2029
ECO 1	**Implementation of CHP installation working with animal and plant waste**								
	Electricity sold to the NEC	(MWh/yr.)	1,537	6,099	6,099	6,099	6,099	6,099	6,099
	Light Fuel Oil	(t/yr)	144	575	575	575	575	575	575
	Methane gas consumption	(1000 Nm^3/yr)	-376	-1,506	-1,506	-1,506	-1,506	-1,506	-1,506
	Operation and maintenance costs	EUR/yr	-14,178	-56,712	-56,712	-56,712	-56,712	-56,712	-56,712
Total for the Project									
	Electricity sold to the NEC	(MWh/yr.)	1,537	6,099	6,099	6,099	6,099	6,099	6,099
	Light Fuel Oil	(t/yr)	144	575	575	575	575	575	575
	Methane gas consumption	(1000 Nm^3/yr)	-376	-1,506	-1,506	-1,506	-1,506	-1,506	-1,506
	Operation and maintenance costs	EUR/yr	-14,178	-56,712	-56,712	-56,712	-56,712	-56,712	-56,712
Tariffs									
	Electricity tariff (medium voltage) - purchased by NEK	(EUR/MWh)	96	96	96	96	96	96	96
	Light Fuel Oil	(EUR/t)	933	933	933	933	933	933	933
	Methane plus O&M, waste fuel supply and misc. expenses	(1000 Nm^3/yr)	153	153	153	153	153	153	153
Cash Savings and Revenues									
ECO 1	**Implementation of CHP installation working with animal and plant waste**								
	Revenues from electricity sales to the NEC	(EUR/yr.)	146,987	583,161	583,161	583,161	583,161	583,161	583,161
	Light Fuel Oil	(EUR/yr.)	134,155	536,642	536,642	536,642	536,642	536,642	536,642
	Methane plus O&M, waste fuel supply and misc. expenses	(EUR/yr.)	-57,744	-230,984	-230,984	-230,984	-230,984	-230,984	-230,984
	Increased operation and maintenance costs	(EUR/yr.)	-14,178	-56,712	-56,712	-56,712	-56,712	-56,712	-56,712
Total Cash Flow		**(EUR/yr.)**	**209,221**	**832,107**	**832,107**	**832,107**	**832,107**	**832,107**	**832,107**

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