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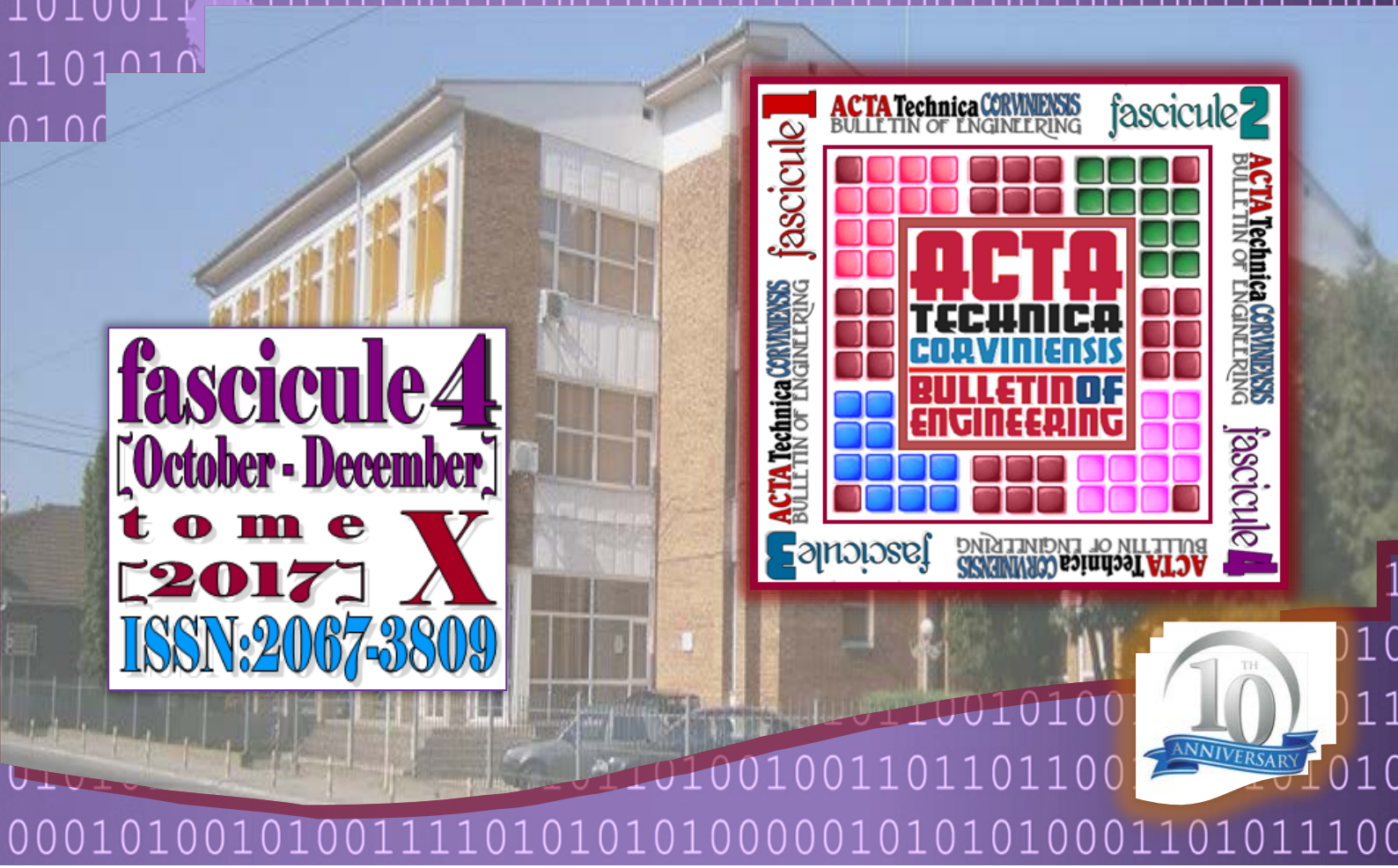

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10TH ANNIVERSARY

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In a very short period the **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** has acquired global presence and scholars from all over the world have taken it with great enthusiasm.
We are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!

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Keywords: four wheels steer, steering system, suspension system, computer analysis

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Keywords: Intelligent Production, Industrial Logistics, Fourth Technological Revolution

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of solar energy utilization is distinguished. These are the so called passive and the active forms. Passive solar energy utilization means energetically more favourable orientation of buildings. The conscious building orientation is discernible since the ancient times, to take advantage of the solar radiation. In this publication after a short description of solar energy utilization, the temperature dependence of solar panels is described. A compiled off-grid solar system is also presented and the system efficiencies, maximum loads, current and voltage waveforms together with other measurement results in case of different load levels are described. The final system's operability and the switch-over are shown too.

Keywords: Solar energy, temperature dependence, off-grid, UPS

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Keywords: Causes, Defects, Early building, Jigawa State, Nigeria

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Keywords: design project, CAD models, bench for daily activities

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Keywords: monitoring system, technological arrangement, Layout question

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Abstract: Natural gas development in Nigeria is currently facing numerous challenges amid growing competition from shale gas, coal bed methane and tight gas in the U.S., Europe and China. This has undoubtedly had some damning economic implications for the Nigerian gas market whose major patronage have traditionally been the US and Europe. According to a recent report published by Nigerian National Petroleum Company (NNPC), the gas market in Nigeria witnessed sharp drop in 2012 when virtually no single export was made to US as a result of shale gas currently being developed in that country. This continuous decline in gas export to US and Europe may further worsen power project

development in Nigeria due to other challenging issues like pipeline vandalism, youth restiveness in the Niger-Delta and un-harmonized government policies. Couple with the fact that crude oil production has witnessed significant drop in Nigeria due to low oil price and glut in the global market, it may be of utmost interest to explore viable gas utilization option with a view to promote further investment in gas business. Sustainability of Nigeria power sector depends largely on power plants which are driven by gas and the current power outage in Nigeria may not be unconnected with gas shortage to power these power plants. In this study, the authors x-ray sustainable gas utilization option aimed at promoting gas export, boasting investors' confidence in Nigeria gas market and the authors equally beam searchlight on government's policies that are inimical to the free gas market among other pressing issue. Part of the conclusion drawn from the research reinforces the need to widen gas utilization options most especially in the area of Gas-to-Liquid conversion technology in order to sustain electricity generation in Nigeria.

Keywords: Natural gas, electricity generation, crude oil production, sustainable gas utilization, future gas investment

8. **Gabriel GHEORGHE, Cătălin PERSU, Mihai MATACHE, Marinela MATEESCU, Dan CUJBESCU – ROMANIA**
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Abstract: The intelligent control system is a software-hardware system that achieves a differentiation of crop plants from the weeds and after that it destroys the weed. It is based on two intelligent cameras. Each camera surveys two rows of culture and digitally transmits the commands obtained after processing the images, to a logical programmable controller (PLC). This paper presents general aspects and a comparison between two smart cameras; the first one is black-and-white and the second is a colour camera. Recognition and processing of images algorithm depends on colour, shape or position. If the first uses shape to recognize and make the difference between weed and plant, the second uses the difference of colour pixels to make that difference. The paper also includes the stages of algorithm realization and implementation for images processing and recognition. The experiment was performed on lettuce at INMA Bucharest.

Keywords: intelligent, hoeing, images recognizing method

9. **M.A. ANIFOWOSE, S.A. ADEBARA, S.O. ODEYEMI, A.B. OLAHAN, T. ALIYU – NIGERIA**
DENSITY, WORKABILITY AND COMPRESSIVE STRENGTH ASSESSMENT OF STEEL SLAG IN CONCRETE 63

Abstract: This study examines the use of Steel Slag (SS) as a partial replacement of coarse aggregate in concrete. The replacement levels of crushed stone (granite) with SS were 0%, 10%, 20%, 30%, 40% and 50%. A total of 72 concrete cubes of sizes 150 mm x 150 mm x 150 mm were cast and cured in water for 7, 14, 21 and 28 days respectively. A mix ratio of 1:2:4 was adopted and batching was done by weight. Slump test were conducted on fresh concrete while density test and compressive strength test was conducted on hardened concrete. The compressive strength result shows that the strength of concrete increases with respect to curing age as the percentage of SS increases (i.e the higher the percentage of SS, the higher the compressive strengths of the concrete cubes). The replacement of coarse aggregate (crushed stone) with Steel Slag (SS) will produce a concrete of higher strength compared to plain concrete (conventional concrete). However, Steel Slag (SS) can successfully be used as a partial replacement of coarse aggregate (crushed stone) in concrete for concrete grade M20 since the strength of concrete with 10%, 20% and 30% 40% and 50% is higher than the control mix.

Keywords: Concrete, Coarse Aggregate, Compressive strength, Steel Slag (SS)

10. **Radostin DIMITROV, Penka ZLATEVA, Siyka DEMIROVA – BULGARIA**
INVESTIGATION OF THE CHARACTERISTICS OF BIOGAS FUELS AND OPPORTUNITIES FOR THEIR DISTRIBUTION IN BULGARIA 69

Abstract: Road transport is one of the main sources of air pollution. When the full and insufficient combustion of fuels to generate complex mixture of gaseous and solid pollutants, many of which are dangerous to human health. In the article examined the characteristics of biogas fuels and presented opportunities for distribution in Bulgaria. For this purpose have been made studies on the composition of the biogas fuels derived from various starting materials. Analyzed the possibilities for use of biogas fuel, depending on the content of the various concentrations of methane and carbon dioxide. An in-depth analysis of the possibility of distributing raw materials to finished filling stations in Bulgaria, according to the application. Consider the possibility of distribution of finished materials and comply with the requirements for the transport of dangerous goods.

Keywords: Biogas, Algorithm, Distribution, Lower calorific value, Gas generators stations

11. **Dominika PALAŠČÁKOVÁ, Miroslav ŠTOFA – SLOVAKIA**
DEVICE FOR USE IN MANUFACTURING EQUIPMENT 73

Abstract: Nowadays is possible to find in global markets tremendous number of robotic handling equipments that provide manipulations in space. It is recommended to use handling equipments which reach at least five degrees of movement freedom. This condition ensures successful manipulation in space. The number of freedom degrees

depends on number of modules that are connected to each other in the kinematic chain. The authors focus on modifying parts of the Rotational Universal Module joint system. The main task of the joint system is to create a solid bond between two adjacent modules. This is called the rotary coupling, because two adjacent modules rotate to each other. The main objective was to achieve improved locking system in comparison with the initial design. Also facilitate the assembly operation during the construction of kinematic structures. A detailed description of the adjustments made, see the following chapters.

Keywords: rotation universal module, rotary unit, locking pin, large flange of bearing

12. **Ramë LIKAJ, Ahmet SHALA – KOSOVO**
DESIGN AND CONTROL OF FULL VEHICLE SUSPENSION SYSTEM 77

Abstract: This paper deals with the design and control of vehicle suspension system for a full vehicle model with the aim to improve the ride comfort and to guarantee permanent contact between road and wheel. For the design of full vehicle active suspension system we will start by reduced model with 7 DOFs, this model contains all the basic elements to evaluate the ride comfort and tire load variations of the full model with 13 DOFs model. Full vehicle model with 7 DOFs contains 14 state variables which are very difficult and sometimes impossible to measure. These difficulties will be solved by using state estimator or Kalman filter. The selection of weighting factors is very important task to design an active vehicle suspension system, in such a way that during the process a defined goal function is minimized and provide the possibility to emphasize quantifiable issues of vehicle suspensions like; ride comfort and road holding for varying external conditions. Simulations are performed in SIMULINK/MATLAB for full vehicle model, both active and passive suspension system, linear and nonlinear models, while these systems are excited by the white noise disturbance and the linearization around the equilibrium point are performed in MathCAD.

Keywords: passive, active, suspension, optimal control, Kalman Regulator

13. **Mirela DINCĂ, Mariana FERDEŞ, Gigel PARASCHIV, Gheorghe VOICU, Nicoleta UNGUREANU, Mariana IONESCU, Gabriel MUŞUROI, Bianca ZĂBAVĂ – ROMANIA**
AGRICULTURAL FEEDSTOCK CHARACTERIZATION USED IN BIOGAS PLANTS 81

Abstract: In the last period, the anaerobic fermentation of organic fraction has been recognized as a valuable method that can convert the substrate used into useful products such as biogas and digestate. The most commonly used substrate for biogas production by anaerobic fermentation process is the manure containing nutrients necessary for the growth of anaerobic microorganisms. Anaerobic digestion is a biochemical decomposition process that is used for the treatment and energy recovery from biomass, like organic residues, agricultural and industrial wastes, animal manure and energy crops. The paper presents results of experimental research on the physico-chemical characteristics of the agricultural biomass (corn stalks, wheat straw and alfalfa) that can be used in co-digestion with animal manure in biogas plants. Parameters with a significant role in the process of anaerobic fermentation were assessed: total soluble solids (TSS%), the pH, the moisture content as well as the reducing sugars in the liquid fraction of the tested substrate.

Keywords: agricultural feedstock, corn stalks, wheat straw, alfalfa

14. **Z.S. ALIYU, A.D. GARKIDA, E.A. ALI, R.M. DODO – NIGERIA**
SUITABILITY OF THE LOW GRADE KALAMBAINA LIMESTONE DEPOSIT FOR GLASS MAKING 85

Abstract: A study to determine suitability of the low grade Kalambaina limestone deposit for glass making has been carried out. Samples were collected from four different locations. The representative samples were analyzed and characterized to determine the chemical composition, mineral phase and microstructural morphology using X-ray fluorescence (XRF), X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) respectively. The results of the XRF showed that the deposit consists of 45.66 wt% CaO, 0.38 wt% MgO, 0.35 wt% Fe_2O_3, 0.22 wt% Al_2O_3, 1.13 wt% SiO_2, 0.19 wt% TiO_2 and the amount of material lost on ignition was 42.99% (LOI). Qualitative and quantitative XRD analyses revealed that calcite was the dominant mineral followed by quartz which occurred as the lesser phase. The percentages of calcite and quartz in the sample were99.23 wt% and 0.77 wt% respectively. SEM/EDS analysis depicted the major elemental composition of the deposit and then the SEM-micrograph demonstrated the spherical calcite dust as dominant phase. The composition of the limestone deposit compared favorably with standard except for high concentration of iron oxide (0.35 wt%) which is objectionable but the concentration of iron oxide is still tolerable for making green container glass (0.96 wt%). Notwithstanding, low grade Kalambaina limestone can be upgraded through beneficiation to minimize the iron oxide concentration.

Keywords: Limestone; Kalambaina; low grade; Glassmaking; River Sokoto

15. **Dragoş MANEA, Andrei DUMITRAŞCU, Eugen MARIN, Marinela MATEESCU, Gabriel GHEORGHE, I. DUMITRU – ROMANIA**
STUDY ON IRRIGATION SYSTEMS IN AREAS THREATENED BY DESERTIFICATION – REVIEW 89

Abstract: Global climate change increases the areas subject to desertification, the greatest scourge that threatens Earth. One third of the globe is subject of aridity, affecting more than one billion people in 110 countries, including five countries in the European Union, including Romania. In this paper there are presented some modern methods of irrigation, applicable effective in areas threatened by desertification, namely: drip irrigation, with variants wetting the

surface and water underground, irrigation by condensation of water vapor existing in the pores of the soil or the atmosphere and the complementary systems for irrigation by condensation, such as systems to optimize the temperature in the root zone of the plants.

Keywords: irrigation systems, desertification, condensation

16. Sabolč PAP, Veselin BEŽANOVIĆ, Mladenka NOVAKOVIĆ, Dragan ADAMOVIĆ, Ivana MIHAJLOVIĆ, Maja ĐOGO, Anica BABIĆ, Sanja ŠARIĆ, Jelena RADONIĆ, Maja Turk SEKULIĆ – SERBIA
ADSORPTION OF PHOSPHATE AND ORGANIC MATTER FROM MEAT INDUSTRY WASTEWATER BY ACTIVATED CARBONS NORIT SA2, HYDRODARCO AND ZEOLITE ZSM–5 97

Abstract: This paper presents the ability of new and not previously studied commercial activated carbons Norit SA2, Hydrodarco C and Zeolite ZSM-5 to remove phosphate ions and reduce the organic load, after the secondary treatment of the meat industry wastewater. The influence of pH, contact time and initial concentrations are studied. Adsorbent Hydrodarco C shows substantial capacity to adsorb phosphate ions, as well as organic matter from meat industry wastewater (removal efficiencies of 81.20% and 84.92%, respectively). The best fit of the experimental results with theoretical models was obtained for the Langmuir and Freundlich's equilibrium models, while the kinetics was the best described by the pseudo second-order model. This study proved the effectiveness of commercial activated carbons for removal of phosphate ions and organic matter and their possibility to be used for tertiary treatment of meat industry wastewater.

Keywords: phosphate, organic matter**,** meat industry wastewater, adsorption kinetics, commercial adsorbents

17. Emeka Segun NNOCHIRI, Helen Oluyemisi EMEKA – NIGERIA
IMPROVEMENT OF GEOTECHNICAL PROPERTIES OF LATERITIC SOIL USING WALNUT SHELL ASH 105

Abstract: This study assesses the improvement of geotechnical properties of lateritic soil stabilized using walnut shell ash. Three natural soil samples A, B and C were collected from different locations in Akure and subjected to the preliminary tests for purposes of classification and identification. Engineering property tests such as California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS) and Compaction tests were performed on the three natural soil samples and thereafter the soil samples were treated with walnut shell Ash (WSA) at varying proportions of 2, 4, 6, 8 and 10% by weight of soil. The results showed that the addition of WSA improved the strength of the three soil samples. The unsoaked CBR values of the three samples increased to 15.85% at 8% WSA, 28.45% at 8% WSA and for sample C, it increased to 26.90% WSA by weight of soil at 6%. The Unconfined Compressive Strength (UCS) of samples A, B and C increased from 148.70 to 320.76 kN/m^2, 153.42 to 381.28 kN/m^2 both at 8% WSA and from 185.23 kN/m^2 to 490.67 kN/m^2 at 6% WSA respectively. It can therefore be concluded that WSA can effectively stabilize poor lateritic soil.

Keywords: Geotechnical properties; lateritic soil; stabilization; strength; walnut shell ash

18. Andrei Lucian CRĂCIUN, Teodor HEPUȚ, Camelia PINCA BRETOTEAN – ROMANIA
MECHANICAL TESTING OF COMPOSITE MATERIALS WITH ORGANIC FIBRES FOR AUTOMOTIVE BRAKE PADS 111

Abstract: Society is directed to use composite materials reinforced with natural fibers due to ecological catastrophes and the exhaustion of natural resources. Natural fibers have low mechanical properties, but these have some advantages such as: low density, low price of raw material and biodegradability. Thanks to these advantages, organic composite materials are appreciated in areas where material weight plays an important role, such as automotive. The weight of the materials used in the construction of automotive influences the amount of CO_2 emitted in the atmosphere with adverse effects on the environment. The paper presents some experimental research results from mechanical testing of new organic composite materials for automotive brake pads without any harmful effect. In this sense, four different laboratory formulations were prepared with varying percentage of coconut fiber, friction modifiers, abrasive material and solid lubricant using powder metallurgy technique. The results obtained provide useful information's about the behavior of these materials in operations.

Keywords: mechanical, organic, composites, pads, test, sample

19. Azem KYÇYKU, Ahmet SHALA – KOSOVO
ANALYTICAL-GRAPHICAL ANALYSIS OF VARIOUS INFLUENCES IN THE CARRYING ABILITY OF V-BELTS WITH NARROW PROFILE 115

Abstract: In this paper is analyzed in detail influential that have important role in carrying ability of transmitters with trapezoid belts, better known as V-belts with narrow profile. While belt is determinate element for power, which V-belt transmitters can carry, then in detail is analyzed all constructive influential in their carrying ability. For analysis purpose are taken V-belts of type: SPA, SPB and SPC. In the work are given analytical formulae for the calculation of nominal and corrected carrying ability for these types of belts manufactured with coating. Corrected carrying ability is gained when nominal carrying ability is corrected through addition of Power, as a result of influential of these parameters: contact angle between belt and guiding wheel (α_1), transmission ratio (i) and length of belt (L). These influential are presented in this work in analytical and graphical form.

Keywords: V- belt, Nominal ability, Belt drive, Graphic analysis

20. Fatai O. ARAMIDE, Idris B. AKINTUNDE, Patricia A. POPOOLA – NIGERIA
EFFECTS OF TITANIA AND SINTERING TEMPERATURE ON THE PHASE DEVELOPMENT AND PROPERTIES OF SINTERED MULLITE-CARBON COMPOSITE SYNTHESIZED FROM OKPELLA KAOLIN 121

Abstract: The effects of the addition of titania and sintering temperatures on the phases developed, physical and mechanical properties of sintered ceramic composite produced from kaolin and spent graphite electrode was investigated. The kaolin and graphite of known mineralogical composition were thoroughly blended with 2 and 4 (vol.) % titania. From the homogeneous mixture of kaolin, graphite and titania, standard samples were prepared via uniaxial compaction. The test samples produced were subjected to firing (sintering) at 1300˚C, 1400˚C and 1500˚C. The sintered samples were characterized for the developed phases using x-ray diffractometry analysis, microstructural morphology using ultra-high resolution field emission scanning electron microscope (UHRFEGSEM) various physical and mechanical properties were determined. It was observed that microstructural morphology of the samples revealed the evolution of mullite, cristobalite and microcline. The mineralogical phase of the samples revealed the increments in the evolution of mullite and also the variation in other phase attained as the sintering temperature was raised from 1300˚C to 1500˚C for the sample having the same composition. It was concluded that the optimum mechanical property of the ceramic samples produced was achieved with sample that contain 4 (vol.) % titania and sintered at 1300˚C.

Keywords: titania; kaolin; carbon; sintering temperatures; phases developed; sintered ceramic composite

21. Attila TÓTH, Tibor KOVÁCS – HUNGARY
QUALIFICATION SYSTEM OF THE PRIVATE SECURITY SECTOR 131

Abstract: Elaborating a system of qualifying enterprises operating in the private security sector is a topical problem nowadays. It is necessary to introduce an unbiased qualification system with which every Hungarian enterprise operating in the field of property protection within the private security sector can be properly categorized and classified. On the one hand, the introduction of the system would rule out enterprises that are operating illegally, and on the other hand it would provide assistance to the Principals in selecting the companies being appropriate to carry out the task in question, in wording tender requirements, and in the long run it would result in the improvement of the entire sector. Later on the rating activity could be extended. During complete safety audits, the plans of security systems, for example, could be inspected, alongside with the already functioning systems. In the long term, the implementation and consistent operation of a professional rating system could entail clarification and transparency of the private security sector, improvement of the enterprises engaged in the sector as well as an increased prestige of this trade. As a consequence of the foregoing, the value of services provided by this sector is expected to rise, too.

Keywords: qualification, private security, planning, security technology

22. Ion SARACIN, Olimpia PANDIA, Marian NEACSU,
Ioan GANEA–CHRISTU, Diana Loredana RĂDULESCU – ROMANIA
INFLUENCE OF AGING HEAT TREATEMENT ON SOME MECHANICAL PROPERTIES OF THE AlZn5.7MgCu ALLOY THROUGH EXPERIMENTAL RESEARCHES 137

Abstract: AlZn5.7MgCu alloy is part of special aluminum alloys from Al-Zn-Mg-Cu system, of zicral type. These alloys have high mechanical characteristics and low density, which is why they are interesting for the aviation industry and automotive industry. There is a close relationship between the development of the aviation industry and the evolution of the materials it uses. It is well known that this top area of the technique requires advanced materials with special physical and mechanical properties. The paper presents the results of experimental research at laboratory scale on the influence of AlZn5.7MgCu alloy thermal processing mode. Two types of aging heat treatment were studied, namely: a natural aging and an artificial aging treatment. For each of the two types of technological heat treatment, the change of the mechanical properties was monitored according to the parameters of the aging procedure. The experimental research of this paper highlights the advantage of artificial aging as compared to natural aging, but this advantage must also be seen in terms of the costs implied by the two types of treatment.

Keywords: aluminum alloy, heat treatment, mechanical characteristics

23. Irina PAVLOVA, Maria DONCHEVA – BULGARIA
ERGONOMIC ASPECTS OF THE SPORTS ACTIVITIES MICROENVIRONMENT AT THE TECHNICAL UNIVERSITY OF VARNA 141

Abstract: Working environment is a multi-component system including the conditions at which certain activities are carried out. It is affected by the following factors: illumination, noise, vibrations, microclimate (air motion and humidity, temperature, dustiness, etc.). As a complex interdisciplinary science based on knowledge of methods and science of humans and human labor which are aimed at altering working environment, ergonomics provides for maximal preservation of working capacity and human health. Ergonomic norms are part of the norms limiting harmful effects on human health. Using them, the limit of people's satisfaction by the effects of environment is determined. Failure to observe these norms, especially in the conditions of active motor activity, causes various physiological reactions in athletes' organisms and increases the risk of respiratory diseases. The article reflects on the

parameters of the microclimate in the sports hall of the Technical University of Varna. The experimental part includes measuring of the temperature, relative humidity, air dust and light in the hall. An analysis of the data obtained is carried out and the conformity of the data to the ergonomic standards and requirements is established.
Keywords: microclimate, air parameters, ergonomics

24. Gelu Ovidiu TIRIAN – ROMANIA
ROBOTIC ARM FOR AUTOMATED COLORED OBJECT SORTING 147

Abstract: One of the first definitions given to the robot takes into account that it is a device that mimics man to a certain extent, either as a form or as a means of action. Thus, the robot is defined as an automatic mechanism that can substitute man for some operations, being able to modify its execution cycle by photoelectric detection, electronic brain, servomotor, etc. The technical characteristics of industrial robots include: dimensions, achievable travel values, precision, repeatability, freedom of movement, type of drive, robot weight, workspace volume, command and control system capability, speed, transportable load, working conditions, etc. This paper presents aspects related to the design, construction and operation of the mechanical structure and the action of an anthropomorphic robot with 4 degrees of freedom and prehensive mechanism. The robotic arm is equipped with a color sensor and several servomotors, is completely autonomous and has the ability to sort different color objects. Depending on the color of each object, it moves to a predetermined position and catches the object which is a randomly chosen color by the operator, rotates and positions over the color sensor, depending on the value returned by the sensor, inserts it into one from the red, green or blue boxes on the stand. Robot programming is done using the Arduio software.
Keywords: robotic arm, color sensor, Arduino, servomotors, programming

25. O.A. OYEM, A.J. OMOWAYE, O.K. KORIKO – NIGERIA
THERMO-PHYSICAL EFFECTS OF THERMAL RADIATION AND HEAT GENERATION ON FREE CONVECTIVE HEAT AND MASS TRANSFER OVER A VERTICAL PLATE 151

Abstract: The thermo-physical effects of thermal radiation, heat generation and species concentration on Magneto-hydrodynamic free convective heat and mass transfer flow over a vertical plate with variable thermal conductivity is considered. The governing partial differential equations are transformed into coupled nonlinear ordinary differential equations with similarity transformations. The resulting coupled nonlinear differential equation is solved numerically by Runge-Kutta forth order with shooting technique. The effects of the thermo-physical properties on velocity, temperature and concentration profiles are illustrated graphically and numerical values of skin friction, Nusselt number and Sherwood number are presented in tables.
Keywords: MHD free convection; heat generation; thermal radiation; variable thermal conductivity; vertical plate

*** MANUSCRIPT PREPARATION – GENERAL GUIDELINES 161

The **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Tome X [2017], Fascicule 4 [October – December]** includes original papers submitted to the Editorial Board, directly by authors or by the regional collaborators of the Journal.

Also, the **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Tome X [2017], Fascicule 4 [October – December]**, includes scientific papers presented in the sections of:

» **The International Conference on Agricultural and Mechanical Engineering (ISB-INMA-TEH2016)**, organized by the **National Institute of Research-Development for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest** and **Biotechnical Systems Engineering – ISB Bucharest**, in **Bucharest, ROMANIA, 27–29 October 2016**. The current identification number of the papers are the **#5, #8, #13, #15** and **#22**, according to the present contents list.

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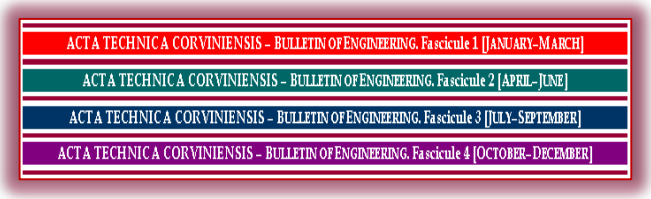
We are very pleased to inform that our international and interdisciplinary journal **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** completed its nine years of publication successfully [**issues of years 2008 –2016, Tome I–IX**].

In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm.

Every year, in four online issues (**fascicules 1 – 4**), **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** [**e-ISSN: 2067-3809**] publishes a series of reviews covering the most exciting and developing fields of science and technology. Each issue contains papers reviewed by international researchers who are experts in their fields. The result is a journal that gives the scientists and engineers the opportunity to keep informed of all the current developments in their own, and related, areas of research, ensuring the new ideas across an increasingly the interdisciplinary field.

Now, when will celebrate the tenth years anniversary of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!

On behalf of the Editorial Board and Scientific Committees of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we would like to thank the many people who helped make this journal successful. We thank all authors who submitted their work to **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**.



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[1.]Naser LAJQI, [2.]Shpetim LAJQI

MODELING AND SIMULATION OF THE TERRAIN VEHICLE WITH FOUR WHEEL STEERING

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Abstract: This paper presents early development of the special four wheels driven vehicle intended for use in rough off road conditions. Especially attention is focused on the development of the steering and suspension system that should fulfill pretentious requirements about the stability, safety and maneuvering ability. To fulfill the requirements from the check list as better as much the new design of both mentioned systems are proposed. The analytics and computer modeling including the simulation of the vehicle equipped with improved new suspension and steering is done by considered two main regimes. First regime takes into account the vehicle traveled at low speed and second at higher speed. Few chosen suspension and steering systems are analyzed into the very details in order to find out the optimal design of it. Afterwards the results of computer kinematics simulation are accomplished and detailed discussed in order to precisely point out the influence of turning radius in maneuvering ability. Finally it is clearly shown how the vehicle behavior at low speed regimes is limited by the cornering radius in dependence of terrain roughness. It is also clearly demonstrated how at higher speed regimes stability conditions are decisional. On the basis of the presented investigation the new special mechanical steering system is proposed that on the one hand ensure quite good driving characteristics of the treated vehicle that includes good maneuvering at low speed and on the other hand this design ensure satisfactory stability at higher speeds. Achieved results that are presented may in general help the designer of modern vehicles equipped with all wheels drive.
Keywords: four wheels steer, steering system, suspension system, computer analysis

INTRODUCTION

The aim of this paper is to conceive and design the suspension and steering system of the four wheels driven and four wheels steered in special terrain vehicle (off road vehicle), Figure 1. The subject treated here is research and development work of the terrain vehicle that is conceiving for special purposes.

The suspension system should be done by mechanical way including standard components such as beams, bearings, mechanical and hydraulic springs, dumper, etc. The steering system should be done by mechanical way also. It should contain some kind of transmission and drives. All the components of both systems should be chosen in order to keep the weight as low as possible and to ensure the highest reasonable efficiency. The number of components should be low in order to satisfy the reliability conditions.

The wider aim of this paper is to use simple and more or less standard components that are positioned on the best way on the vehicle chassis.

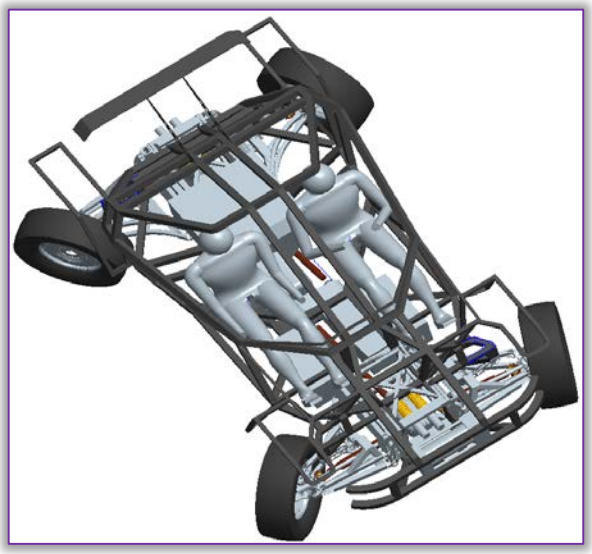

Figure 1: Top view of special terrain vehicle [1]

In Table 1 check list are presented in order to meet the requirements counted in it as better as much the many

original and new concepts of suspension and steering system are checked and carefully analyzed [1].

Table 1: Check list with characteristics and factors, which impact the suspension and steering systems

No	Characteristics	Value	Unit	Remarks
1.	Engine: P_e =	400	kW	Limit
2.	Power transmission: Gearbox	Mechanical		Request
3.	Driving speed: v =	0 - 180	km/h	Limit
4.	Maximal grade angel of road: α =	50	deg	Wish
5.	Geometric dimensions: Wheelbase: l = Track: w = Distance: a = Distance: c =	2800 2100 1400 1700	mm	Limit
6.	Mass of vehicle: M =	1150	kg	Limit
7.	Dimensions of front and rear wheels: Diameter: D = Width: B =	800 250	mm	Request
8.	Number of seats: n =	2		Request
9.	Camber angle γ =	0	deg	Limit
10.	Radius of turning center	2.24	m	Limit
11.	Suspension system design:	Mechanical		Request
12.	Steering system design:	Mechanical		Request
13.	Vertical displacement of wheels up to	500	mm	Request

SUSPENSION AND STEERING SYSTEM

In the paper is focused into the suspension and steering system design for the terrain vehicle. It is required four wheels drive, four wheels steering, good maneuverability and good comfort. Good comfort requires great vertical movements. Good maneuverability requires extensive rotations of the wheels around kingpin axles. Consequently the four wheel drives is space consuming and all counted requirements should be compensate by the development of completely new steering system. On the basis of the previous experiences it is clear in advance that conventional steering system won't meet the expected and prescribed conditions. It is assumed to equip the terrain vehicle with the same steering and suspension systems on all wheels, front and rear.

Suspension system

Suspension system of the vehicle performs multiple tasks such as maintaining the contact between tires and surface, providing the vehicle stability, protecting the vehicle chassis of the shocks excited from the terrain unevenness [2-4].

The suspension system is in general done by some mechanical way. The design of it is divided into two main groups: dependent suspension system (Figure 2) that consists mainly from solid axis and independent suspension system (Figure 3) that include a plenty of moving members. Dependent suspension system is easily to make but has a lot of weaknesses.

For example the own mass is to large, the decisional angels are changed by vertical movement drastically etc. Because of counted reasons dependent suspension is not acceptable solution for terrain vehicles at all.

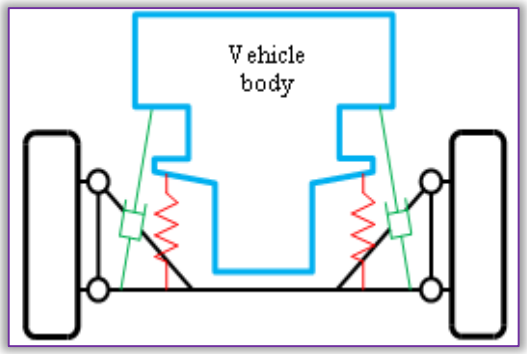

Figure 2: Dependent suspension system

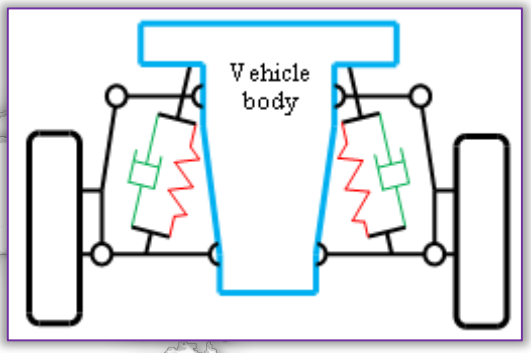

Figure 3: Independent suspension system

The only acceptable solution seems to be an independent suspension system. Independent suspension has roughly more consisting parts, but by using it can be successfully controlled all the decisional characteristics of the suspension such as many angels, etc. The problem is that this kind of suspension for all wheels driven and all wheel steered terrain vehicle is not a 'standard' design. It should be developed yet.

In general, most of independent suspension systems could be categorized in three groups: MacPherson, double wishbone and multi – link suspension system, Figure 4.

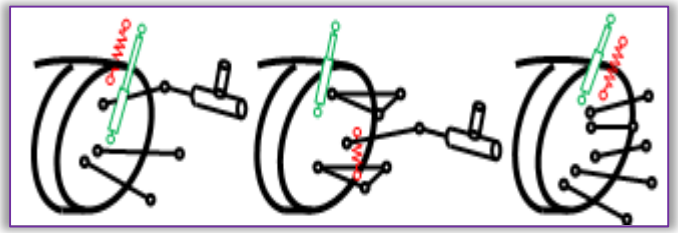

Figure 4: Independent suspension system: a) MacPherson, b) Double wishbone and c) Multi link [4-6]

Nearly all type passenger cars, many light track and some of terrain vehicle use independent front suspension because it provides a quite good insulation about the steering vibration for example. Counted systems ensure also enough space for engine installation and on some way they ensure a higher performance of the vehicle including the passenger comfort. The design of front and rear suspension system of the passenger cars may be different. The main disadvantage of already described suspension systems is basically in fact that they not allow the vertical movement of the tires big enough to give good characteristics of the terrain vehicles.

Steering system

The steering system design is a decisional component of all type vehicles. It represents a connection between driver and vehicle. The main task of this system is to steer the vehicle to follow in advance provided trajectory. This should be done safety and easy as much. The traditional steering system design is usually done by some kind of mechanical way. By such mechanism the safety is ensured. Mechanical system consists from steering wheel that is operated by driver, the steering shaft that transmits driver's commands to the power steering and the steering linkage that is connected indirectly to the steered wheels (Figure 5).

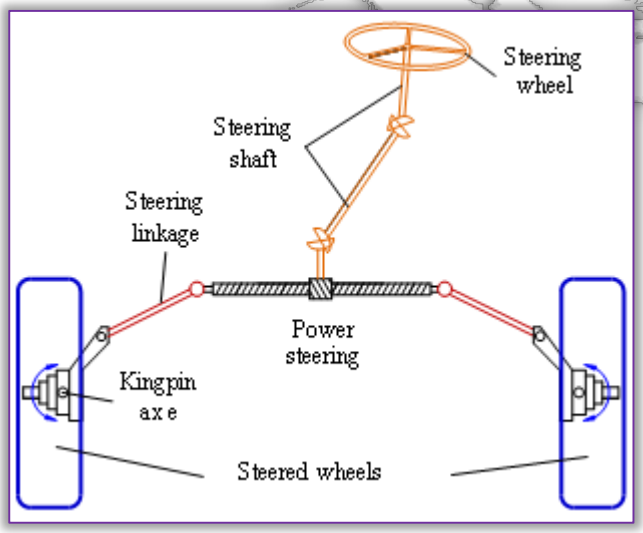

Figure 5: Traditional steering system

In general, the driver not only steers the vehicle but he gets a feedback from the road that is expressed by the contra torque on the steering wheel. The steering mechanism is exposed to the wheel forces that are generated by moving the vehicle over the different terrains. The design of the steering components is limited by these forces and by many other geometrical limits such as vertical movements, etc.

However, nowadays the mechanical steering mechanisms are good enough developed to fulfill the expectations for the most more or less ordinary vehicles. On the safe way they ensure quite good maneuverability of the vehicle by a maximum rotating angle of the front steered wheels approximately 30° that is characteristics for the passenger car and about 55° that is characteristics for the common terrain vehicle, busses and trucks. Meanwhile already all mentioned vehicles mostly run on the let say perfect flat roads the terrain vehicles should conquer much bigger surface roughness. It means the terrain vehicle should move his tires much more in vertical direction and that could represent a lot of problems by the efficient steering mechanism (Figure 6).

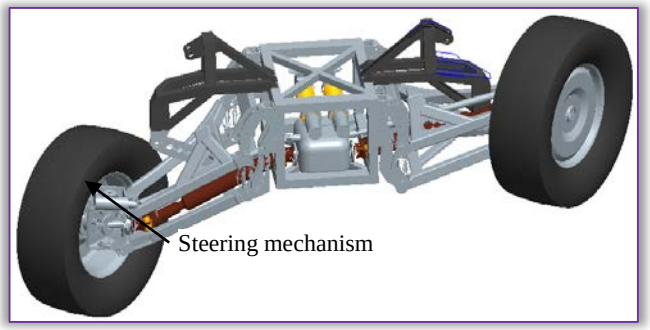

Figure 6: Design of new mechanism of steering system

These already described problems are multiplied by the greater wheels and by shorten wheelbase, which is certainly characteristics for the modern development of the terrain vehicles.

Four driven wheels is additional deepening the problem of terrain vehicle steering because of the place shortage. The power supply to the wheel and steering mechanism share now the same place. The mass is complete when four driven wheels and four steered wheels are requested at the once.

In order to ensure good maneuverability of the terrain vehicle that is first of all defined by steering mechanism firstly the suspension system should be properly designed.

DEVELOPMENT OF THE SUSPENSION SYSTEM OF TERRAIN VEHICLE

Development of suspension system (multi – link suspension system) should be more complex than conventional suspension system because as is mention above the terrain vehicles require the biggest vertical displacement of the wheel up to 500 mm or more from lowest point to the maximum (Figure 7), while in passenger vehicles such displacement are considerably smaller. For domination of the vertical displacement of the wheel required the new design. This suspension mechanism except acting dynamic vertical loads at the same time acting the lateral and longitudinal loads due of contact between wheels and surface of road which increases even more the complexity of building mechanism from which is required with successfully dominates these loads.

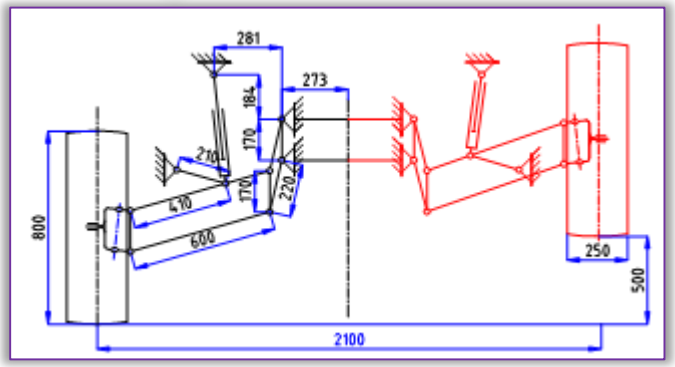

Figure 7: Front view of developed suspension system

The mechanism of suspension system is creating by few components connected to the chassis, on side, and to the wheel hub, on the other side. Mostly of these components are standard elements such as revolute joins - bearing (free maintenance), beams, linkages, springs, dampers, etc. Upper and lower arm of suspension system is connected to the chassis by four longitudinal revolute joints and others parts also are connected with a lot of revolute join, Figure 8.

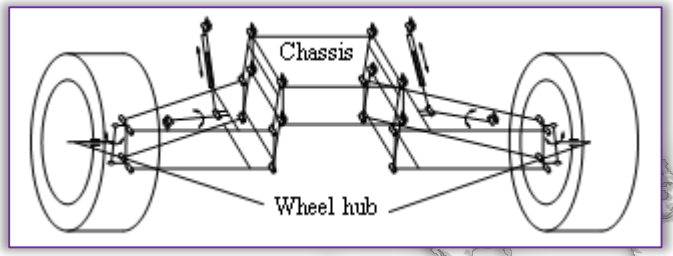

Figure 8: 3D developed suspension system

Other problems that may occur during large vertical displacement of the wheel is increasing the camber angle (angle between the vertical axis of the wheels and the vertical axis of the vehicle when viewed from the front or rear), which will directly affect in reducing of stability of vehicle as a result of small contact of wheel with the road. Developed suspension mechanism enables camber angle to be zero ($\gamma = 0$) during the vertical movement of the wheel and directly increase stability of the vehicle. In suspension system special attention should be paid designing of the best point of connection suspension mechanism with shock absorber and spring with improving ride comfort.

DEVELOPMENT OF STEERING SYSTEM OF TERRAIN VEHICLE

Conventional steering system includes a kind of power gear that is steered by the steering wheel and by a kind of mechanical transmission that consists of simple levers, arms and trusses mainly. To make the proper steering system it is foreseen that develop new transmission and drives that are located on each wheel separately is to be developed. Transmission is not standard component. It works such as reduction and multiplication because when vehicle cornering on the left or right the steer angle of the left and right wheels are different. Developed steering box consists from several pairs of gears such is cylindrical, variable gear ratio, etc. Variable gear ratio used to adjust steer angle of wheels. Connection between steered front and rear axles is realized by propeller shaft which is possible to lock in high speed.

New drives are fitted close to or even on the kingpin on each drive. The working principles of these drives are probably based on worm gears (Figure 9).

All counted new component are rarely used in steering systems but in case of terrain vehicle offer these components probably the best solution. However, it is expected that newly designed suspension system enables even bigger turning of the steered wheel as conventional one. On that way the good maneuverability is ensured. Because all wheels of the vehicle are steered it is assumed that the cornering radius of the vehicle is much lower as it would be by using the conventional Ackermann steering geometry. Of course this characteristic comes to point by lower speeds of the vehicle only. At higher vehicle speed it is proposed to lock the steering of the rear wheels. That enables to the vehicle riding on the regular roads to behave as all other vehicles, which are designed according to the standard Ackermann steering directions.

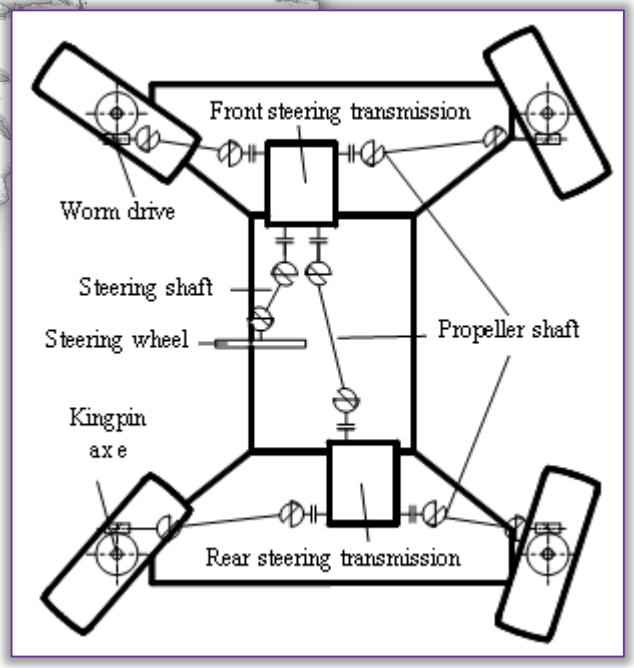

Figure 9: Developed new steering system

To control the stability of the vehicle during the ride across the troubled surface the very effective steering system is necessary.

KINEMATIC OF FOUR WHEEL STEERING

The scope of this paper is to review some aspects of the kinematical theory of four wheels steer vehicle and present some results and conclusions that we came across during research.

Turning radius of four wheel steer (R_{4ws})

In these analyses, it assumed the sideslip angel of the wheels is negligible. That is valid for low speed of motion of the vehicle [8]. Kinematic steering condition is the perpendicular lines to each wheel and to intersect at one point. The intersection point is the turning center of the vehicle, Figure 10.

The longitudinal distance between point O and turning center of the vehicle are indicating by c and d, in Figure 10.

Steer angles of the left and right front wheel (δ_{LF} and δ_{RF}) it is calculated from the triangle ΔOAC and ΔOBD, while steer angles of the left and right rear wheel (δ_{LR} and δ_{RR}) calculated from the triangles ΔOCE and ΔODF as follow:

$$\tan\delta_{LF} = \frac{2\cdot c}{2\cdot R_{4ws} - w} \quad (1)$$

$$\tan\delta_{RF} = \frac{2\cdot c}{2\cdot R_{4ws} + w} \quad (2)$$

$$\tan\delta_{LR} = \frac{2\cdot d}{2\cdot R_{4ws} - w} \quad (3)$$

$$\tan\delta_{RR} = \frac{2\cdot d}{2\cdot R_{4ws} + w} \quad (4)$$

when are:

δ_{RF}, [°] – steer angles of the right front wheel,
δ_{LF}, [°] – steer angles of the left front wheel,
δ_{RR}, [°] – steer angles of the right rear wheel,
δ_{LF}, [°] – steer angles of the left rear wheel,
w, [mm] – track (width of the vehicle) and
l, [mm] – wheelbase (length of the vehicle).

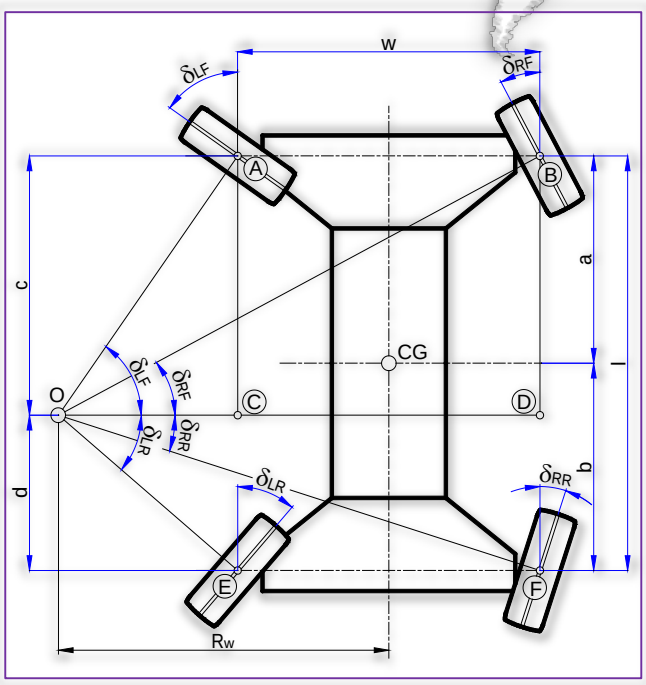

Figure 10: Four wheel steering of terrain vehicle

From equation (1) and (2) turning radius of four wheels steer (R_{4ws}) can be calculated by expression:

$$R_{4ws} = \frac{c}{\tan\delta_{LF}} + \frac{w}{2} = \frac{c}{\tan\delta_{RF}} - \frac{w}{2} \quad (5)$$

After some mathematical arrangement in expression (5) it gets the kinematic condition between the front steering angle δ_{RF} and δ_{LF}, by expression:

$$\cot\delta_{RF} - \cot\delta_{LF} = \frac{w}{c} \quad (6)$$

In the same way deal with expression given in (3) and (4) and turning radius calculated by expression:

$$R_{4ws} = \frac{d}{\tan\delta_{LR}} + \frac{w}{2} = \frac{d}{\tan\delta_{RR}} - \frac{w}{2} \quad (7)$$

Kinematic condition between the rear steering angle δ_{LR} and δ_{RR} is given by expression [7]:

$$\cot\delta_{RR} - \cot\delta_{LR} = \frac{w}{d} \quad (8)$$

From Figure 10 indicate that:

$$c + d = l \quad (9)$$

By combining equation (6) and (8), the expression obtained:

$$\frac{w}{\cot\delta_{RF} - \cot\delta_{LF}} + \frac{w}{\cot\delta_{RR} - \cot\delta_{LR}} = l \quad (10)$$

Relation (10) also can be written as:

$$\frac{(\cot\delta_{RR} - \cot\delta_{LR}) + (\cot\delta_{RF} - \cot\delta_{LF})}{(\cot\delta_{RF} - \cot\delta_{LF})\cdot(\cot\delta_{RR} - \cot\delta_{LR})} = \frac{l}{w} \quad (11)$$

Equation (10) and (11) present kinematic condition between the steer angles of the front and rear wheels for a four wheel steer vehicle (4WS).

Four-wheel steering it is applied on special terrain vehicles to improve maneuvering response, increase the stability at high speeds by locking the rear steering axis, or decrease turning radius at low speeds [9-10].

Turning radius of front wheel steer (R_{2ws})

In these analyses, it assumed that the rear wheel steering angle is zero (δ_{LR}=0 and δ_{RR}=0) and sideslip angel of the wheels also is negligible. To have all wheels turning freely on a curved road, the normal line to the center of each wheel must intersect at a common point. Figure 11 illustrates a vehicle turning left. This is the Ackerman condition.

Steer angles of the left and right front wheel (δ_{LF} and δ_{RF}) it is calculated from the triangle ΔOAC and ΔOBD as follows:

$$\tan\delta_{L} = \frac{2\cdot l}{2\cdot R_{2ws} - w} \quad (12)$$

$$\tan\delta_{R} = \frac{2\cdot l}{2\cdot R_{2ws} + w} \quad (13)$$

From equation (12) and (13) turning radius of front wheels steer (R_{2ws}) can be calculated by expression:

$$R_{2ws} = \frac{l}{\tan\delta_{L}} + \frac{w}{2} = \frac{l}{\tan\delta_{R}} - \frac{w}{2} \quad (14)$$

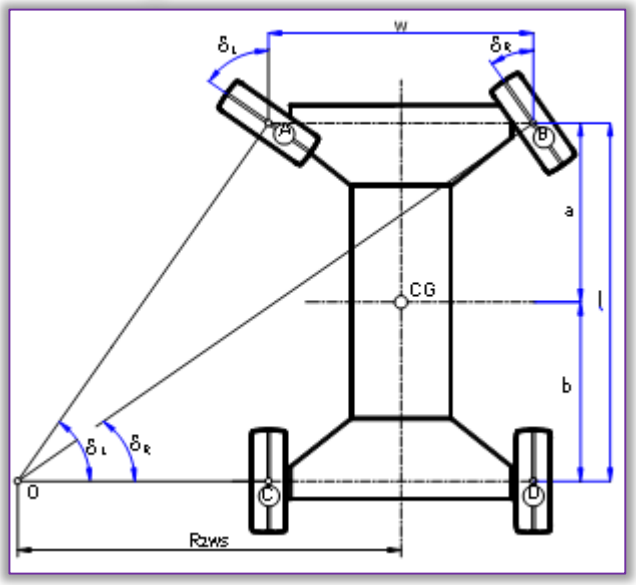

Figure 11: Front wheel steering of vehicle (2WS)

After some mathematical arrangement in expression (14) it gets the Ackerman condition between the front steering angle δ_R and δ_L, by expression:

$$\cot\delta_R - \cot\delta_L = \frac{w}{l} \qquad (15)$$

Expression (15) present Ackerman condition.

CALCULATION OF THE STEERING ANGLES AND TURNING RADIUS OF TERRAIN VEHICLE

Expression (1), (2), (3) and (4) for determine left and right steer wheel angles on the front and rear axis also can given by matrix form through expression:

$$\begin{bmatrix}\delta_{LF}\\ \delta_{RF}\\ \delta_{LR}\\ \delta_{RR}\end{bmatrix} = \begin{bmatrix}1&0&0&0\\0&1&0&0\\0&0&1&0\\0&0&0&1\end{bmatrix}^{-1} * \begin{bmatrix}a\tan\left(\frac{2\cdot c}{2\cdot R_{4ws}-w}\right)\\ a\tan\left(\frac{2\cdot c}{2\cdot R_{4ws}-w}\right)\\ a\tan\left(\frac{2\cdot d}{2\cdot R_{4ws}-w}\right)\\ a\tan\left(\frac{2\cdot d}{2\cdot R_{4ws}-w}\right)\end{bmatrix} \qquad (16)$$

After replacing values in expression (16) that are given in Table 1 by check list, steer wheels angles are:

$$\begin{bmatrix}\delta_{LF}\\ \delta_{RF}\\ \delta_{LR}\\ \delta_{RR}\end{bmatrix} = \begin{bmatrix}55.00\\ 27.33\\ 42.75\\ 18.49\end{bmatrix}, deg \qquad (17)$$

To fulfill the requirements of terrain vehicle given in Table 1, as better as much, required the steer wheels angle to have same values given in expression (17).

It is assumed that the return of wheels around kingpin axis from straightaway position to the maximum position on the left or on the right to be realized with 540° rotation of the steering wheel. This means that if the vehicle turns on the left, driver turn on the left steering wheel for 540° and left front wheel will turn 55° around kingpin axis. Transmission ratio will be 540°/55° = 9.82, while the right wheel will turn in same direction for 27.32° and also creates a transmission ratio of 540°/27.32° = 19.76 (Figure 12).

It is required designing transmission which allows the same wheel rotates 55° in one direction and in the other direction 27.32°. Transmission will work as reduction and multiplication. The diapason of regulation of the transmission will be:

$$D = \frac{i_{max}}{i_{min}} = \frac{19.76}{9.82} = 2.01 \qquad (18)$$

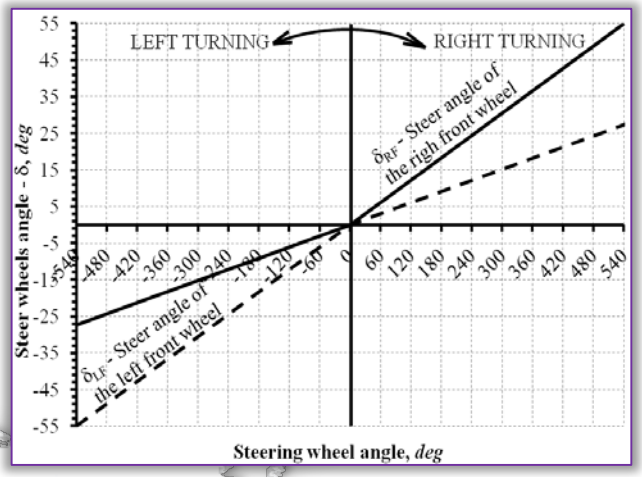

Figure 12: Steer angle of front wheels of 4WS

To have better maneuvering of the terrain vehicle required the wheels in rear axis to rotate around kingpin axe in the opposite direction with front wheels and in this case the rotation angles are not identical with the front wheels (Figure 13).

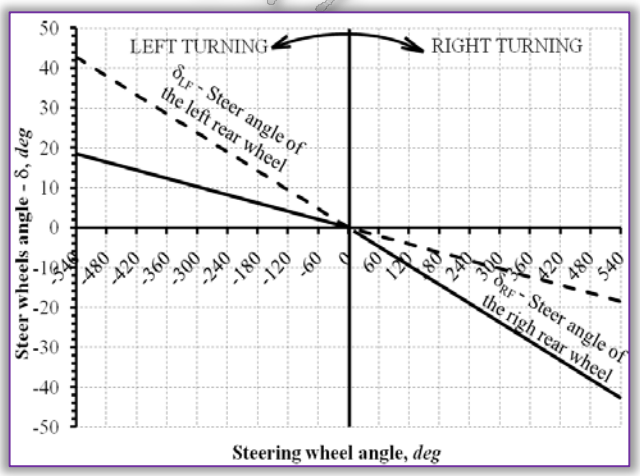

Figure 13: Steer angle of rear wheels of 4WS

To improve the stability of the terrain vehicle when it moves with high speed is necessary that the wheels in rear axis to lock and the vehicle will operate as conventional vehicles.

Expression (12) and (13) for determine left and right steer wheel angles on the front axis can given by matrix form through expression:

$$\begin{bmatrix}\delta_L\\ \delta_R\end{bmatrix}=\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}^{-1}*\begin{bmatrix}a\tan\left(\dfrac{2\cdot l}{2\cdot R_{2ws}-w}\right)\\ a\tan\left(\dfrac{2\cdot l}{2\cdot R_{2ws}+w}\right)\end{bmatrix} \quad (19)$$

After replacing values in expression (19) that are given in Table 1 by check list, steer wheels angles are:

$$\begin{bmatrix}\delta_L\\ \delta_R\end{bmatrix}=\begin{bmatrix}55\\ 34.59\end{bmatrix},deg \quad (20)$$

When vehicle turns on the left, driver turn on the left steering wheel for 540° and left front wheel will turn for 55° around kingpin axis. Transmission ratio will be 540°/55° = 9.82, while the right wheel will turn in same direction for 34.59° and also creates a transmission ratio of 540°/34.59° = 15.61, Figure 14. Transmission also will work as reduction and multiplication. The diapason of regulation of the transmission is different from 4WS:

$$D=\frac{i_{max}}{i_{min}}=\frac{15.61}{9.82}=1.59 \quad (21)$$

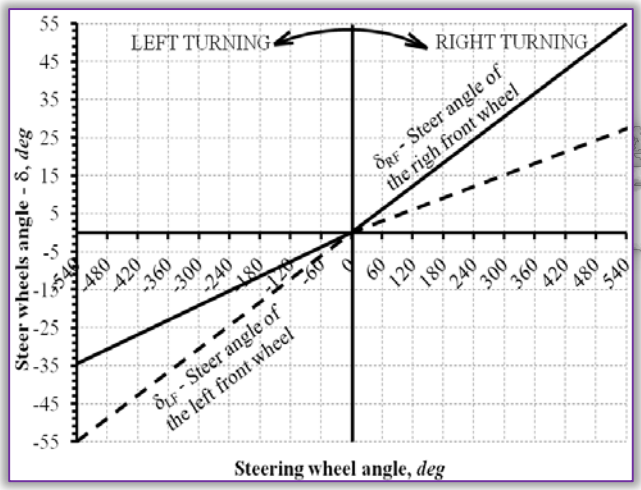

Figure 14: Steer angle of front wheels of 2WS

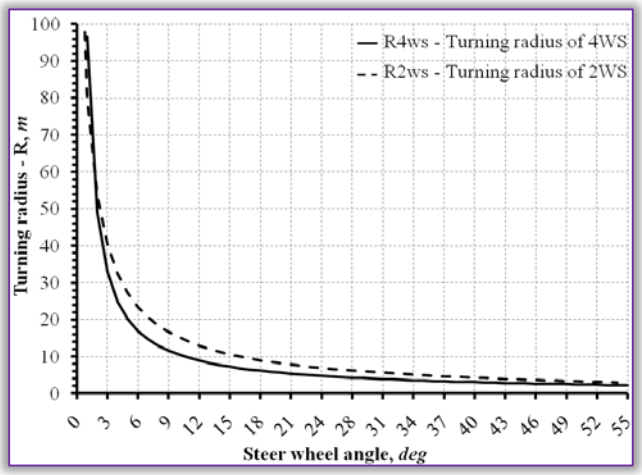

Figure 15: Turning radius versus steer wheel angle

In Figure 15 is presented diagram of changing the turning radius of the terrain vehicle versus steer wheel angle around kingpin axis when four wheel are steered (4WS) and the when only the front wheels is steered (2WS).

The diagram presented in Figure 15 shows that the turning radius is the smaller values when all the wheels are steer, thus ensure the best maneuvering the vehicle and also when the vehicle moves at high speed steer by lock rear axis, vehicle provides the better stability due to the increasing radius of the return.

CONCLUSIONS

In this paper the development of four wheels steered and four wheels driven terrain vehicle is presented. The special attention is focused on suspension and steering system. The following conclusions are presented:

- Presented suspension system developed for the terrain vehicle allows vertical displacement of the wheel up to 500 mm from lowest point to the maximum.
- Suspension system mechanism enables camber angle to be zero (γ=0) during the vertical movement of the wheel and directly increase stability of the vehicle.
- Terrain vehicle with four wheels steer has maneuvering advantage than front wheel steer only if its rear wheels can turn in the opposite direction to its front wheel, because only in that way have a relative reduction of the turning radius, and
- Stability of vehicle will increase by lock the steering of the rear wheels. That enables to the vehicle riding on the regular roads to behave as all other vehicles.

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INDUSTRIAL INFORMATION TECHNOLOGY – A REVOLUTIONARY FACTOR IN LOGISTICS

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Abstract: Within the new strategic industry development (fourth technological revolution) offers maximum use leading role of industrial information technologies, which are currently a major revolutionary factor of technological progress. The purpose of this article is not only to demonstrate the leading role of information technology in industrial activity, but also to propose an approach for the construction of optimization models for intelligent link between technological and logistical processes. This means that through technological and logistical compatibility using smart industries will share real information to better meet the ever increasing customer demands. This flexible technology and business development at a well-established logistics system will lead to greater individualization in the provision and use of intelligent and tailor-made industrial products and services. This qualitatively new step in computerization of technological and business processes is the basis for building a so-called "intelligent production".
Keywords: Intelligent Production, Industrial Logistics, Fourth Technological Revolution

INTRODUCTION : BUSINESS PROCESSES AND IT ENVIRONMENT

Development and linking of technology and business processes with a high degree of automation due to introduction of new information and communication technologies pose new challenges for the industry. These are new industries that are characterized by more efficient use of resources, ergonomic design flexibility of the production chain and integration of customers and partners in both manufacturing and business processes and those with added value in the entire business chain [2,4,5]. Development of the industry is closely linked with the maximum use of industrial information technology as a major revolutionary factor of progress. There are conditions to create intelligent production with technological and logistical compatibility and exchange of real information to better meet the ever increasing customer demands. Flexible build technology and business systems development, which will lead to greater customer satisfaction in the use of smart and tailored to the specific needs products and services [8,11]. Linking technology and business processes with a high degree of automation due to introduction of new information and communication technologies pose new challenges for them. This qualitatively new step in the information environment of technological and business processes is the basis for the construction of so-called intelligent production. These intelligent productions will feature in-effect resource use, ergonomic design, flexibility of the production chain and integration of customers and partners in both manufacturing and business processes and in those value-added along the entire business chain. The circuit integration is shown in Figure 1.

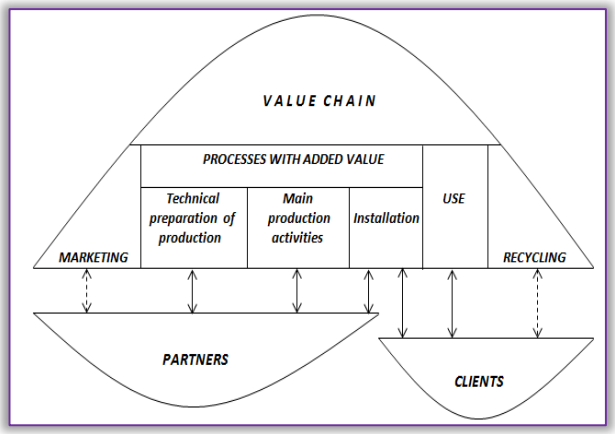

Figure 1. Chain of Integration

Practice has proved that in this whole process have important data standards. Almost all are already used uniform standards for data and Internet. It is used for internal data exchange between employees in companies. The correlation between data standards in operational and administrative areas is of great importance. In case of discrepancy of data standards leading to higher costs.

Intelligent proceedings are not only a technical challenge and technological change which will have lasting consequences organizational and creating opportunities for new production models and corporate concepts, but also a new concept of Network World. In the knowledge society, the Internet is to serve all needs, leading to a change in the definition of the needs of society, such as smart grids (Smart Grids), sustainable mobility concepts (Smart Mobility, Smart Logistics), social welfare (Smart Health) and new technological concepts. In the proceedings leading to increased intelligence products and systems in their network vertical and horizontal integration through the value chain of the product.

Or as a result of the rapid development of new networked world in the industry expect intelligent industries to develop in the direction of (in Figure 2):

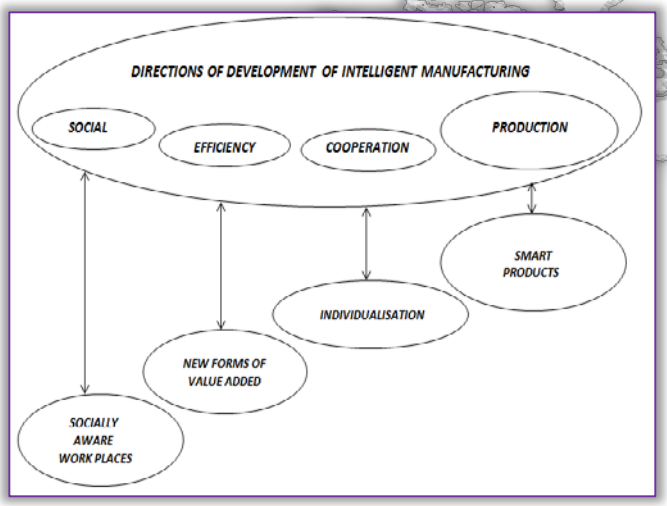

Figure 2. Directions of Development

First direction – Production:

» Production of intelligent products.
» Intelligent industrial methods.
» Intelligent processes (technology and logistics).
» The production and engineering processes can dynamically be designed so that the industry can change quickly and flexibly and to respond to disturbances.
» The production processes are fully transparent and provide optimal solutions.

Second direction – Cooperation:

» Satisfying individual customer requirements and even profitable to produce single items.
» Digital Network allows direct involvement of customer requirements and inexpensive customization of products and services.
» There is huge potential for new products, services and solutions.
» More intensive cooperation between business partners (suppliers and customers) as well as between employees, resulting in new opportunities and benefits.

Third direction – Efficiency:

» In the process of work can be created new forms of added value and new technology and business models.
» An opportunity to increase the efficiency of start-up small businesses, and to develop new services;
» It can respond to challenges such as resource saving and energy efficiency, urban production and demographic change;
» Resource productivity and efficiency can be improved along the whole chain of value creation.

Fourth direction – Social:

» Workplaces can meet the demographic factor and be socially involved.
» On the basis of intelligent systems support staff can focus on creative value-added activities and be exempt from routine tasks. Given the upcoming shortage of skilled workers as possible, thus the productivity of older workers to keep for a longer working life.
» Flexible work organization allows employees to better combine work and family life, and to combine it with better training and improve Work-Life-Balance (balance of life).

LOGISTIC MANUFACTURING SYSTEM AND BUSINESS ENVIRONMENT

Modern information system for automation of industrial activities in the companies was constructed in the following pyramidal form:

≡ at the base are automated process control (SCADA),
≡ in the middle are MES (Manufacturing Execution System),
≡ a tip of the pyramid ERP systems.

The boundaries of this pyramid of automation emerge primarily in the range of processing and data transmission. But with the development of industrial network components in the Internet of Things and Services (IoTS), processing will influence the amount of data. Growing volumes of data (Big Data) in the future will begin to create problems of business and corporate level because the higher level in the pyramid, the more reduced the rate of transmission.

ERP (Enterprise Resources Planning) systems are designed primarily for resource planning. Logistics is an integral part of this system, it is a module of this system. In the first years of this century appeared ERP

postmodern. It is a web-based software that provides employees and partners real-time access to ERP system itself [6,10]. These systems are synchronized with the dynamic technology and business processes that are part of lean manufacturing. Their Internet of Things enables direct communication of the ERP system with cyber-physical systems (CPS) and intelligent products at the manufacturing. This means that domestic production logistics system reacts as a module of the ERP system or technology and business processes have been adapted into a single market service. Connections of the ERP system with cyber-physical systems is illustrated in Figure 3.

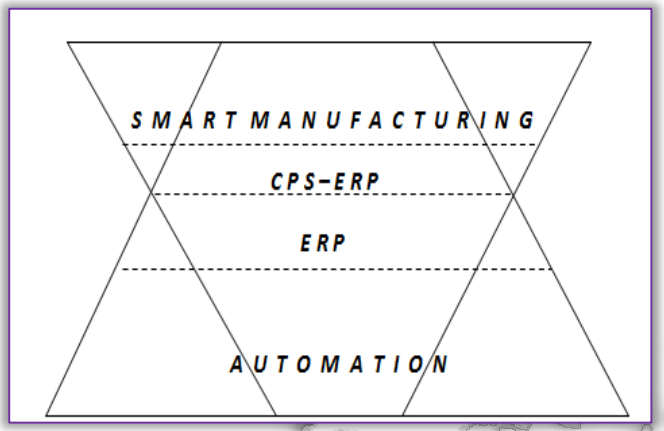

Figure 3.Links of ERP-system with CPS-system

Solutions for ERP-systems in businesses can use these new generation that are suitable for use in environmental conditions. This is an intelligent ERP-system using a service-oriented architecture (SOA), a service-oriented architecture (SOA). It allows to enjoy the facilities and services and other software vendors through standardized interfaces. Systems of this type are suitable for use in the rapidly changing technological processes applicable to flexible manufacturing. These might online connection with CPS (cyber physical systems) and intelligent products of stage production level [9,12,13].

With the use of in-memory databases, or large databases, sensors CPS can process all production information in real time. Or occurring any changes in the production is performed simulation and optimization using in-memory information technology, but in real time. When changing production processes, they can now be optimized much faster, more qualitative and better. Direct access to production data from the ERP-system provides greater transparency of technological and business processes of all individual orders [3]. These decisions are easier to perform as simulations and optimizations forecasts, which creates ERP-system are presented in a user-friendly way of easily accessible mobile devices. In addition, the new ERP-system leverages Cloud Computing for Internet access services (IOS). This part of the website includes services and functions that are implemented as web-based software components.

Characteristic about them is that sensors CPS can process all production information if changes occur in the production, respectively, and logistics, as soon optimization is performed in real time. Thus it is done quickly and flexibly optimize all processes on the scale of government [1,7,14].

Direct access to production data from the ERP-system ensures transparency of technological and business processes at all levels. So decisions become easier to implement, since the simulation and expected outcomes are easier and more accessible for use by mobile devices such as tablets or smartphones.

Now ERP-systems can react very quickly and provide integration modules. Figure 4 shows the connection of the module Logistics (Supply Chain Executions) with other modules of ERP-systems.

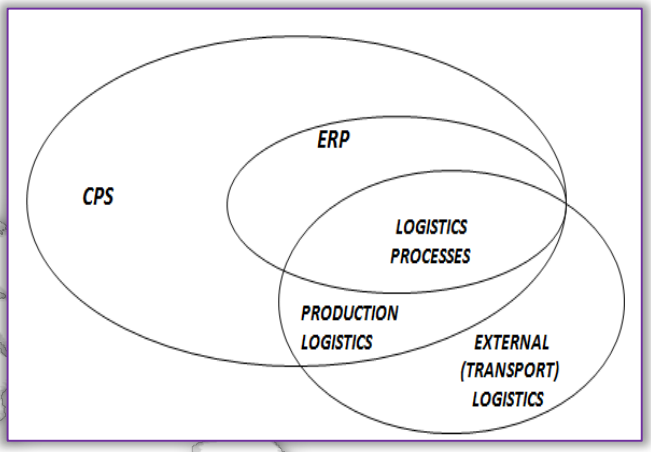

Figure 4. The Connection of Logistics Module with other Modules of ERP-Systems

CONCLUSIONS

Now can be drawn the following conclusions:

- Clarified is the leading role of industrial information technology in the creation of intelligent industries, which are currently a major revolutionary factor of technological progress.
- Clarified is the place of logistics and business processes in IT.
- Analyzed is the dependence and commitment to technological and business processes with a high degree of automation due to introduction of new information and communication technologies in industrial activities.
- ERP-systems are designed primarily for resource planning. Logistics is an integral part of this system, it is a module of this system.

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OPERATING EXAMINATION OF AN OFF-GRID SOLAR SYSTEM IN CASE OF INDUCTIVE NATURED LOADS

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Abstract: Two ways of solar energy utilization is distinguished. These are the so called passive and the active forms. Passive solar energy utilization means energetically more favourable orientation of buildings. The conscious building orientation is discernible since the ancient times, to take advantage of the solar radiation. In this publication after a short description of solar energy utilization, the temperature dependence of solar panels is described. A compiled off-grid solar system is also presented and the system efficiencies, maximum loads, current and voltage waveforms together with other measurement results in case of different load levels are described. The final system's operability and the switch-over are shown too.
Keywords: Solar energy, temperature dependence, off-grid, UPS

INTRODUCTION

Energy is one of the centre elements of our world. The renewable energy sources, mainly the Sun increasingly came to the view nowadays, so the subject of examining solar power production is very actual. The Sun is not only the base of ground life, but the central planet of our Solar System too. Fusion processes are taking place inside of the Sun, where hydrogen atoms combine into helium atoms. The weight loss (4 million ton/sec) that comes into being during the reaction transforms into energy. About180 million kWh energy is released during the formation of 1 kg helium. The energy of solar radiation is 1.37 kW/m^2 at the edge of our atmosphere, this is called solar constant. The energy of this solar radiation at the earth's surface is much lower, maximum 1.000 W/m^{2}can be measured at a sunny summer day. Third of this number is direct radiation and the rest is called scattered light [3, 7].

If the energy that reaches the top of the atmosphere counts as 100%, than the direct radiation on the surface is 33% while the scattered is only 18% of that energy. The sum of these two numbers means the global radiation. 10% of the global radiation is reflected by the surface. The composition of the radiation defines its usability [3, 7].

Two ways of solar energy utilization is distinguished. These are the so called passive and the active forms. Passive solar energy utilization means energetically more favourable orientation of buildings. The conscious building orientation is discernible since the ancient times, to take advantage of the solar radiation.

Active solar energy utilization happens with the help of solar panels. With these solar panels it is possible to produce electricity or directly heat from solar radiation. Heat production means heating water for different reasons. Energy production nowadays can happen even at the roof of a family house in an environmental friendly way.

As the internal resistance of solar panels is influenced by its temperature and the intensity as well, it is needed to set the same resistance as a load to produce the maximum electrical power [1, 2, 7].

TEMPERATURE DEPENDENCE OF SOLAR PANEL'S VOLTAGE AND CURRENT

U_{oc} open circuit voltage and I_{sc} short circuit current can be measured on solar panels. If any load is connected to the solar panels, the measureable I current and U voltage will always be lower than in case of no load. The I current is the difference between the dark current (I_{dark}) and the photo current (I_{photo}). The dark current exponentially depends on the temperature and linearly depends on the

I_s saturation current because of the semiconductor character of solar panels. This is described by the equation (1) [1, 4, 5]:

$$I = I_{dark} - I_{photo} = I_s\left[\exp\left(\frac{eU}{kT}\right) - 1\right] - I_{photo} \quad (1)$$

The short-circuit current (2) and the open circuit voltage (3) can be expressed by the substitution of$U=0$ and $I=0$.Open circuit voltage logarithmically depends on current values and linearly depends onU_T temperature dependent thermic voltage. According to these [1]:

$$I_{sc} = I_{photo}\,, \quad (2)$$

$$U_{oc} = \frac{kT}{e}\ln\left(\frac{I_{photo}}{I_s} + 1\right) = U_T\ln\left(\frac{I_{photo}}{I_s} + 1\right) \quad (3)$$

The U-I characteristics can be seen on Figure 1 in case of different intensities of illumination.

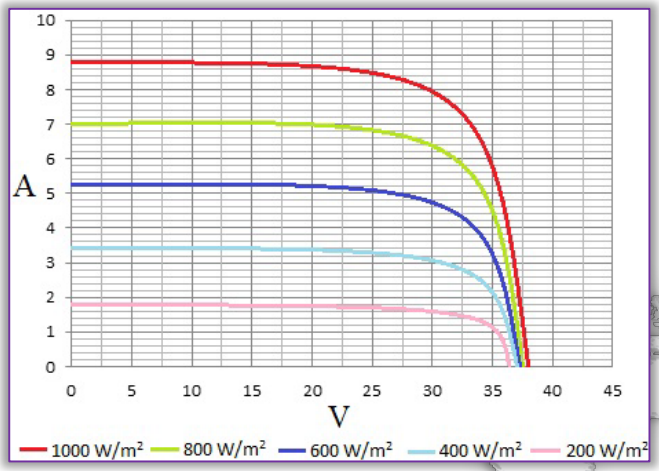

Figure 1- Voltage-amperage characteristics of solar panels in case of different intensities

It can be seen, that the short circuit current is directly proportional to the intensity of illumination, as the value of the photocurrent increases by light intensity increase and equation (2) says that the photocurrent equals to the short circuit current. It can also be seen in equation (3), that the idle voltage logarithmically depends on the intensity of illumination.

TEMPERATURE DEPENDENCE OF ELECTRICAL POWER AND EFFICIENCY

Effective electrical power (P) of the solar panel can be determined by the multiplication of the I amperage and U voltage measured on the R resistance [1, 4, 5]:

$$P = IU = I_{sc}U - I_sU\exp\left(\frac{U}{U_T} - 1\right) \quad (4)$$

To produce the maximum electrical power, it is needed to suit the electrical load. To find the extreme values of equation (3), it is needed to partially derive the function as the solution of the $\frac{\partial P}{\partial U} = 0$ equation is needed. The amperage of the operating point (5) and its voltage (6) can be determined this way [1, 4, 5]:

$$I_m = -\frac{U_m}{U_T}I_s\exp\frac{U_m}{U_T} \approx -I_{sc}\left(1 - \frac{U_T}{U_m}\right) \quad (5)$$

$$U_m = U_0 - U_T\ln\left(1 + \frac{U_m}{U_T}\right) \quad (6)$$

The optimal value of load can be determined from equation (5) according to Ohm's law [1, 4, 5]:

$$R_m = -\frac{U_m}{I_m} = \frac{U_T}{I_s\exp\left(\frac{U_m}{U_T}\right)} = \frac{U_T}{I_m + I_s + I_{sc}} \quad (7)$$

The value of load resistance ideally equals to the solar panel's internal resistance. The so called fill factor (φ) shows how the multiplication of operating voltage (U_m) and amperage (I_m) relate to the multiplication of open circuit voltage and short circuit amperage [4, 5]:

$$\varphi = \frac{U_mI_m}{U_{oc}I_{sc}} \quad (8)$$

The value of the fill factor depends on the illumination and the chosen operating point [4, 5,]. The value of the φ in case of solar panels used in practice, moves between 0.75 and 0.85. It can be seen that the fill factor shows how the square of the maximum operating power (grey square) relates to the square of the multiplication of I_{sc} and U_{oc} on Figure 2.

The maximum efficiency of the solar panel (η_{max})can be counted by dividing the maximum operating power of the solar panel and the light power (P_{light})on the effective surface [4, 5]:

$$\eta_{max} = \frac{I_mU_m}{P_{light}} = \frac{\varphi I_{sc}U_{oc}}{P_{light}} \quad (9)$$

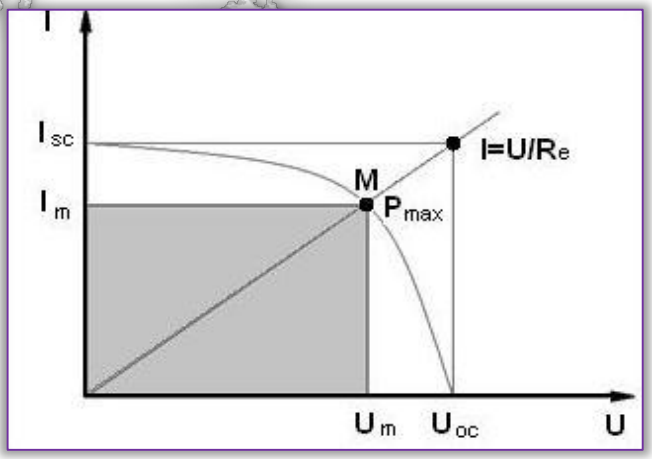

Figure 2-The operating point (OP) of maximum power on the U-I characteristic of solar panels

THE MEASURING SYSTEM

Measurements were made with two CFSR-SP250W polycrystalline solar panels operating in parallel. The maximum power of this kind of solar panel is 250 W, but the value of the electrical power is affected by the temperature dependence of the PV, the intensity of illumination, the resistance of the electrical load, the age of the solar panel and their orientation, so the power of

solar panels was measured too during the measurement, using MPPT (Maximum Power Point Tracking) charge controller, which follows and sets the right load resistance to produce maximum electrical power [6]. The two solar panels were placed on the roofing of the workshop hall at the University of Miskolc, as it can be seen on Figure 3.

Figure 3 -Solar panels used for the measurement

THE COMPILED SYSTEM

The solar cables, the battery and the inverter are directly connected to the charge controller. The maximum current of the charge controller is 30A and it was charging a 90 Ah, 12 V car battery with a maximum of 720 A start-up current. DC was transformed to AC by a maximum of 1 kW effective powered, 12 V inverter. The switching between the energy sources was provided by a US-12N automatic switching station. A boiler pump with 3 power levels and an electric drill was applied as electrical loads.

With the help of the right instruments, which were CAT analysers, it was possible to measure the voltage of the solar panels and the battery together with their current, on both DC and AC sides. The electrical power of the battery and the solar panels together with the efficiency of the system in case of different loads were measured too. The compiled system can be seen on Figure 4.

The compiled system proved to be functional. Blackouts were simulated by switching off the household power manually. As the effect of the simulated blackout, the switching station automatically switched-over to the alternative energy source, and the load device was operating flawlessly. When the household power was switched back on, the switching station switched back to that in a short time.

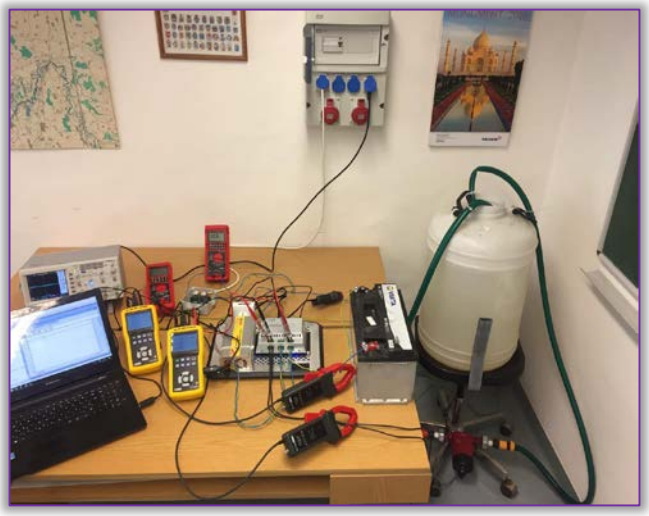

Figure 4 -The compiled measuring system

MEASUREMENT RESULTS

Efficiency measurement

During the efficiency measurement inductive natured loads were applied, like a boiler pump and an electric drill. The battery was disconnected from the system while the boiler pump operated, but in case of the drill it was connected too, because of the high amperage while starting-up. Table 1 contains the measurement results.

Table 1 – Efficiency measurement results

	Boiler Pump			Drill
	I. level	II. level	III. level	
P_{pv}	-17.1 W	-34.4 W	-57.5 W	-235 W
$P_{battery}$	0 W	0 W	0 W	-135 W
P_{load}	8 W	23 W	44 W	308 W
Efficiency	46.78%	66.86%	76.50%	83.24%

In case of connecting a greater load to the system than the maximum power of solar panels, the extra energy is provided by the battery. The last column of Table 1 contains the measurement results of this case.

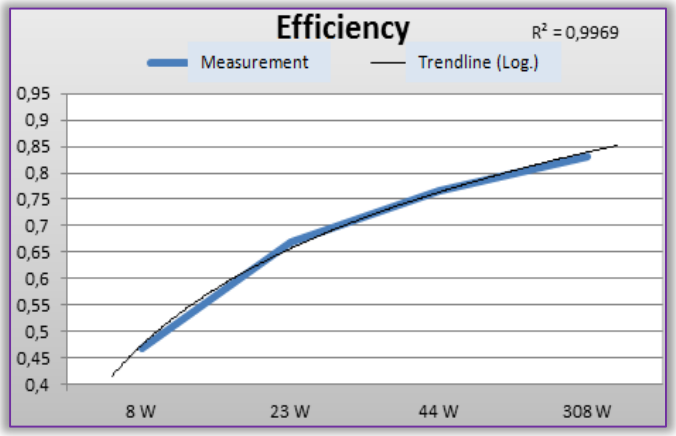

Figure 5 – System efficiencies in case of different loads

Figure 5 shows the system efficiencies in case of different loads. The efficiency of the system is almost the same as the efficiency of the inverter. It can be seen that

the increasing value of electrical load increases the efficiency of the inverter too, until the maximum power of the inverter is reached.

Current and voltage waveforms

The battery was connected to the system during the measurement of voltage and amperage of the boiler pump, which operated on maximum power.

Figure 6 contains the measurement results, where the darker line is the current while the lighter one is the voltage waveform. It is noticeable that the voltage of solar panels decreases exactly when its current increases, as the multiplication of these values give the power of solar panels.

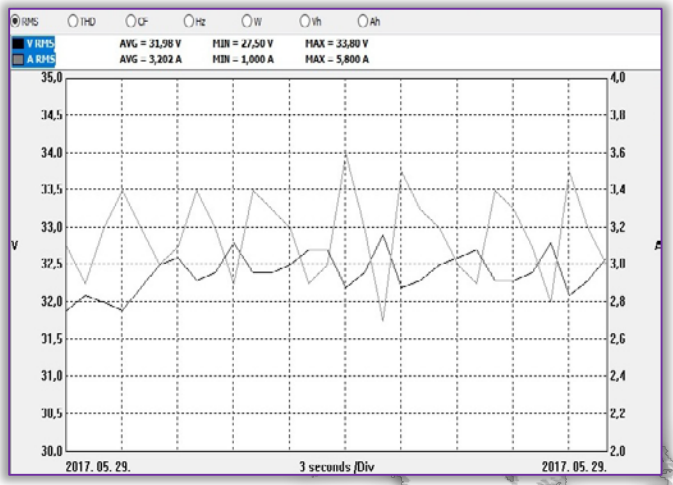

Figure 6 – Current and voltage waveforms

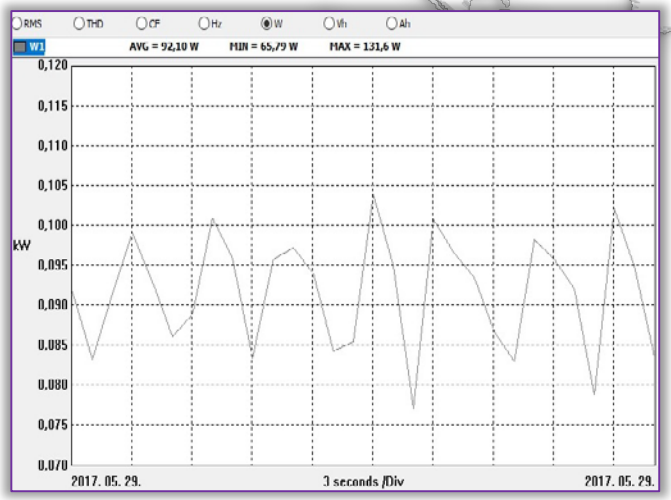

Figure 7 – The power of solar panels

Figure 7 shows that the average power of the solar panels was 92.1 W. The system used up 44 W to operate the boiler pump and 12 W to charge the battery. The rest power was power loss in the system.

The primary energy sources of the charge controller were the solar panels. At the time of the measurement, the maximum power of solar panels was 235 W, the rest energy that needed to operate was provided by the battery. The waveforms of solar panels were smoothed, as they provided their maximum power during the examination. Figure 8 shows these waveforms.

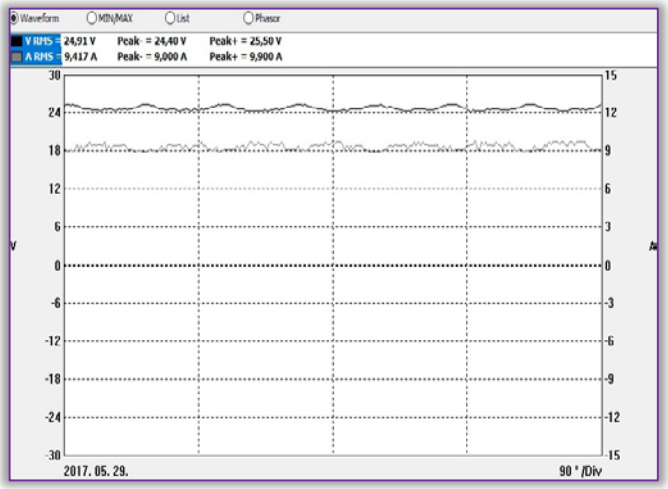

Figure 8 – Voltage and current of solar panels in case of operating a drill

Start-up current

Inductive natured electrical loads need high current while starting-up. Solar panels are not able to provide this high current, so it is provided by the battery during starting-up. Later on, during the operation of the boiler pump the solar panels provide the required electrical power. The waveform of this high current can be seen on Figure 9.

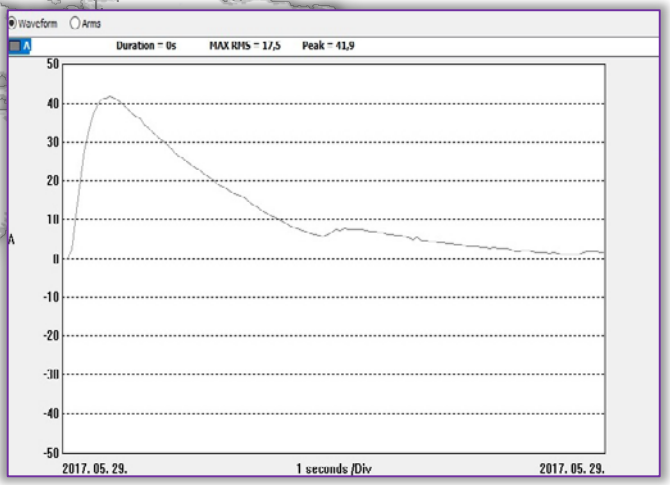

Figure 9 – Start-up current in case of operating a boiler pump

Figure 9 also shows that the maximum of this current is 42 A in case of the boiler pump. Operating the drill leads to higher start-up current with a similar waveform. In case of the 308 W electrical drill, this maximum amperage was 113 A, so it can be said that higher power requires higher start-up current too.

Switch-over

As an automatic switching station was also connected to the system, it was possible to create an uninterruptable power supply system. For this, it was needed to choose the household power as the primary and the inverter as the secondary energy source of the system. In case of a blackout, the operating of the device is assured by the alternative energy source. The effective voltage of

household power was 229 V, while in case of the inverter it was 237.5 V. Because of this effective voltage difference, the two energy sources are differentiable on Figure 10, where the switch-over can be seen. The blackout was simulated by turning off the circuit breaker of household power manually. The switch-over was so quick that the boiler pump did not turn off during it.

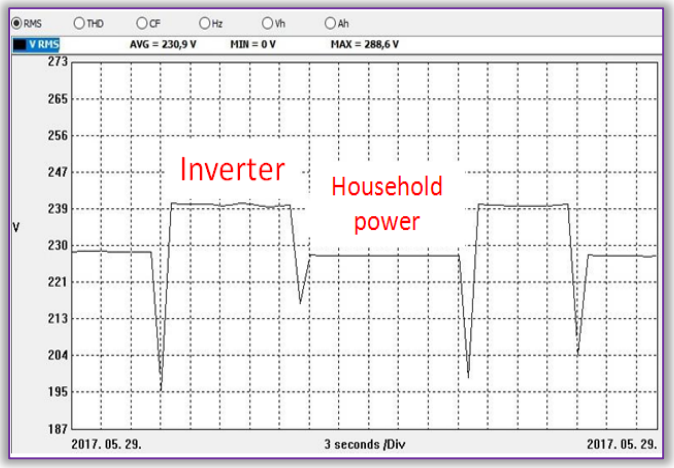

Figure 10 – Switching-over the energy sources

SUMMARY

The designed and compiled system proved to be functional. The MPPT mode is necessary for producing the maximum power because of the intensity and temperature dependence of solar panels, which can be counted by the mentioned equations above. It is important to find and set the internal resistance of solar panels as load resistance.

The blackout of the household power was simulated by switching off the circuit breaker of household power manually. The switching station automatically recognized it and switched-over to the alternative energy source until the blackout was over. This proved that the compiled system works as a safe uninterruptable power supply system (UPS).

As it can be seen, the battery is an important part of the system, because in case of inductive natured loads, the start-up current is provided by it. Also important to mention that the battery is the only part of the system that can store energy and provide it even at night, when there is no sunshine.

Nowadays it is very important to take care of our planet and solve the energy problem of the population. Solar energy together with other renewable energy utilization may be the solution of this problem but it is still needed to develop the current technology of solar energy utilization to reach higher efficiencies.

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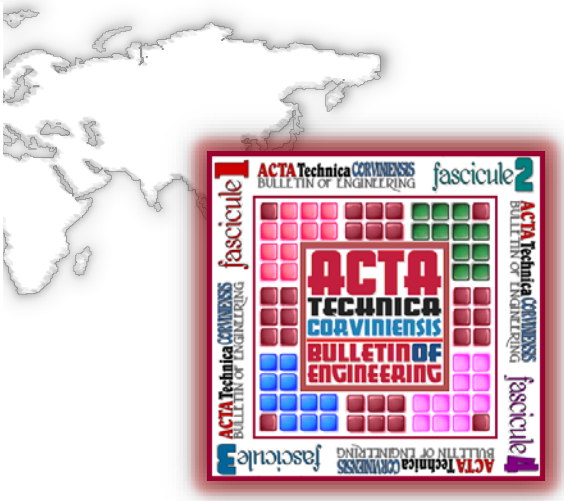

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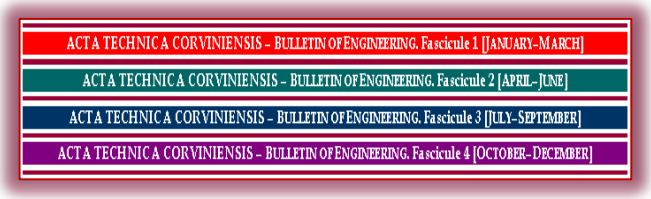
We are very pleased to inform that our international and interdisciplinary journal **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** completed its nine years of publication successfully [**issues of years 2008 –2016, Tome I–IX**].

In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm.

Every year, in four online issues (**fascicules 1 – 4**), **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** [**e-ISSN: 2067-3809**] publishes a series of reviews covering the most exciting and developing fields of science and technology. Each issue contains papers reviewed by international researchers who are experts in their fields. The result is a journal that gives the scientists and engineers the opportunity to keep informed of all the current developments in their own, and related, areas of research, ensuring the new ideas across an increasingly the interdisciplinary field.

Now, when will celebrate the tenth years anniversary of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!

On behalf of the Editorial Board and Scientific Committees of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we would like to thank the many people who helped make this journal successful. We thank all authors who submitted their work to **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**.



ACTA TECHNICA CORVINIENSIS
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INVESTIGATING THE CAUSES OF EARLY BUILDING DEFECTS IN FATARA HOUSING ESTATE IN NIGERIA

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Abstract: This study investigates the occurrence of early building defects in public housing estate Jigawa State, Nigeria. An early building defect is considered as those originate from poor workmanship or deficient materials used in the construction project, defects occur due to the fact that improper skills and care are assigned on the building. Defects can be caused by the wrong selection or specification of materials by the designers. Questionnaire method was selected to perform the study to meet the aim and to answer the research questions. As results, the respondents' feedback, the results indicate that defects such as crack caused by settlement (RII = 0.785), "dampness" (RII = 0.725), and "cracks" (RII = 0.710) as the common types of building defects observed in construction projects in that state. It can be concluded that proper communication is a necessary tool in building construction industry to provide communication between supervisors and construction labors, proper communication and teamwork are also necessary between contractors and subcontractors. Also, strict supervision is highly required for solving the problem of causes of early building defects in Jigawa State.
Keywords: Causes, Defects, Early building, Jigawa State, Nigeria

INTRODUCTION

Housing refers to buildings or other shelters in which people live. To most nations, housing is a critical component in their social and economic landscapes. It serves as a fundamental foreground of human needs. Being a unit of the environment, it has deep influence on the many things, such as health, efficiency, social behavior, and so on (Onibokun, 1998). A lot of us would see housing to mean shelter but to others it is the best hallmark for a person's standard of living and his or her status and position in the society (Nubi, 2008). Attaining a good living standard is a priority and thus, is important to the rural and urban people. Housing could be provided by the government, as well as through private developers.

Public housing is a form of housing provision, at the same time stressing the role of the government and its agencies in helping to fulfill housing requirements, especially for the disadvantaged groups in the society. The public housing or other descriptive terms, which are often used in its place such as social housing, state housing, state-sponsored housing, and so on (Van Vilet, 1990) had been one of the most prominent housing challenges worldwide and the forms are varied in different geographical contexts. Many countries have had to deal with the issue of adequate housing that has to be delivered to the various economic groups. Thus, in most of nations, housing was claimed as a problem. Despite the fact that many countries have a variety of materials allocated to urban-based residents, housing in developing countries like Nigeria is generally low in quality and less spacious than housing in developed countries, and government efforts to upgrade housing conditions have been showing slow progress.

Nigerian governments including states and local council have been providing public residential quarters since independence (Wazri & Roosli, 2013). These houses are often subject to early collapse which is linked with building or structural defects. Building defect suggests that there is an element constructed that has somehow violated the contract, or the result of some actions not authorized by the contract (Nigel, 1996). Summerlin and Ogborn (2006) opined that Building defects can result from manufacturing flaw, architects' erroneous designs,

and wrong installation of materials or a few others. When the standard materials specified in the contract is deficient and quality of workmanship inadequate, the building works are put at stake. Alan (1990) described building defects in building works as premature failure stemming from errors of workmanship, design, to name a few. In a legal context, a building defect is a violation of the applicable building code, the standard of care in the community in which the project is located, or that of the manufacturer's recommendations. Various studies have demonstrated that building defects are caused by activities associated with the construction processes. As it can be seen in the case in Fatara housing estate in Jigawa state, building defects are more pronounced in public housing.

Therefore, the agitating research question lies in the causes behind buildings' early defects? A study conducted by Assaf et al. (1996) stated that some major causes in early building defects are generated from civil design, architectural design, among others. However, in another way, Thomas et al. (1995) elaborated that contractors and designers are collectively responsible for causing early building defects occurred by wrong specification's, which are totally interpreted as faults of Architectural designers for not followed the specification which is the contractors' responsibility. Watt (1999) suggested that unsuitable materials applied to the building and poor expert decisions are causes of early defects. There are two dimensions for the term 'defect', a common term for a physical defect and for a process defect. It would be regarded as a physical defect when project documentation, a building material, a structure or a part of a structure lacks the expected abilities according to the construction contract, public requirements or good building practice. It is considered a process defect when the construction process is carried out in a way that represents a significant loss in resources or time. Jigawa state is one of the Nigeria's states that are very much provided with public housing for its various social groups. The focus of this study is to look into the immediate and remote causes of early building defects in Fatara Housing Estate, Jigawa State. This estate is less than two years' old since the commission but what is striking is that it already demonstrates a substantial degree of noticeable early obsolescence within and across the built structures.

In this context, the study was focused intensively on causes of early building defects, in Fatara housing estates in Jigawa State Nigeria. It was an attempted to find the answers to *why* this problem happens and how to avoid early defects in buildings. Building defect is one of the major components of building that requires serious attention, because when a building fails to perform as it should, there must be an immediate action to be taken towards this problem. The study is also attempted to find an answer to whether be possible for identifying someone to be the person responsible for the problem? Is the problem an act of nature? Was the proper maintenance of the building not performed as it should have been? Watt (1999) proposed on his study improper equipment used during the building construction and also bad making decisions by experts are the two causes for defects in building. Abdul Razak et al. (2010) had quoted from Pratt (2000) when he states the quality of Malaysia construction project is still below par. By contrast, through a survey of the 27 building projects which had been done by Andrew (1999), the "quality decline" would be caused by the "lack of skill", "lack of knowledge" of the site operative, "careless", "hard to build" and "unclear project information". To add, in a research that has been done in Singapore, "the most common defects found were pointing, hollowness in tiles, rough finishing, chip offs, evenness problem, cracks, stains, gap, and alignment out" during the construction phase and these defects are mainly due to the deteriorating quality of workmanship (Kiong and Pheng, 2005). Hence, it is necessary to identify the source of the problems and then find out some alternative for solution.

LITERATURE REVIEW

In building construction projects delivery, construction defects cannot be avoided and they are usually contentious between the parties which are directly involved. The qualities of a project which are unacceptable can be identified and remedied are the construction defects stage (Malleson, 2003). The construction industry still hails as one of the most dangerous industries due to the number of accidents reported every year (Jaselskis & Suazo, 1994). Studies by Lingard & Rowlinson (1994) and Spillane et al. (2011) reported that the construction industry in most developing and developed countries have been reviewed to be performing very poorly in the area of safety according to the international standards. Omran et al. (2010) added that the construction industry is globally characterized as one with a poor safety culture. Narrowing the scope of this study, a very serious safety problem facing Nigeria is the problem of building defects which occurs in respect of bad quality and poor workmanship. Defects in construction project can also encompass the incompliance or lack of conformity with the contract agreement.

The problem of defective construction as seen in the construction sector is tackled by the introduction of "Quality Assurance (QA) techniques" as has been initiated by other industries, however, the technique is still being improved to make sure that it is more adaptable for the construction companies. A study by Wai-Kiong & Sui Pheng (2005) claimed that the absence of incentive is the key factor that affects workmanship

quality. Defects in buildings can therefore arise from either one, or a combination of the occurrences in the following situations; faulty designs by the Architect, manufacturing flaws, material defects and many others. General forms of defects can be the defects in structure contributing to cracks or collapse, defects or faults in installations, inadequacy of drains, insufficient ventilation provision, and so on. In addition, defects in building may also be resulting from fungus, termite, or vermin infection to name but a few. Damages resulting from earth settlement or land movement can also destruct the building. The certainty over the defects in building can only be validated by experts, who will be able tell the crux of the problem, based on their training and experience.

EARLY BUILDING DEFECTS

Early building defects can be elaborated as faulty electrical wiring or defective and /or lighting; structural defects further causing cracks or collapse; inadequate or faulty ventilation; heating; and various others (Kenneth, 2002). Early building defects can contribute to serious or fatal injuries. Early on, most defects can be discovered through detectable symptoms. If not rectified the soonest possible, minor defects can become more serious, leading to even more grievous failure or sudden collapse, endangering lives and becoming more expensive to fix.

Even worse, these effects sometimes extend to the loss of human life, and loss of materials and capital investments, not to mention long-term psychological pains (Arayela and Adam, 2001). Buildings can start to collapse from the time they are complete, and ready for use and to that time when maintenance is needed. This gradual deterioration cannot be prevented, but the speed of deterioration can be slowed down judging from the way buildings are maintained (Olagunju, 2011). Thus, the rate of building deterioration depends largely on the nature and manner of maintenance. Poor building maintenance can contribute to the fragility of the building structure; most especially when unplanned maintenance is expected out of the building owner/user.

DEFECTS RELATED TO THE CONTRACTOR

In many occasions, contractors' failure to build according to plans and specifications or poor mixing and placement of concrete can largely contribute to structural defects. These actions often boil down to contractors' inexperience, lack of care or high profit pursuits. On the other hand, poor inspection of construction materials and mix ratio by the engineers may also spark the ill-intention of the contractors to undermine the importance of doing their job to prevent structural defects from occurring. Salty sand used to make concrete, substitute inferior steel for the original specified are some precursors to defects in buildings. Contractors and designers are the parties responsible for defects derived from poor specifications, which are generally the fault of designers but failures to comply with specifications can be placed on the contractors; there are the implied warranties on design and construction works that can protect the building owners from possible early building defects (Thomas et al., 1995). Khalid et al. (2006) agreed with the fact that the role of subcontractor can attribute to construction project deficiency of poor workmanship and a lots of people have overlooked this factor. Indeed, the role of the subcontractor is very important in the construction project, some serious issues in the co-ordination of work and attainment of quality standards (quoted from Shui On, 1991; Fan, 1994).

Since there are various types of subcontractors involved in the same construction project, the main contractor may have to deal with the difficulty in inspecting, supervising and controlling the works that have been done by the subcontractors. These primary causes may operate independently or in combination, and result in defects indicated by changes in the composition of materials. With regards to the care and conservation of historic buildings in Malaysia, Ahmad (2004) pointed out that understanding the nature of the building materials and accurate diagnosis of defects are very important. He associates historic buildings with older people, where both are vulnerable to various diseases. Therefore, in order to tackle this problem, conservators, architects, and others directly involved in building conservation should first adapt themselves to the building materials before penetrating into the proper techniques.

FACTORS CONTRIBUTED CAUSES OF EARLY BUILDING DEFECTS

A study by Abdul Rahman et al. (1996), had been mentioned some factors that contributed causes of early building defects. These factors are:

(i) Poor Project Management;
(ii)Complicated role of Subcontractor;
(iii) Lack of Experience and Competency of labors;
(iv) Language barrier to Communication and lack of Communication;
(v) Unsuitable Construction Equipment's;
(vi) Poor weather Condition;
(vii) Limited time; (viii) Limited cost; and
(ix) Poor Quality of Materials and Construction methods.

Dai et al. (2009) mentioned that ineptitude management is generally known as a major factor of poor construction productivity (Sanvido, 1988). It is further mentioned that the management factors may be explained by the lack of supervision on site. In fact, poor supervision on site can contribute to the poor site workmanship and it can be seen in many occasions on-site (Kasun and Janaka, 2006). Moreover, the ability of management on the construction site is the primary

cause that affects labors' daily productivity (Dai et al., 2009). Jha and Chockalingam (2009) stated that the quality of project manager is one of the causes that affect project quality (has quoted from Anderson, 1992). Concerning the complicated role of subcontractor, Khalid et al. (2006) stated that the role of subcontractor is one of the factors that contribute to construction deficiency (poor workmanship) and many people do not seem to be aware of this.

The role of the subcontractor is essential in construction work. This is because most of the site work is completed by subcontractors and the main contractors have full reliance on the subcontractors (Khalid et al., 2006). They further stated that roughly 90% of the site work is executed by various subcontractors whereas the main contractor stresses on management and coordination. Besides, Chan et al. (2006) had also mentioned that labor sub-contracting also creates severe problems in the co-ordination of work and attainment of quality standards (Shui On, 1991; Fan, 1994). Since there are various types of subcontractors involved, the inspection, supervision and controlling of the works that have been done by the subcontractors can become a major stumbling block. Therefore, the complicated role of subcontractors in construction projects can lead to poor workmanship.

Lack Experience and Competency of Labors

As mentioned by Kasun and Janaka (2006), productivity cannot be achieved by speed and harder work only without adopting better work practices (Banik, 1999). Besides, industry stakeholders have agreed that insufficient skilled manpower is the most important matter that they are concerned about (Jorge et al., 2005). In Turkey, Kazaz and Birgonul (2005), stated that some construction companies usually favor employing short-term unskilled labors and consequently have problems which relate to the quality of work produced. Hence, the lack of experience and competency of labors must be accounted for, as a contributing factor to poor workmanship.

Language Barrier to Communication and Lack of Communication

The language barrier between the foreign labors and local supervisors does contribute to the communication failure at the site. This is supported by Augusto et al. (2009) as they stated that the most general trouble faced by American site supervisors when communicating with the foreign subordinates is the language.

To add, from the work of Kasun and Janaka (2006), more than 40% of the respondents from the construction site had qualms about the lack of communication. Not understanding what the other one is saying can lead to some misunderstanding by the labors regarding their work and tasks, and this can easily lead to bad workmanship.

Unsuitable Construction Equipment's

The equipment used in the construction can also influence the workmanship quality in construction. Faisal et al. (2006) cited from Adrian (1983) and Al-Hazmi (1987) stated that the lack of the most recent information about equipment can influence the project quality. In a research done by Kazaz and Birgonul (2005) shed light on the poor quality of the housing projects for the public in Turkey. They confirmed that the dismal condition is mostly due to the low cost construction techniques which have been totally overlooked. Poor weather condition is another factors contribute to early defects. Dai et al. (2009) had pointed out that extreme climate condition can also affect labor productivity and workmanship in construction sites. Also, Faisal et al. (2006) who based on their study on the sites in Saudi Arabia, the Saudi's climate that is hot and severe during summer is the reason for the troubling construction work such as concreting. Insufficient time indicates that the project executed has to be rushed. According to Andrew (1999), a number of "show houses" on the site, which are very crucial for many construction projects, tend to be the products of hurried work. Due to such speed, the senior managers had to perform checking, which is inadequate.

Limited Cost

An inadequate allocation of cost in construction projects would easily determine the 'fate' of the project- the project will have to deal with insufficient cost. As labor cost is a fraction of the construction cost, Proverbs et al. (1999) point out that labor has been the most difficult component to price. Obviously, labor cost estimation has always been volatile (Proverbs et al., 1999). In addition, contractors who have not prepared enough budgets for the project will cause the labor cost to be reduced.

Consequently, the labor supplied to complete a project is not sufficient and there will be construction defects. According to Watt (1999), unsuitable materials applied to the building and poor expert decision making can also justify why a building would be defected. Nonetheless, Anand et al. (2003), propose in their study that better design could rectify some future issues in workmanship. BRE (1991) and Richardson (1990) had highlighted the importance of weather, environmental condition, soil impart, among other things. Calder (1997) has discovered that poorly worded specifications and unclear designs are also causes for building defects. Meanwhile, Seeley's (1987) study also mentioned that more than 50% of the defects were caused by faulty design, while a survey conducted by Ransom (1981) names poor design decision and poor material and workmanship. Josephson and Hammarlund (1999) further showed the chain effects of building defects, and they stressed on the importance of process control, management, knowledge, and the termination of the

chain reactions that would lead to early causes of building defects.

Inadequate information, unawareness, incorrect assumption, and lack of knowledge, also several organization and motivational factors also contribute to early defects, as stated by Sunyoto and Minato (2003). However, Ilozor et al. (2004) demonstrate that some defects tend to be the precursor to several other defects, and preventing them would be a wise move.

- **Poor Quality of Materials & Construction Methods**

The use of inferior material is also the contributor to building defect cases in Nigeria (Oyewande, 1992). Likewise, most block industries in this country tend to fail to use required measures and they need to be aware of this. Mohammed (2004) had asserted that the ideal measure is to blend a certain quantity of cement by weight with an appropriate quantity of sand, but most block molding industries in Nigeria prefer to go by volume. Such is the attitude of contractors, whose habit is to use materials that do not adhere to the standard requirements.

STEPS IN MINIMIZING AND PREVENTING OF EARLY BUILDING DEFECTS

There were six possible measures adopted to mitigate and prevent early building defects:

(i) strict supervision;
(ii) training and education;
(iii) proper communication among parties involved;
(iv) proper construction management;
(v) proper manpower management; and
(vi) proper design.

Concerning the strict supervision, Ghaffar et al. (2010), cited from Howell and Ballard (1998) had noted that quality enhancement by strict supervision at the site is one of the common features in the construction sector's recent practices. Daily supervision should be done by the contractors or subcontractors so issues regarding workmanship can be identified and the remedy work can be executed instantaneously. As supervision is performed, contractor supervisory staff must possess the necessary criteria to administer the construction work and monitor the craft worker efficiently (Maloney, 2002). With regard to training and education, Chan et al. (2006) stated that many researchers opined that appropriate training and enlarging experience are vital for quality project transfer. Similarly, Osama and Khan (2010) stated that labor productivity is becoming important in construction because of its impact on project completion. Proper Communication among Parties Involved was one of possible measures adopted to mitigate as it is an essential in construction. As found out by Augusto et al. (2009), 80% of the Hispanic workers in the U.S. construction sector claimed that the communication with the supervisors needs to be improved. Therefore, supervisors in America have suggested that the training in communication skills is carried out soon, to eradicate the language barrier formed among themselves and the foreign labors. Ling et al. (2007) stated that effective communication can help expedite the project completion (Walker and Walker, 1998). As Tai et al. (2009) mentioned that no communication means no management. Other than that, proper communication and teamwork are also vital to be developed between the contractors and subcontractors. With this ongoing communication among parties involved, working relationship among the construction parties can be better. Xiao and Proverbs (2002) have found that better quality performance of Japanese construction projects can be attained subsequent to the good working relationship between the contractors and subcontractors. Therefore, proper communication is very important to improve the relationship among members in the construction team, and consequently the workmanship quality in the domain of construction. Another possible measure to be adopted in mitigating early building defects is by providing a proper Construction Management.

A study by Olson (1982) stated that the capability of construction managers to organize the work would affect the constructions labor productivity. Therefore, it can be said that proper construction management is set to improve the workmanship quality in construction. Another measure can be through proper Manpower Management, a study by Robby et al. (2001) suggested that manpower management with regards to the amount and quality of skill workers is an important determinant of contractor performance, and this is one of the leading concerns of the employers. A construction project with proper manpower will produce a high quality project. Besides, Abdulaziz (2010) had mentioned that manpower is the sole productive resource; thus the total reliance of construction productivity to human Endeavour and performance is undisputable.

Therefore, the management of manpower in construction projects should be skillfully arranged. The last measures to be considered is the proper design, Wai Kiong and Sui Pheng (2005) found that better design is the solution to workmanship defects and a good way to avoid defects. Inadequately worded specifications and the continuously-changing designs are common causes for low construction quality (Calder, 1997). Wai Kiong et al. (2006) as quoted from Anand's et al. (2003) also stated that a better design may have the capability to correct some defects in masonry work. In addition, Robby et al. (2001) further stated that well-prepared designs and drawings can make future projects easier and the defects in particular, can be better identified and rectified.

RESEARCH METHOD

Questionnaire method was selected to perform the research to meet the objectives and to answer the research questions. The questionnaire was adopted from previous published studies, after they were modified to tailor for the study context. It had four sections; section one deals with the demographic profile of the respondents. Section two concerns with the common types of building defects, while section three was to identify the immediate causes of early building defects, and section four suggest some strategies that will help monitor the building defects in the early stage and foresee the defects.

The questionnaire for the study was measured based on a 5 point Likert scale, which is from 'strongly disagree' to 'strongly agree'. However, for the last part of the questionnaire, open-ended questions are included to elicit further details from respondents. The distribution of the survey instrument began on 6th February 2014 to Jigawa, Nigeria and the survey was completed on 10th March 2014. The data were collected through the self-administered questionnaires. Thus, the perceptions of the respondents toward the causes of early building defects in Fatara housing estate in Jigawa, Nigeria were obtained using the survey method. A total of 80 questionnaires were administered to the respondents. However, only 50 questionnaires were subsequently completed and retrieved for analysis, yielding 62.5% response rate. Various analyses techniques were run to authenticate the psychometric properties of the instruments used in this study.

The data collected were analyzed using the statistical package for social science (SPSS) version 20.0 for MS Window. First of all, the demographic profile of firm and respondent were analyzed using the frequency statistics. The Relative Importance Index (RII) is used for the following sections to describe in detail the statistical analysis performed in this study. Data obtained was screened prior to the frequency statistics.

RESULTS ANALYSIS AND DISCUSSION

Respondents Background

The data shows that male 45 (90%) while female are only 5 (10%). This proved that the population of male in professional in the study area is higher than that of female. Table (1) indicated 31-40 years are 27 (54.0%), then 41-50 years are 15 (30%), while 21-30 and 50 years above are equally the same 4 each (8%). The respondents' professional which indicated in Table (1) shows that Architect was the highest of 14 (28%), followed by Quantity surveyor and Engineer (24%). The data also shows that most workers had experience from 6-10 years 16 has (32%), 11-15 years 12 (24%), more than 20 years 10 (20%) and 6 each (12.0%) for 1-5 and 16-20 years. In term of qualification, Table (1) illustrated that the respondents who had BSc/HND 21 gets (42%), then 14 (28%), from MSc while PGD 9 has (18%) and ND 6 (12%).

Table 1. Frequency Distribution of Type of Professional

Items	Frequency	Percent
Age Group		
21-30 years	4	8%
31-40 years	27	54%
41-50 years	15	30%
50 years and above	4	8%
Type of professional		
Project manager	6	12%
Architect	14	28%
Engineer	12	24%
Quantity surveyor	12	24%
Builder	3	6%
Others	3	6%
Level of Education		
MSc	14	28%
PGD	9	18%
BSc/HND	21	42%
ND	6	12%
Respondents' background in respect of organization		
Building in residential & Non-residential Construction	28	(56%)
Infrastructure in civil engineering Construction	15	(30%)
Mechanical & Electrical	5	(10%)
Others	2	(4%)

Analysis the common types of Building defects in construction projects

As shown in Table (2), ten common types of building defects in the construction projects that identified. However, based on the respondents' feedback, the results of the Relative Important Index (RII) analysis indicates that Crack caused by Settlement was the first ranked types of defects with (RII = 0.785), followed by "dampness" with (RII = 0.725), then the third one was "cracks" with (RII = 0.710).

Table 2. The Common types of Building defects in construction

Factors	RII	Ranking
Crack caused by settlement	0.785	1
Dampness	0.725	2
Cracks	0.710	3
Peeling Paint	0.685	4
Shrinkage cracks	0.675	5
Durability of Cracks	0.645	6
Insect or Termite Infestation	0.615	7
Salt Attack	0.600	8
Cracks caused by structural distress	0.595	9
Wooden Defect	0.590	10

Factors causes of early building defects in construction projects

In order to determine or identify the causes early building defects there are twenty-one different kind causes have been identified and the RII results of the

respondents' feedback shown as the first among other listed items "Unsuitable construction equipment's (RII = 0.680), then the second was ranked "Lack experience and competency of labors" (RII = 0.655) and "Poor quality of materials" was ranked third (RII = 0.650), as per shown in Table (3).

Table 3. Immediate causes of early Building defects in construction projects

Factors	RII	Ranking
Unsuitable construction equipment's	0.680	1
Lack experience and competency of labor's	0.655	2
Poor quality of materials	0.650	3
Bad civil design	0.645	4
Poor project management	0.635	5
Improper construction method	0.625	6
Defects due to Specification	0.625	7
Bad Architectural design	0.620	8
In adequate project manager's work	0.615	9
Design issues on Maintenance Practicality and adequacy	0.610	10
Defects due to Consultant firm administration	0.600	11
In effective planning scheduling of projects	0.590	12
Complicated role of subcontractor	0.580	13
Poor weather condition	0.560	14
Conflicts between project manager and other parties	0.555	15
Limited cost	0.545	16
Frequent change of sub-contractors	0.540	17
Defects due to Construction drawing	0.525	18
Delay in sub-contractor work	0.515	19
Limited time	0.505	20
Language barrier to communication and lack of communication	0.505	21

Table 4. Strategies that can help in minimizing the defects

Factors	RII	Ranking
Good quality materials on site	0.745	1
Standard sub-contractor	0.740	2
Proper project planning and scheduling	0.725	3
Good project manager and experience	0.722	4
Proper design	0.690	5
Proper manpower management	0.675	6
Proper construction management	0.660	7
Make accurate initial cost estimate	0.650	8
Proper communication among parties involved	0.640	9
Proper equipment on site	0.635	10
Strict supervision	0.630	11
Training and education	0.625	12
Make frequent progress meeting	0.620	13
Proper emphasis on past experiences	0.595	14

Strategies for minimizing the defects in the early stage before it happens

In this section, fifteen factors were identified in relation with investigating the causes of early building defects but these fifteen item is the proposed strategy ways that can help to monitoring the defects in the early stage before it happens.

Table (4) presents the RII results of such factors ranking "Good quality materials on site" as the first factor with (RII = 0.745), followed by "Standard sub-contractor" second with (RII = 0.740), the third one "Proper project planning and scheduling" (RII = 0.725).

CONCLUSION AND RECOMMENDATIONS

This study investigated the occurrence of early building defects in public housing estate Jigawa State, Nigeria. There are three objectives of this research which has been achieved as follows. The first research objective was to identify the common type building defects. This objective was successfully investigated and achieved, where a total of ten common types of building defects were identified. With regard to the second objective, it was to identify immediate the causes of early Building defects in Fatara housing estate in the mentioned state in which identified twenty-one causes of early building defects.

The last objective was to recommend some strategies that can be used to minimize the early building defects in Fatara housing estate, Jigawa State so that to achieving improve performance on cost, time, quality, productivity and safety. Therefore, it needs a special attention in term of management because of the importance that it brings to construction industry in Implication of this study is that project managers and other stakeholders should take focus on these factors at the early stage of project proposal and planning; and when project have been awarded, all the construction teams must ensure strict compliance to the strategies put in place to manage the contributing success factors. Some general problems and common types of defects occurred in building cracking, spalling, and salt, peeling paint, insect or termite attack, erosion of mortar joints, wood defects and dampness. It is vital to recognize and diagnose the defect that occurs at various locations with deferent types of causes and symptoms.

Some factors were identified to be the immediate causes of early building defects such as workmanship quality and proper measure for minimizing and preventing were identified. These factors are poor management, complicated role of sub-contractor, lack of experience and competency of labors, language barrier to communication and lack of communication, unsuitable construction equipment, poor weather condition, limited time and cost.

From the above, it was concluded that:

- Proper communication is a necessary tool in building construction industry to provide communication between supervisors and construction labors, proper communication and teamwork are also necessary between contractors and subcontractors.
- Limited cost or fund for the public building projects was the major factor that causes of early building defects in Jigawa.
- All these factors identified are fairly important to be the only problem facing poor workmanship in Jigawa.
- Identified solutions to the problems are important based on the study with points and these are strict supervision, training and education, proper communication among parties involved, construction management and manpower management and quality with strong and positive correlation.
- Out of these solutions, strict supervision is highly required for solving the problem of causes of early building defects in Jigawa.

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A NEW DESIGN CONCEPT: BENCH FOR DAILY ACTIVITIES

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Abstract: This paper has the objective to propose a new Eco-design project and also to introduce the design project of an innovative product in order to improve the use of eco-design for daily activities. Because of the innovative nature of the project, a first study to assess the subject of the project is to be done. So, we focused our project on the activities of design. Before starting the design project, it is essential to propose a planning for every stage of the project from defining the needs to the CAD models. This planning takes place via Gantt chart to represent the different stages of the design process to do with the needed time. The first stage consists in defining the users' needs of the product. This could be realized by collecting the maximum of information to get a vision about the project. So, we made a survey for the users' bench. The next stage is the functional analysis to define the functions of the future product by analysing the different life cycle situations of the product. After that, the phase of creativity is started to find solutions by the design team and a choice of final solution is made. Finally, the final solution is described and evaluated using the predefined specifications document. Based on this evaluation, several modifications are imported to the design.
Keywords: design project, CAD models, bench for daily activities

INTRODUCTION

Eco-urbanism is a new approach to urban planning that is taking into account many restrictions (restraints and indicators) imposing the urban development on the environment. The adjustment degree of eco-friendly urban design is to be seen in every stage of urban planning [4, 7, 9]. Such decisions environment-conscious will lead to a sustainable city in this new information era. The sustainable city model is outlined by the morphology and its complexity [13, 15]. In this model, the city has a core based on different kind of knowledge and technology, maintaining the urban metabolism and the social cohesion [1, 6].

The products developed for performance and for a preferential life cycle are monitored through behaviour analysis within the range of an established period of time and are corrected via feedback in the project stages [13]. The eco-design is meant to deliver eco-friendly products [3, 9, 10]. Ecologically, the assessment of the quality of a product is based on the volume of the damages to the environment during the entire life cycle [11]. The assessment of the damages is a complex procedure that could extend production time and cost [2, 6, 14].

The eco-friendly project consist in different ways of action: the development of a methodology in order to assess the ecological impact; investigating, analysing and synthesizing the implementing procedures of the eco-friendly aspects in order to obtain higher performance in developing the product [1, 2, 6]. For higher eco-friendly performance of the eco-designed products there are used several methodologies, instruments and software, that are created based on the industrial eco-design.

ECO-FRIENDLY DESIGNING

The term urban furniture is used for items and equipment in the public space, installed for different purposes [5, 8, 12]. Urban furniture means benches, street lights, playgrounds, platforms, curb-stones, pavement endings, traffic lights, road signs, bus stations, tram stations, taxi stations, fountains, public statues, traffic barriers and trash cans [17].

The street lights, for example – in order to have spaces to be used during the night time the solution was to lighten them. The public spaces poorly lit are the most dangerous ones, because it is the place of the most crimes. The lighting could be general lighting or accent lighting. The general lighting is obtained in most cases

using tall lighting pillars, uniformly distributed in the public space. Their height is determined by the height of the constructions around [16, 17].
The defining elements of a public space must be outlined with accent lighting. To outline an item, the lighting must be placed very near. The most important elements of a public space are: the main building, the statue or the fountain in the square, an ensemble of buildings, vegetation, and urban furniture [12, 16].

MATERIAL AND METHOD

The paper is envisioning designing a concept for the Coltea park. The project is a bench with a lighting frame (figure 1). The purpose was to maintain the main theme of the park, therefore the design being very suggestive, inspired by the musical note of "two fourths".

Figure 1 – Side view of the piece

The material of this kind of furniture is recyclable plastic, very hard and resistant. This kind of furniture is meant for different purposes (figure 2). The round shape at its base serves as bench, the upper part is a pergola and the other side is open to the park.

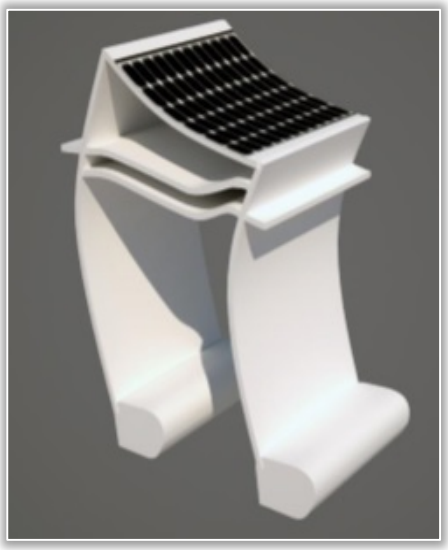

Figure 2 - Side view of the piece

The upper part consists in a solar panel in order to recharge the battery of a phone at the base. The exterior ends have also a lighting purpose at a height of 250 cm.

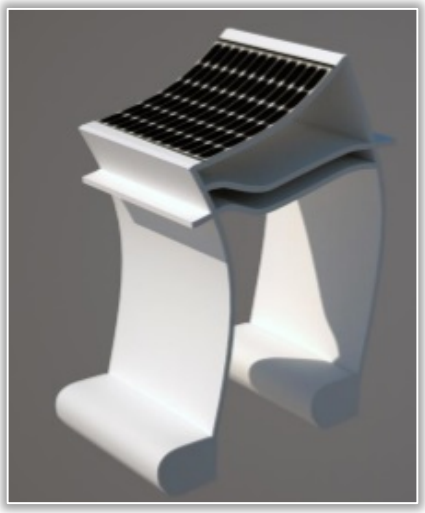

Figure 3 - Side view of the piece

The bench is 120 cm tall, with a width of 55 cm. The distance between the two benches is 150 cm (figure 3). The product is waterproof, easy to clean, flexible to design options, sustainable, better than wood, except the wood composite, and it's easy to paint and repair.

RESULTS

The recycled plastic products are very sustainable and need minimum maintenance. Moreover, these products can be re-recycled at the end of their life cycle (figure 4).

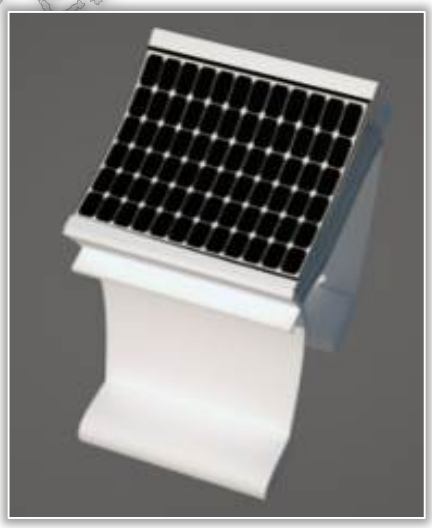

Figure 4 – View from above of the public bench concept

These materials are completely inert, presenting no leaks of chemicals in waters or soil, even in humid environments. The purchase of recycled plastic products stimulates the demand collected for recycling, materials that are saved from the landfill. Instead of being painted, the material is restored only where it presents tiny scratches (figure 5). These interventions do not diminish the product visually.

Figure 5 – Side view of the ensemble

Figure 6 – View of the ensemble with lighting

The light is essential for our wellbeing. A good lighting could transform for the better a room, a building, an item. Depending on the activities that are taking place in a certain space, we would need a direct lighting but also an indirect or diffuse lighting (figure 6). Our product totally respects the consumer's needs as the major component of the development process, strictly connected to the conception of a product, the selection of the best quality/price ratio, the testing of technical and aesthetic performance and also the competitive promotion on the market.

CONCLUSIONS

The innovation concept serves to design, develop and manufacture new products. These new products will have to be able to combine functionality, sensible fabrication methods, use of natural materials and an interface attractive and useful at the same time.

The developing of new products is an important, but risky activity. Usefulness means to meet certain physical and biological human needs at the level of performance for which the product has been conceived. Our product is no exception. Therefore, the ensemble has a usefulness based on the general human needs: to artificially create a good environment for different activities. From the usefulness we get to the end use of the product.

The ensemble is for large, crowded spaces, and without the natural light is the perfect product for those who are out after dark. As any new product, it must replace an old one. As such, an essential criterion is to introducing a new feature for the user's benefit or to enhance the technical performance of the previous product. Our product totally fulfils that request. Another important aspect is that the product must be innovative and attractive.

To develop a new concept is never an easy or direct activity; it requests careful research, right planning, and deep control. Therefore, it is a multidisciplinary approach, with methods form marketing, engineering and industrial design. Combining social sciences, technology and practical arts is never easy, but mandatory in order to meet the demand.

No matter the product, it must be very careful designed in order to be efficient. It must be comfortable, inexpensive, easy to use or repair, simple, economical, ready to be manufactured and distributed in order to have a powerful advantage on a competitive market.

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USE OF MONITORING SYSTEM IN THE PRODUCTION PROCESS

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Abstract: An essential step in this process should be made aware of the risks, the identification and analysis. This awareness is the first step towards the preventive measures taken to minimize risks and prevent such potential crisis phenomena in production. The current situation in all the European and world markets is that firms have to operate at full throttle and able to produce competitive products with low price and good quality. Companies still have to invest a lot of money to innovate technology park and marketing in order to remain on the market.
Keywords: monitoring system, technological arrangement, Layout question

INTRODUCTION

Production is business activity, within which to transform the inputs into outputs, creating a final product that is a finished product. In the process of production is the creation of material goods to the company to ensure coverage of production costs and their own profit. Business in manufacturing is very diverse activities. Each product and therefore each manufacturing process require other technologies, procedures, other material, technical and personnel support. However, regardless of the technology used in each production process there is a potential for the existence of a risk. As in other areas of social and economic life, and in the production of the tendency to ongoing modernization and improvement of the production process. These trends are realized through automation and robotics manufacturing.

Simultaneously with higher levels of technology, machinery and equipment is increasing but also the level of risks that follow from them. In addition to efforts to manufacturing plant to achieve the greatest profits take the best place in the market and secure the long-term prosperity, it is necessary to focus our attention on the risk aspect of production. An essential step in this process should be made aware of the risks, the identification and analysis. This awareness is the first step towards the preventive measures taken to minimize risks and prevent such potential crisis phenomena in production.

MONITORING THE PRODUCTION PROCESS

Monitoring is an important part of the manufacturing process, which streamlines. The monitoring system is beneficial not only for the management of the company, which receives regular reports from the production, but also for the actual use of machines having the imaging located nearby to-date information (production plan, number of units, number of units yet to be produced, etc.). The production plan is entered to the display via a web application that is accessible from the designated points on the local network (access is protected by username and password).

Today clearly stands out interested companies reduce costs, increase efficiency and profitability of work. Manufacturing enterprises are under increasing pressure to reduce production costs. More are forced to optimize their production processes and increase productivity of manufacturing processes, people and material. This is reflected in high demands on the manufacturing management in terms of management and production planning. For the right decision, it is necessary to have information on the critical points in production can know the real production capacity, various downtime and losses arising under specific conditions and combination of different variants. This can be achieved only on the basis of a good overview of all parts of the workforce. In any production losses arise which make it impossible to achieve the maximum possible theoretical performance of production and maintenance.

The monitoring system allows not only to collect data from the production (information on whether the machine is or is not in service, the number of units and the like.) As well as report a variety of disorders. This function can be implemented using special controls called switchbox. Faults can be displayed on the central panel. Another option is sending messages Fault

designated group of workers via SMS or email. Of course there is audio-visual fault signaling directly on the machine. This feature speeds up troubleshooting and streamlines the entire production process, figure 1.

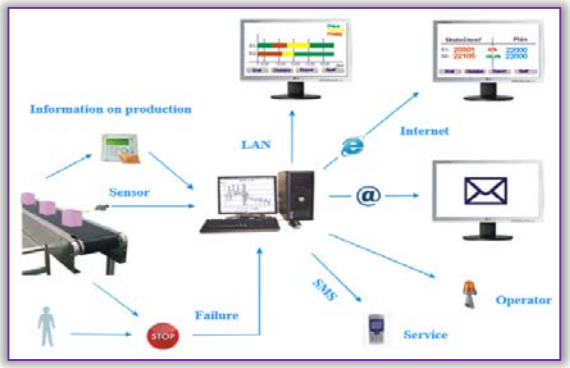

Figure 1: Signaling directly on the machine

An important part of the system for monitoring the production of the display device. The most commonly used combination of resistant LCD and LED panels. LCD panels are used for shorter viewing distances (designed primarily for operators). As a central display that includes comprehensive information on production, it is appropriate to use a large LED panels because they are read to tens to hundreds of meters, which is on the premises of large production halls welcome feature. The source signal can be any PC equipped with a video output if necessary the panel may be provided with its own control unit connected to the computer network company (including WiFi), where it will automatically draws data on the display –eg.from the corporate information system. If within the system and obtain the necessary information, it can be assembled viewer and controller easily supplemented by enabling data input terminals of any production site. These terminals can be either simple, with few buttons to manually enter information service, or can be equipped with its own small computer screen and barcode scanner or RFID tags to complex input, if necessary fully automatic, linked by means of sensors and channels of communication directly to a production facility. It drives the system not only displays information but also to collect and report processing.

THE BENEFITS OF MONITORING THE EFFICIENCY OF PRODUCTION

Monitor the effectiveness of production is a tool that helps the company management to monitor and evaluate manufacturing processes within the company. It helps to analyze weaknesses and reserves. Of course, some loss of production and maintenance cannot be completely removed, but the great majority of these have influence. Monitoring the effectiveness of industrial machines, the system is focused on the production process, from which it receives information leading to the possibility of improving its profitability. It provides a better overview of production, downtime and its causes, the performance of the machine and the operator.

The production monitoring, product performance machines and their use of time is used for operational monitoring and evaluation:

- production and productivity of the machines, plants,
- finding reserves and savings opportunities,
- the work of individual professions,
- the work of individual employees with the possibility of creating a payroll service,
- moving the products on a production line
- various stages of production
- failure of machinery, evaluation repair service.

Tracking system offers advantages like efficiency:

- determining the actual performance of the machine by means of objective indicators obtained,
- the pursuit and achievement of the required system parameters and workload,
- recognizing the potential to optimize production through increasing transparency,
- extension of trouble-free operation of the machine by means of targeted measures for the evaluation of the production cycle,
- quick response to faults or organizational shortcomings on the basis of evaluation of the state machine,
- shortening times to repair equipment during maintenance, due to the rapid acquisition of the causes of failure.

Monitoring data, conditions:

- manufactured product,
- number hassle,
- length of downtime,
- length and type of fault,
- speed of response services,
- consumption monitoring computer time, man-hours and other costs.

Evaluation - a variety of data analysis and evaluation:

- worker at his machine sees the size of its production,
- production manager has an overview of the production flow and provide an overview of the reserves,
- reports for managers,
- daily production statistics interim results,
- materials for creating real and preliminary calculations,
- the current situation can be viewed through a corporate network or the Internet,
- outputs can also be effectively used in the calculation of wages.

Inputs to the system:

- automatic processing status monitoring / sensors via contactless identification elements,

- manually enter information into the system, for example. position switch,
- manually entering the monitored state through the operator panel / creating databases,
- through barcodes.

MANAGEMENT OF WORK IN PRODUCTION AND POSITION OF MAN IN PRODUCTION

The labor force is the decisive factor in active production. Its role is further enhanced in the context of the technical-scientific development, leading to the growth of mechanization and automation of manufacture and with regard to the equipment of the worker to the growth technique. The sum of all input elements of production, however, is only the possibility of achieving a useful effect. Obtaining factual effect depends on the level of skills and abilities of individuals. Production automation, using computer technology, new technology and rapid product innovation leading to increased complexity of the work required and therefore to the ability to mobilize human. Placed on the workers of cell new requirements such as the ability to adapt to changing conditions, occupational mobility, the ability to upgrade their skills or retrain. It turns out that the development and use of qualifications are equally or even more important factor for development as an investment.

Competition requires continuous improvement of production and the products and reduces costs. This is possible only with the active participation of all workers in improving the work of the company. To ensure high production efficiency has a significant potential increase in activation of the human factor. Factors influencing the activation of the human factor in production are mainly educational system, social conditions, work incentive system and work management. Increasingly complex and very expensive production systems require paying attention to issues of human reliability in the system of human-machine- working environment. Practice shows that man is the most important, but also 'the weakest link in the system. Reliability of man lies in his ability to perform the required tasks (functions) with the requisite accuracy at the time and under the given operating conditions.

Reliability man is given by the probability of faultless work. Failure of man consists in full or partial incapacitation and may be due to internal causes (eg. Non-registration of change of incentives, poor identification initiative, unresolved complaint ignorance of the correct response to a stimulus) or external causes (eg. Unergonomic addressing machine, inadequate working environment etc.). It is necessary to examine the causes and consequences of human failure and to seek ways of increasing its reliability. Increase human reliability it is achieved mainly: removal of ergonomic machine failure, optimizing the working environment and working methods and the introduction of mechanization and automation of production. Human reliability issues are mainly in modern productions of great importance and economic security. Therefore they should be given special attention. The issue of employment is engaged in a number of sciences work, including in particular psychology of work, sociology of work, labor economics, labor law, ergonomics etc. Production management, which is an important part of the organization of work, must be used the knowledge of all these disciplines.

Work organization is looking for the optimal alignment of human activity and technology in production so that the working and material resources were best used to achieve a high production efficiency and to ensure the protection of human health. Labour Organisation assumes that determines the appropriate qualitative and quantitative proportions between different types of work, the choice of an appropriate division of labor and cooperation.

The division of labor is a division of work on certain parts that are attributed as workloads work teams or employees. Cooperation work is to be bonded sub-part of the working process in individual work processes being coupled in various sectors of work, resulting in the final product. Both as a division of labor as well as cooperation work interact. The division of labor has a significant impact on the production structure of the company, qualifications and profession personnel structure as well as the number and composition of work. Cooperation and division of labor depends on the development of techniques and technology. A degree of development and technology conform to the appropriate division of labor and cooperation.

CONDUCT A WORKPLACE LAYOUT

When we know what we produce, we have to rethink what we start. Each unit can be broken down into groups, subgroups, parts to components. At the same time the simplest element in the product made from one piece of material or blank. It is part of several connected components. Sub-group consists of a number of parts and components. The group is composed of several sub-groups, as well as parts and of the parts, and the like and the whole is made up of several groups, and individual parts and components. Such a breakdown product is best represented graphically, so to see follow-up of production processes. Also shown is said assembly diagram of the product. Furthermore, the technologist estimates or calculates the duration of each procedure of the assembly diagram. All this then recorded in a chart of line, wherein the bars represent the different duration. The Explodes into line graph is a tree-like branched, so it is called herringbone diagram. See Opinions timing of the production in an arbitrary unit of time. The spatial structure of the production system is

formed by determining the proportional relationship between elements of the system particularly with regard to forms of working arrangements, funding, and distribution of labor resources, labor and objects of labor, the relative distribution of production and other areas necessary for the implementation of the production process.

Proposal spatial structure of production is thus technological - organizational solutions of the production process in a limited area with respect to a given range and volume of production. We must in fact take into account the particular conditions:

- High-quality, cost and timely production.
- Ergonomically correct.
- Easy control and process control.
- Easy and economical handling of materials, tools, waste.

In practice there are two basic types of spatial structure of production:

- Technological arrangement – consists of clusters of technology jobs to the resort by common technologies (eg. lathes, to lathing presses to mill etc.). Technological arrangement is characterized mainly universality (exchangeability machines and flexible adaptation to changing production program) and therefore applies especially to we produce, figure 2.

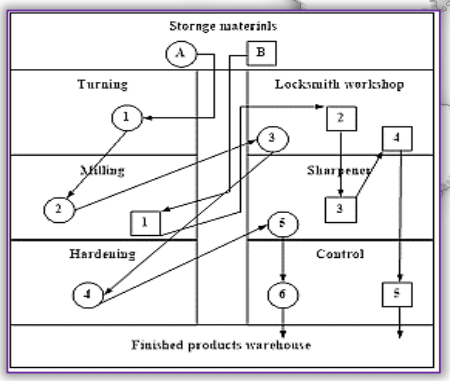

Figure 2: Technological arrangement

- Layout question – is also where the relevant space technology behind grouped by subject produced during a particular operation. Objects of arrangement is particularly characterized by its purposeful specialization (short interim period, and easy management of production at the cost of higher investment costs and the difficulty of change in the production program) and therefore applies especially in the field of higher series. It can be said that it is preferably the one method, the disadvantage of the other and vice versa. Decision should depend on the production program and production volumes, figure 3.

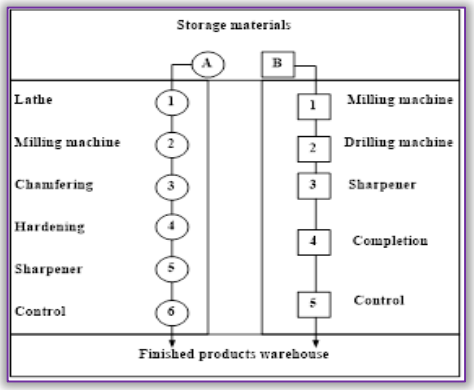

Figure 3: Layout question

CONCLUSION

After short-term operational experience with a well-designed system of collection and presentation of information from production appear before the first results in the form of improved continuity of work, improving production quality and to reduce outages due to breakdowns or restrictions in some parts of the production chain. In addition, such a system could become one of the elements of an integrated monitoring and control system of the company, it combines information on production status and production facilities and make them as data on energy consumption, enabling the design of measures to achieve savings while maintaining the volume and quality of production.

Acknowledgement

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SUSTAINING THE NIGERIA POWER PROJECTS IN THE FACE OF DWINDLING GAS INVESTMENT

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Abstract: Natural gas development in Nigeria is currently facing numerous challenges amid growing competition from shale gas, coal bed methane and tight gas in the U.S., Europe and China. This has undoubtedly had some damning economic implications for the Nigerian gas market whose major patronage have traditionally been the US and Europe. According to a recent report published by Nigerian National Petroleum Company (NNPC), the gas market in Nigeria witnessed sharp drop in 2012 when virtually no single export was made to US as a result of shale gas currently being developed in that country. This continuous decline in gas export to US and Europe may further worsen power project development in Nigeria due to other challenging issues like pipeline vandalism, youth restiveness in the Niger-Delta and un-harmonised government policies. Couple with the fact that crude oil production has witnessed significant drop in Nigeria due to low oil price and glut in the global market, it may be of utmost interest to explore viable gas utilization option with a view to promote further investment in gas business. Sustainability of Nigeria power sector depends largely on power plants which are driven by gas and the current power outage in Nigeria may not be unconnected with gas shortage to power these power plants. In this study, the authors x-ray sustainable gas utilization option aimed at promoting gas export, boasting investors' confidence in Nigeria gas market and the authors equally beam searchlight on government's policies that are inimical to the free gas market among other pressing issue. Part of the conclusion drawn from the research reinforces the need to widen gas utilization options most especially in the area of Gas-to-Liquid (GTL) conversion technology in order to sustain electricity generation in Nigeria.
Keywords: Natural gas, electricity generation, crude oil production, sustainable gas utilization, future gas investment

INTRODUCTION

Global energy consumption is expected to witness unprecedented rise by 2035 going by the research published by Nwaoha and Wood (2014) and the percentage increase may surpass 40% in view of emerging power demand in developing countries of the world. Of critical attention is the trend in low investment in gas reserves globally as a result of low crude oil price and global economy slowdown.

Nigeria remains a rallying point for gas reserves globally and their energy deficit equally needs attention which cannot be met alone by crude oil production (Economides and Wood, 2009). Nigeria gas reserves alone as at 2012 stood at180TCF (trillion cubic feet) and this projection is expected to rise considering new discovery in some part of the country (Anejionu et al., 2015, Oyedepo, 2014). This huge abundance of natural gas resources need to be fully explored to meet the growing and increasing demand for electricity both locally and in the neighbouring countries of Africa (Loe and Ladehaug, 2012).

Nigeria gas reserve is illustrated in Figure 1 depicting a potential that has the capacity of sustaining a long term investment in gas market. As reported in the some literatures (Fawole et al., 2016, Soltanieh et al., 2016), Nigeria's population as at 2012 was in the range of 169 million people compared to 45.2 million in 1960 with a projection to exceed 200million population by 2030. This prediction places a huge burden on the existing infrastructure most importantly energy demand as power supply continues to be a major obstacle to industrialization in Nigeria.

The impact of natural gas to bridge the growing energy deficit in Nigeria remain undebatable if proper roadmap are available to provide a sustainable gas development in Nigeria. Shale gas exploration in US may be an initial setback to gas development in Nigeria but this unconventional gas may not after all stay for next decade

as the production may decline in face of growing demand (Zou et al., 2010). Key of the challenges of gas development in Nigeria has to do with transportation and storage as these further compound gas delivery when compared with oil, and this may have contributed to its minimum utilisation for a considerable period most especially in Nigeria (Courson et al., 2000, Akinbami et al., 2001). The global gas market has improved drastically in the last twenty years and the market continues to enlarge in leap and bound when compared with other conventional fuels (Economides and Wood, 2009).

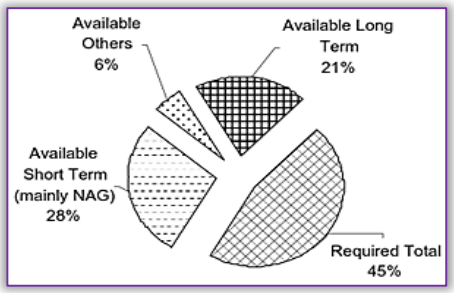

Figure 1: Potential gas reserves and demand balance. Adapted from Odumugbo (2010)

Currently, natural gas remains the third largest energy source globally and it is predicted to overtake crude oil if sustainable roadmap is developed in the management of gas and this may bring the gas demand and consumption to increase substantially in coming years (Hekkert et al., 2005). The current stop-gap in gas investment may be a temporary setback as literatures (Makogon et al., 2007, Makogon, 2010) continue to project gas as sustainable energy for the future. Part of the added advantages of gas energy is its availability, versatility and also reported (Leather et al., 2013) to be cleaner when compared with coal and crude oil.

In line with further submission reported by Economides and Wood (2009), these authors also aligned with other authors (Thomas and Dawe, 2003, Akansu et al., 2004) on the attractive property of natural gas being cleanest in terms of combustion among other convectional fuel and has a tendency to produce high grade energy conversion efficiency when adapted for energy generation in combined cycle power turbines.

One of the paramount concern militating against the exploitation of gas reserves is the delivery mechanism which remain an issue that have not been completely resolved. Natural gas must be conveyed from its production source to market base where demand exists and of great concern to this delivery system is that the infrastructures are completely expensive and available methods are generally cumbersome. According to Odumugbo (2010), virtually 40 to 60% of the world gas reserves are stranded in the sense that their locations are remote and the available methods to convey them to the market base are prohibitive. These delivery infrastructures may hinder huge proportion Nigeria gas reserve from getting to the market for further application based on the survey conducted by (Gudmundsson and Graff, 2003) and this may also affect over 80% of new gas discoveries in Nigeria as large deposit of these reserves are located offshore. This barrier may have necessitated large volume of gas flared from 1999 to 2009 as illustrated in Figure 2 with the proportion of gas flared to gas conveyed to the market shown in Figure 3.

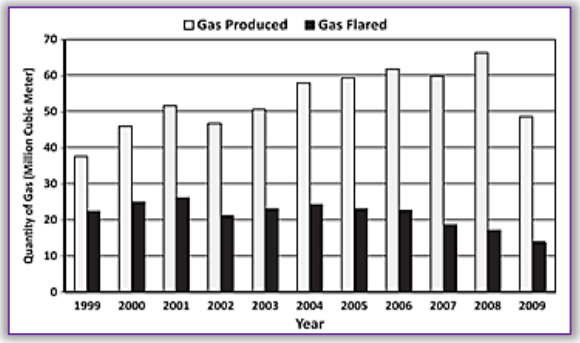

Figure 2: Proportion of gas produced and gas flared in Nigeria from 1999 to 2009. Adapted from Anomohanran (2012)

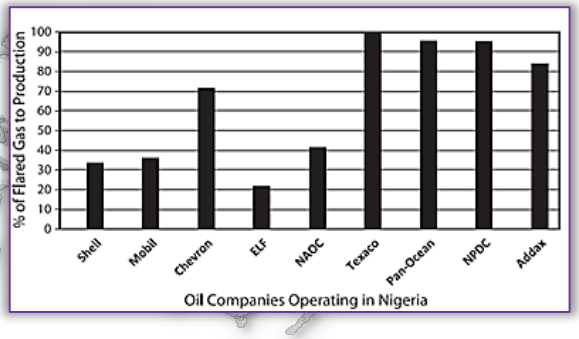

Figure 3: Proportion of gas flared to gas delivered for power generation by oil producing companies. Adapted from Anomohanran (2012)

ELECTRICITY GENERATION FROM GAS FIRED POWER PLANTS

Power generation in Nigeria have relied solely on gas fired power plants and the dwindling gas investment coupled with the youth restiveness in the Niger Delta of Nigeria have worsen the flow of interest in this sector. Nigeria's electricity generation and distribution ranges between about2500 MW and 3000 MW, despite the liberalization policy of government and these output alone cannot cater for huge demand from industries (Olugbenga, 2009). According to other authors(Ubi et al., 2012),the estimated power demand in Nigeria may be in the range of 10,000 MW and that only insignificant proportion of the population (about 30%) has access to epileptic power supply. Gas development has been identified as only measure to promote private sector participation in energy growth in Nigeria. According to the survey conducted by Energy Sector National Technical Working Group (2009), suggested among

other issues, that the power supply need to be overhauled considering the projection of attaining 25000-40000MW by 2020 in view of growing population. The new gas transmission model is shown in Figure 4 and in line with the agenda of government in ensuring transparency in the distribution plan, many authors (Adekomaya et al., 2016) have raised a lot of concerns considering the bottleneck this model is likely to create as most transmission companies have not been able to convey power to end-users as a result of vandalism and gas shortage from Nigerian Liquefied Natural Gas (NLNG). The evolution of National Integrated Power project (NIPP) has largely contributed to the success of increased access to transmission and distribution networks at various level of energy development but the growth of this project is currently being hindered by emerging global player in oil and gas.

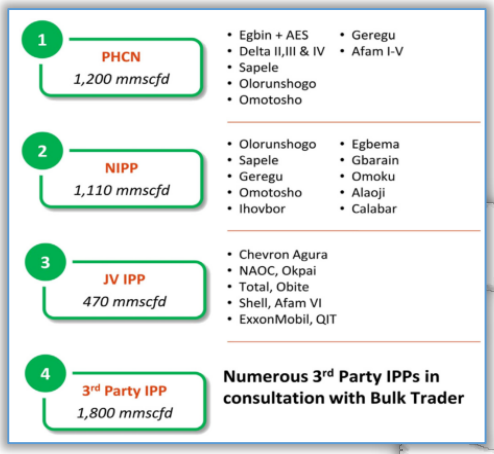

Figure 4: Gas supply chain process in Nigeria. Sourced from Nigerian National Petroleum Company

Gas development remain a Herculean task in Nigeria and once these gasses are not conveyed to demanding power plants, this may result to flaring and resultant environmental degradation (Hassan and Kouhy, 2013). According to a projection cited by Nwaoha and Wood (2014) as shown in Figure 5, the forecast for gas demand by various existing power plants may likely be in excess of over 3.5 bcf/d of gas demand by over 30 existing and proposed power plants. Although, these stranded gasses are abundant at various offshore production facilities, the appropriate distribution channels may likely hinder these estimated volume of gas from being assessed (Soltanieh et al., 2016). Gas delivery and transportation provides a large network for gas market and these opportunities can only be exploited if the infrastructure to transport and store these gasses is available at every offshore production platform in Nigeria. The dwindling fortunes of gas market may also be attributed to low crude oil price and gas being a product of crude oil production has also experienced huge decline in price. This low gas price sometimes deters investors as returns from investments may not likely justify various commitments earlier made (Chidebell-Emordi, 2015). Development of gas transportation networks involves large capital expenditure, as it is currently being experienced in the U.S.A and other developed countries (Andre et al., 2009), the prospect of this network in Nigeria has been a subject of debate in many studies (Andre et al., 2009, Woldeyohannes and Majid, 2011) as factors like pipeline vandalism, resource control by Niger-Delta agitators among other pressing issue remain a stumbling block.

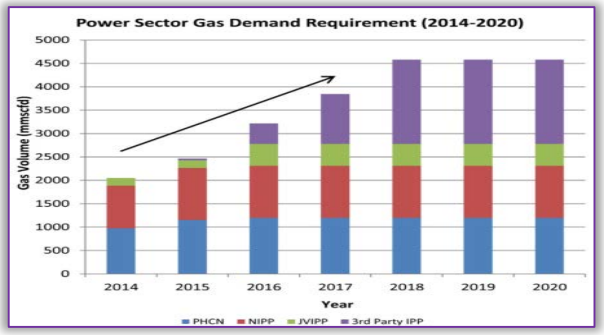

Figure 5: Power sector gas demand in the future. Adapted from NNPC

SUSTAINABLE GAS UTILIZATION OPTION

In order to boast activities in the gas industry, it is equally important to explore other sustainable gas utilization option so that gas flaring will be reduced and equally promote gas viability which will in turn sustain power sector in Nigeria. Onwukwe Stanley (2009) also reiterated the need to develop Gas-to-Liquid (GTL) technology in Nigeria which will on the long run foster cordial gas distribution share in the oil industry. GTL technology has been in existence for many years in US and other developed countries of the world. This technology tends to converts natural gas into clean diesel, naphtha, kerosene and other fuels in order to promote diversification in the oil and gas sector. Part of the concept of this technology is that huge volume of gas flared will definitely be channelled to this technology thereby reducing greenhouse emission and global warming.

Table 1: Quality performance index of refinery diesel and GTL diesel. Adapted from Elisabetta and Roberto, 2009

Diesel fuel characteristics	Standard diesel	GTL diesel
Boiling range (°C)	180-360	150-360
Density(Kg/m³) 15°C	840	780
Sulphur(ppm vol)	50	<0.5
Aromatic(% vol)	23.4	<0.1
Cetane number(CN)	51	81
Cloud point(°C)	0	-15

Nigerian gas reserve is acclaimed to be clean, versatile with abundant reserve, and for these reasons, it is projected to be a good substitute for oil whose environmental impact is far-reaching. Table 1 gives a detailed assessment of diesel fuel and GTL diesel as investigated by Elisabetta and Roberto, 2009. The

results of their experimental study clearly show that the GTL products meet the stipulated conditions provided by all product requirements. GTL technology is appropriate for offshore gas production where gas delivery methods are not economically viable through pipeline and also in order to reduce the incidence of gas flaring associated with this production pattern. GTL, according to some literatures (Chedid et al., 2007, Bao et al., 2010) has the prospects of converting a huge percentage of flared gas to several hundred billion barrels of liquid fuels, which is environmentally friendly and low greenhouse gas impact. Conversion technology of these gases as shown in Figure 6 provides some leverage to host communities in terms of direct job engagement and other means of transportation.

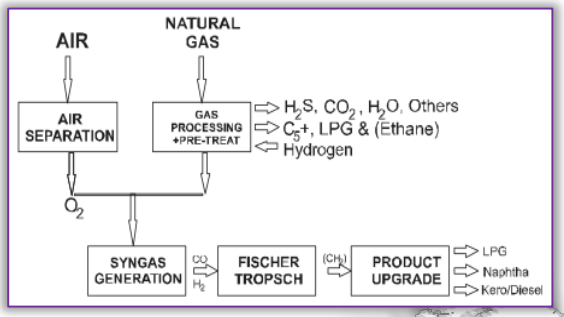

Figure 6: Gas-to-Liquid Technology.
Adapted from Onwukwe Stanley (2009)

Part of the added advantage of this method is that the steam generated through the conversion process could be used for electricity generation necessary for plant usage, while the excesses could still be exported to oil producing communities in order to improve living conditions and thereby douse self-determination struggle in the Niger-Delta.

CONCLUSIONS

Declining crude oil investment occasioned by low oil price possess a challenge to power growth in Nigeria. Nigeria crude oil exports has declined considerable due to youth unrest and pipeline vandalism and this threat remain a stumbling block for Nigeria to realise its full potential in global oil market. Sustaining the existing power project in the face of low gas production must be addressed considering sustainable gas utilisation option as discussed in this study. Nigeria currently ranked 9th in global natural gas reserves and in order to effectively channelled this huge gas reserves appropriately and to further reduce the menace of gas flaring, it may be of high interest to engage different stakeholders in oil and gas industry in order to chart a sustainable roadmap for power development in Nigeria.

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We are very pleased to inform that our international and interdisciplinary journal **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** completed its nine years of publication successfully [**issues of years 2008 –2016, Tome I–IX**].

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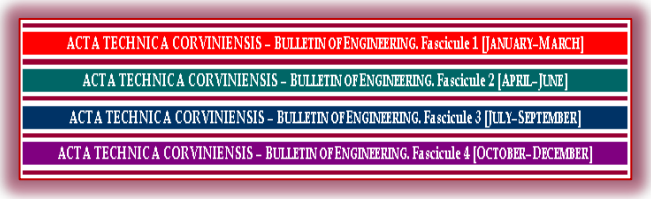
On behalf of the Editorial Board and Scientific Committees of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we would like to thank the many people who helped make this journal successful. We thank all authors who submitted their work to **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**.



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INNOVATIVE METHOD OF IMPLEMENTING THE ALGORITHMS FOR PROCESSING IMAGES IN PRECISION AGRICULTURE

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Abstract: The intelligent control system is a software-hardware system that achieves a differentiation of crop plants from the weeds and after that it destroys the weed. It is based on two intelligent cameras. Each camera surveys two rows of culture and digitally transmits the commands obtained after processing the images, to a logical programmable controller (PLC). This paper presents general aspects and a comparison between two smart cameras; the first one is black-and-white and the second is a colour camera. Recognition and processing of images algorithm depends on colour, shape or position. If the first uses shape to recognize and make the difference between weed and plant, the second uses the difference of colour pixels to make that difference. The paper also includes the stages of algorithm realization and implementation for images processing and recognition. The experiment was performed on lettuce at INMA Bucharest.
Keywords: intelligent, hoeing, images recognizing method

INTRODUCTION

The intelligent control system is a software-hardware system that achieves a differentiation of crop plants from the weeds and after that it destroys the weed. It is based on two intelligent cameras; the first one is black-and-white and the second is colour, endowed with internal memory card able to store the software steps and it has integrated controller aiming to achieve images processing operations. Each camera surveys two rows of culture and digitally transmits the commands obtained after processing the images, to a logical programmable controller (PLC). The experiment was performed on lettuce (Figure1) at INMA Bucharest.

Among the new farming technologies, we must mention the GPS automated guide, fields mapping, aiming to obtain maps with soil features (such as, soil electro-conductivity, PH, nutrients quantity, etc.) which should be used by specialists to obtain a high-performance management of cultures, the use of intelligent algorithms for recognizing images of crops' weed percentage level, for evaluating the crops' health degree, aiming to identify possible pests attack, ensuring a sustainable management of sprinkling, etc.

In figure 2 is presented the experimental model of intelligent hoeing equipment – IHE, produced by INMA Bucharest.

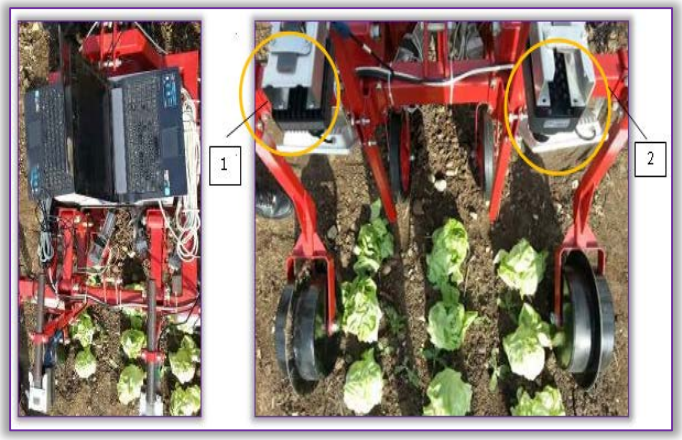

Figure 1. Image from experiment filed with IHE
1) black-and-white camera 2) colour camera

The intelligent hoeing equipment, three-point mounted in front of the tractor, will be traveling in crops with weeds. Through the light sensor, intelligent camera type and the recognition methods implemented in this, the intelligent system will differentiate the weeds from the

plants and will command the knives on plant rows, via electric actuators, to destroy the weeds. To guide the tractor, an agricultural GPS is used. The correlation of the working knives position with the light sensor location will be done through a speed sensor mounted on the equipment wheel.

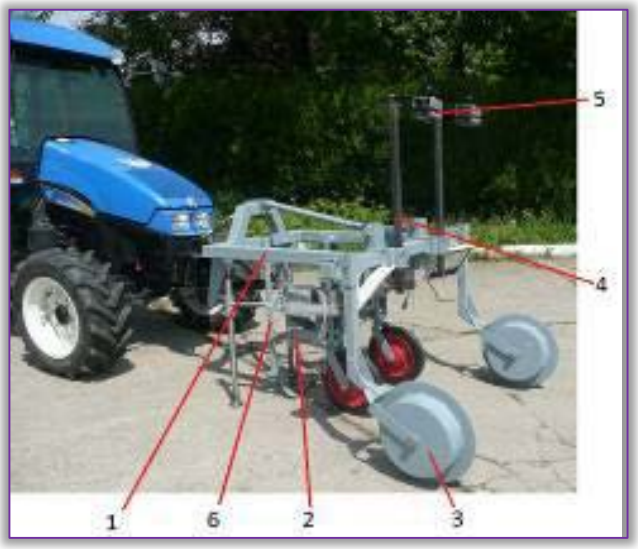

Figure 2. Experimental model IHE
(1–frame, 2 – hoeing section, 3 – wheels of displacement and working depth adjusting, 4 – cameras supports, 5 – cameras, 6 – parking foot)

MATERIAL AND METHOD

The intelligent control system is a software-hardware system that achieves a differentiation of crop plants from the weeds and their 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.

Each camera surveys two rows of culture and digitally transmits the commands obtained after the images processing, to a programmable logic controller (PLC). PLC achieves the synchronization of cameras with the moving speed of the tractor and with the state of the four electric linear actuators, driving the equipment knives.

PLC also commands the opening and closing of actuators in weed areas, by transmitting digital signals to controllers. Interface between technical equipment, intelligent control system and the operator is made by an operation terminal with touchscreen. By the intermediary of touchscreen, the operator can obtain the start-stop functioning commands of TE, monitor the actuators, number the crop plants and assess the weed level.

At the same time, it can guide the technical equipment by means of a GPS, so that it achieves the optimum crop maintenance, without surpassing the distance between rows and destroying the plants. Cameras are designed by National Instruments company aiming the industrial screening installations and using algorithms for images detection.

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 in a large number of fields, including agriculture.

There are several methods of image processing, such as:

- Image restoration aims to eliminate distortions which affect the image distortion due to known physical phenomena, mathematically modelled or estimated.
- Image segmentation realizes separation of uniform regions of interest in the image. Uniformity is a general concept; it does not reduce the consistency of grey levels (the same texture, the same properties, etc.).
- In the case of computer graphics, it starts from a description of the image, aiming in the most general case a synthesis of a realistic image. Obtaining the realistic image is translated by a sequence of algorithms that "closes" the image synthesized from the real one.
- Contour filling algorithms perform the 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 projection in different directions of the section. Having available several such sections (parallel or radial) of the studied body, its 3D reconstruction can be achieved. 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 consists in a classification and / or a description of the image content.

RESULTS

The method for 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 analysed 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, the necessary maintenance works.
- dividing the image in interest areas. The final purpose of this operation is 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 for reference a scale introduced by the user.
- identifying the space between crop plants.
- PLC gives the command according to the 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 mobile knife arm of the multifunctional technical equipment designed to mechanical maintenance in row and between plants of agricultural crops.

Operations described above are performed by making the following steps (described in the software of Vision Builder AI).

Figure 3. Real-time image acquisition with black-and-white camera

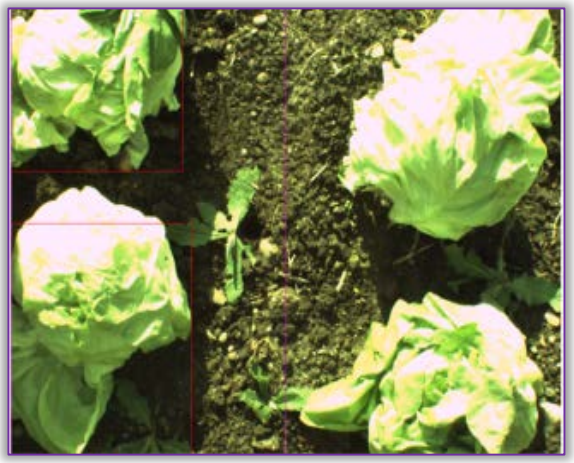

Figure 4. Real-time image acquisition with colour camera

Images are taken in sequences, with 640x480 pixels resolution. Images acquired are stored in the internal memory of the camera. The number of images (frames) the acquisition is made with may be adjustable, according to the exposure time, light and sensor amplifying - figure 3, and with colour camera figure 4.

There are identified the interest objects from image lower part, by numbering the pixels of a certain intensity, appropriate to the respective object (crop plant, weed, stone, etc.). In figure 5 these objects are in the left row identified with black and white camera, while in figure 6 they are in the right row.

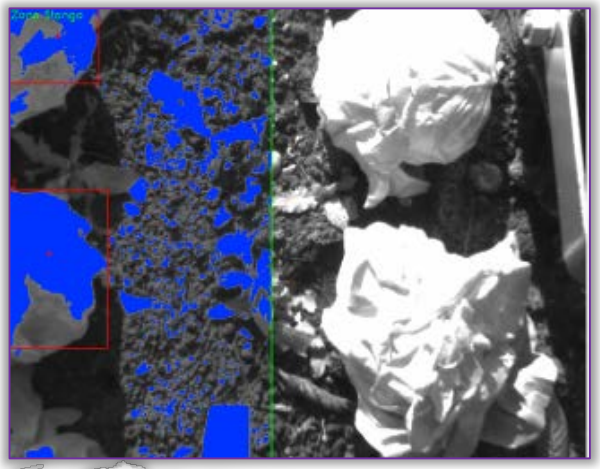

Figure 5. The interest objects from the left row with black-and-white camera

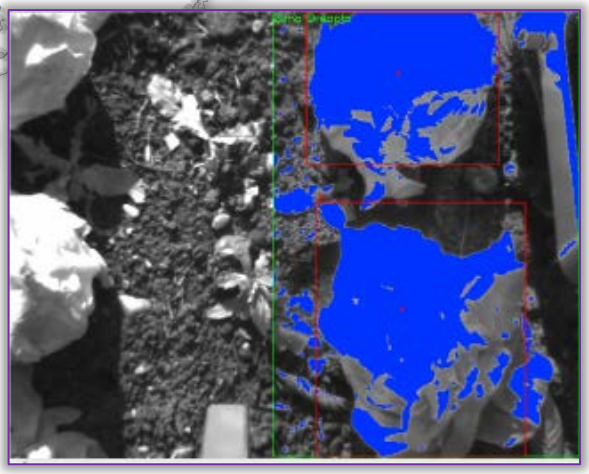

Figure 6. The interest objects from the right row with black-and-white camera

The program identifies the row and makes the acquisition from 2 rows. In the next step, the objects area surpassing 10000 squared pixels is identified (this number can vary according to the crop plant and its average surface at the plant growing level suitable to performing crop maintenance), for image lower part.

The area of weeds location is framed in red, in figure 7, in the left row and, in figure 8, in the right row with colour camera, the gap between them representing the field that requires to be worked.

Figure 7. The area of weeds location with colour camera in the left row

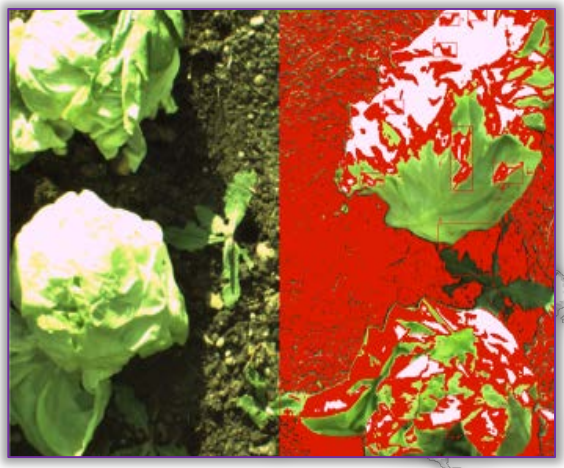

Figure 8. The area of weeds location with colour camera in the right row

During the final step, the output channel, by means of which the signal is sent to PLC, is set as well as the conditions of transmitting it.

CONCLUSIONS

Agricultural research played an important role in order to increase production and the most efficient exploitation of the existing resources, taking into account that the planet's population is constantly growing and exploited agricultural fund is limited and with clear trends of deterioration.

The development of precision farming is one of the main priorities for the development of crops with productivity that satisfy the market demands, in environmentally friendly conditions and with minimal resource consumption. The colour camera is better than the black-and-white one since the number of pixels gives higher accuracy.

Acknowledgement

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DENSITY, WORKABILITY AND COMPRESSIVE STRENGTH ASSESSMENT OF STEEL SLAG IN CONCRETE

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Abstract: This study examines the use of Steel Slag (SS) as a partial replacement of coarse aggregate in concrete. The replacement levels of crushed stone (granite) with SS were 0%, 10%, 20%, 30%, 40% and 50%. A total of 72 concrete cubes of sizes 150 mm x 150 mm x 150 mm were cast and cured in water for 7, 14, 21 and 28 days respectively. A mix ratio of 1:2:4 was adopted and batching was done by weight. Slump test were conducted on fresh concrete while density test and compressive strength test was conducted on hardened concrete. The compressive strength result shows that the strength of concrete increases with respect to curing age as the percentage of SS increases (i.e the higher the percentage of SS, the higher the compressive strengths of the concrete cubes). The replacement of coarse aggregate (crushed stone) with Steel Slag (SS) will produce a concrete of higher strength compared to plain concrete (conventional concrete). However, Steel Slag (SS) can successfully be used as a partial replacement of coarse aggregate (crushed stone) in concrete for concrete grade M20 since the strength of concrete with 10%, 20% and 30% 40% and 50% is higher than the control mix.
Keywords: Concrete, Coarse Aggregate, Compressive strength, Steel Slag (SS)

INTRODUCTION

Concrete has been the most common building material for many years. It is obtained by mixing cementitious materials, water, aggregate (usually sand and gravel or crushed stone) and sometimes admixtures in required proportions (Odeyemi et al., 2015). The aggregates typically account about 75% of the concrete volume and play a substantial role in different concrete properties such as workability, strength, dimensional stability and durability.

Conventional concrete consists of sand as fine aggregate and gravel, limestone or granite in various sizes and shapes as coarse aggregate. There is a growing interest in using waste materials as alternative aggregate materials and significant research is made on the use of many different materials as aggregate substitutes (Saravanan et al., 2015). Thus, waste materials such as coconut shell, palm kernel shell, blast furnace slag, and steel slag aggregate will address global warming and environmental problem.

Use of more and more environmental friendly materials in any Industry in general and construction industry in particular, is of paramount importance. Steel slag aggregates are already being used as aggregates in asphalt paving road mixes due to their mechanical strength, stiffness, porosity, wear resistance and water absorption capacity. Also, steel slag could be used as a partial replacement for coarse aggregate (Padmapriya et al., 2015). Therefore, there is need for the utilization of this by-product (steel slag) in concrete production in Nigeria as cost of natural aggregates (fine and coarse aggregate) is becoming higher.

Saravanan et al., (2015) evaluate the mechanical properties of concrete using steel slag aggregate. They concluded that 100% replacement of conventional aggregate with steel slag aggregate was not found to yield better strength.

However, the result of their study shows that: compressive strength of steel slag concrete increases in 6 % compared to the conventional coarse aggregate concrete; split tensile strength of steel slag concrete increases in 28 % compared to the conventional coarse aggregate concrete and flexural strength of steel slag concrete increases in 34 % compared to the conventional coarse aggregate concrete.

Sharma et al., (2015) examined the effects of steel slag on concrete. From their results, they observed that as the percentage of steel slag is increased (from 0% to 55%), the strength of concrete increases. After 55% replacement of coarse aggregate as steel slag, slight decrease in strength is observed, yet it is higher than 0% replacement without any adverse effect on the strength of concrete.

Ravikumar et al., (2015) investigated replacement of steel slag as coarse aggregate in concrete. In their study, concrete of grade M20, M30, M40 and M50 were considered for a W/C ratio of 0.55, 0.45, 0.37, 0.32 respectively for the replacement of coarse aggregate 30% 60% and 100% by steel slag.

The result of their finding revealed that there is an improvement in compressive strength from 5% to 10% for all the grades of concrete, 4 to 8% increase in split tensile strength in all grades of concrete and flexural strength of concrete increased between 2 to 6% for all the grades.They concluded that steel slag can be used up to 60% replacement in concrete grade M20, M30, M40 and M50 respectively while full replacement by steel slag decreases the strength considerably.

MATERIALS AND METHODS

- **Cement.** The cement used in the production of the concrete was Ordinary Portland cement (OPC) – Dangote cement brands 42.5R which conformed to NIS 444 – 1:2003.
- **Water.** Water is a universal solvent; it increases the workability of concrete mix. Water used for concrete mix in this study was obtained from tap.
- **Fine Aggregate.** The fine aggregate used in this research was natural sand most of which passes through sieve 4.75mm and conformed to IS 383-1970.
- **Coarse Aggregate.** Crushed stone (granite) of maximum size 19.0mm was used and conformed to IS 383-1970.
- **Steel Slag (SS).** Steel slag (SS) is a by-product obtained either from conversion of iron to steel in a Basic Oxygen Furnace (BOF), or by the melting of scrap to make steel in the Electric Arc Furnace (EAF). The molten liquid is a complex solution of silicates and oxides that solidifies on cooling and forms steel slag. Steel slag is defined by the American Society for Testing and Materials (ASTM) as a non-metallic product, consisting essentially of calcium silicates and ferrites combined with fused oxides of iron, aluminium, manganese, calcium and magnesium that are developed simultaneously with steel in basic oxygen, electric arc, or open hearth furnaces (Sharma et.al. 2015).

The Steel Slag (SS) used for this research was collected from Machine Tools, along Osogbo – Ikirun Road, Osogbo, Osun State, Nigeria. The slag was crushed into smaller sizes manually and allow to pass through sieve size No 25mm and retained on sieve size No 19mm. Chemical composition of steel slag as reported by Ravikumar et. al. (2015) is shown in Table 1.

Table1: Typical value chemical composition of steel slag

Oxides	Composition (%)
Aluminium oxide (Al_2O_3)	1 – 3
Calcium oxide (CaO)	40 – 52
Iron oxide (FeO)	10 – 14
Magnesium oxide (MgO)	5 – 10
Manganese oxide (MnO)	5 – 8
Silica	30 – 35

Source: Ravikumar et al., (2015)

This study examines the use of Steel Slag (SS) as a partial replacement of coarse aggregate in concrete. The replacement levels of crushed stone (granite) with SS were 0%, 10%, 20%, 30%, 40% and 50%. A total of 72 concrete cubes of sizes 150mm x 150mm x 150mm were cast and cured in water for 7, 14, 21 and 28 days respectively.

A mix ratio of 1:2:4 was adopted and batching was done by weight with water-cement ratio of 0.45. At the end of the different curing ages, the densities of the cubes were determined and the cubes were crushed using a compression testing machine to determine their compressive strengths. Average values of concrete densities and compressive strengths for the various curing age and percentages of SS replacement with crushed stone (granite) were obtained and presented in Tables 3 and 4 respectively.

RESULTS AND DISCUSSION

Specific Gravity Test

The result obtained from specific gravity of fine and coarse aggregate are shown in Table 2.

Table 2: Specific gravity of Fine, Coarse Aggregate and Steel Slag

S/No.	Test Samples	Specific Gravity
1.	Fine Aggregate	2.53
2.	Coarse Aggregate	2.60
3.	Steel Slag	2.64

The range of specific gravity of aggregates as specified by ACI Education Bulletin E1 (2007) ranges from 2.30 to 2.90. The results of specific gravity of fine, coarse aggregate and steel slag (SS) shown in Table 2 are within the acceptable limits for aggregates.

Fineness Modulus

The fineness modulus was conducted in accordance with ACI Education Bulletin E1 (2007). From the sieve analysis, the following fineness modulus as shown in Table 3 was obtained.

Table 3: Fineness modulus of Fine, Coarse Aggregate and Steel Slag

S/No.	Test Samples	Fineness modulus
1.	Fine Aggregate	2.7
2.	Coarse Aggregate	5.2
3.	Steel Slag	6.1

ACI Education Bulletin E1 (2007) reports that fineness modulus is most commonly computed for fine aggregates, while the fineness modulus of coarse aggregate is needed for some proportioning methods. However, for fine aggregate used in concrete, the fineness modulus (FM) generally ranges from 2.3 to 3.1. The result of fineness modulus in Table 3 falls within the acceptable limits for fine aggregates.

Slump Test on Fresh Concrete

SS EN 206-1 (2009) describe slump test as test related with the ease with which concrete flows during placement. The three kinds of slump (as shown in Figure 1) describe by SS EN 206-1 (2009) are: natural or true slump (the concrete mould simply sinks, keeping its shape more or less), shear slump (the concrete mould falls away sideways) and collapse slump (the concrete mould collapses completely).

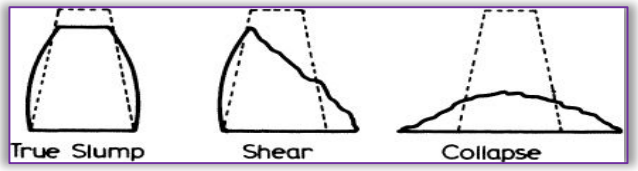

Figure 1: The three kinds of slump (Source: Neville, A.M., 2011)

The slump test was carried out in accordance with ASTM C192/C192M (2006). Table 4 shows the slump tests results for the concrete with varying replacement of SS.

Table 4: Results of Slump Test of concrete with Different Percentages of SS

Concrete properties	Percentage Replacement (%)					
	0	10	20	30	40	50
Slump (mm)	45	43	40	39	38	35

In this study, true slump was exhibited by the concrete in the fresh concrete mix. Table 4 shows that the slump height values reduce and the concrete becomes less workable (stiff) as the percentage replacement of coarse aggregate with steel slag increases. The result is represented in Figure 2.

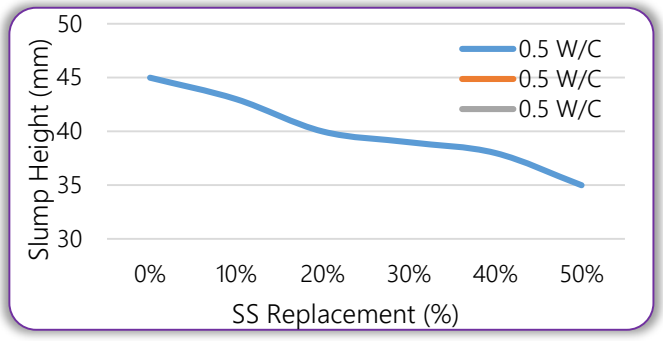

Figure 2: Slump height against SS replacement

Density Test on Hardened Concrete

The mean densities of concrete cubes made with different replacement level of SS for age 7, 14, 21 and 28 days curing (hydration period) respectively are given in Table 5. The density test conforms to BS EN 12390-7: 2009.

Table 5: Results of Mean Densities of Concrete Cube

Curing Age (Days)	Mean Densities of Concrete Cube (Kg/m³)					
	0%	10%	20%	30%	40%	50%
7	2335	2340	2410	2400	2400	2350
14	2364	2337	2400	2407	2430	2390
21	2399	2453	2494	2446	2430	2400
28	2400	2443	2471	2480	2490	2420

All concrete cubes produced falls within the range of 2300Kg/m³-2500Kg/m³ and the densities of all the samples tested fell within the normal range of concrete as reported by Jones (1999). The result is presented in Figure 3.

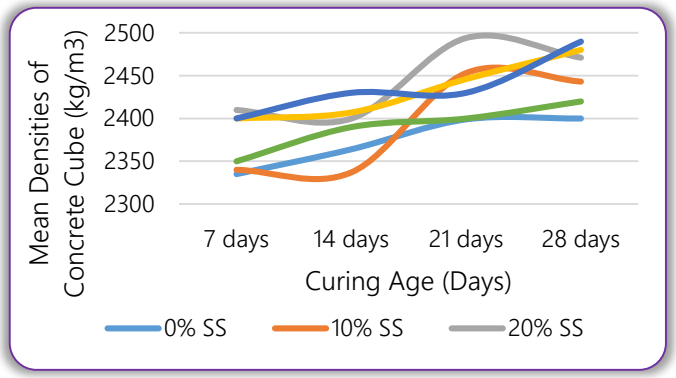

Figure 3: Relationship between concrete cubes mean densities and curing age

Compressive Strength Test on Hardened Concrete

The compressive strength tests on the SS concrete cubes were carried out with compression testing machine (2000kN capacity) at the soil mechanics laboratory, Civil Engineering Department, The Federal Polytechnic, Offa, Nigeria. This was done in accordance with BS EN 12390-3:2009 and CS1:2010. Tables 6 shows the compressive strength test results of the concrete cubes.

Table 6: Results of Mean Compressive Strengths

Curing Age (Days)	Mean of Compressive Strengths aggregate (N/mm²)					
	0%	10%	20%	30%	40%	50%
7	12.11	14.20	15.48	17.04	17.55	15.50
14	17.39	17.88	19.00	19.75	20.00	17.90
21	20.63	21.22	21.99	22.86	22.90	20.55
28	23.55	25.40	26.55	26.79	26.95	23.70

The compressive strength results from Table 6 shows that the conventional mix (0%) is lesser than concrete with 10%, 20%, 30%, 40% and 50% replacement of crushed stone (granite) with SS.

However, the results show that the compressive strength of concrete increases with respect to curing age as the percentage of SS increases (i.e the higher the percentage of SS, the higher the compressive strengths of the concrete cubes).

At 7 days, the compressive strength results of 0% is lower than the minimum required compressive strength of 13.5 N/mm² for concrete grade 20 as specified by BS8110 Part 2:1985 (Table 7) while the strength of 10%, 20%, 30%, 40% and 50% of crushed stone with SS respectively met the minimum required compressive

strength of 13.5 N/mm² for grade 20 concrete specified by BS8110 Part 2:1985 (Table 7).

Table 7: Required/Recommended Strength of Concrete (BS8110 Part 2, 1985)

Grade	Characteristic strength, f_{cu} (N/mm²)	Cube Strength at an age of:				
		7 days	2 months	3 months	6 months	1 year
20	20.0	13.5	22	23	24	25
25	25.0	16.5	27.5	29	30	31
30	30.0	20	33	35	36	37
40	40.0	28	44	45.5	47.5	50
50	50.0	36	54	55.5	57.5	60

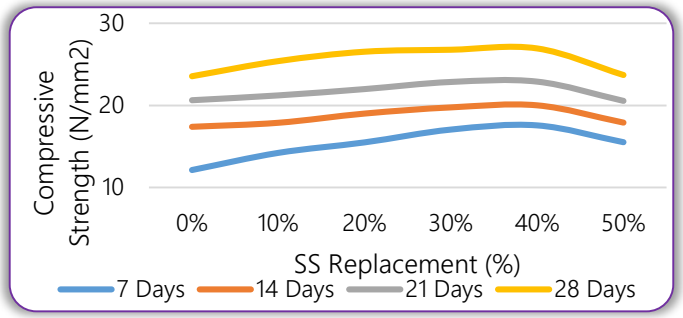

Figure 4: Graphical representation of compressive strength against SS Replacement

At 28 days, the strength of 0% was above the specified value of 20 N/mm²for grade 20 concrete (BS8110 Part 2:1985; Table 7) while the strength of 10%, 20%, 30% and 40% partial replacement of crushed stone with SS respectively was above the specified value of 20 N/mm²for grade 20 and 25 N/mm²for grade 25 concrete respectively (BS8110 Part 2:1985; Table 7).

Moreover, the compressive strength of concrete cubes increase with increase in steel slag from 0%SSto 40%SS but decreases at 50%SS. The results are represented in Figure 4.

CONCLUSIONS

From the experiment and results, the following conclusions can be drawn:

- True slump was exhibited by the concrete in the fresh concrete mix. However, the slump height reduces as the percentage replacement of coarse aggregate with steel slag increases.
- The compressive strength result of the conventional mix (0%) is less than concrete with SS. However, the compressive strength of concrete cubes increase with increase in steel slag from 0%SS to 40%SS but decreases at 50%SS. The compressive strengths result at 28 days shows that 40%SS have the highest compressive strength of26.95N/mm² followed 30%SS (26.79 N/mm²), 20%SS (26.55 N/mm²), 10%SS (25.40 N/mm²), 50%SS (23.70 N/mm²) and 0%SS (23.55 N/mm²).
- Further investigation should be carried out to determine the optimum addition of Nigerian Steel Slag (SS) as partial replacement for coarse aggregate in concrete.
- Steel Slag (SS) can successfully be used as a partial replacement of coarse aggregate (crushed stone) in concrete for concrete grade M20 and structural work.
- The replacement of coarse aggregate (crushed stone) with Steel Slag (SS) will produce a concrete of higher strength and better durability compared to plain concrete (conventional concrete).
- Nigerian government (federal and state) should lay emphasis on the use of steel slag in construction work for contractors in order to economize cost of coarse aggregate (crushed stone).

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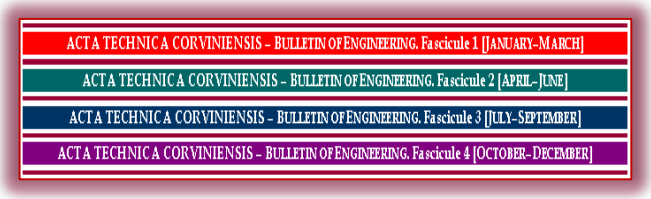
We are very pleased to inform that our international and interdisciplinary journal **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** completed its nine years of publication successfully [**issues of years 2008 –2016, Tome I–IX**].

In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm.

Every year, in four online issues (**fascicules 1 – 4**), **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** [**e-ISSN: 2067-3809**] publishes a series of reviews covering the most exciting and developing fields of science and technology. Each issue contains papers reviewed by international researchers who are experts in their fields. The result is a journal that gives the scientists and engineers the opportunity to keep informed of all the current developments in their own, and related, areas of research, ensuring the new ideas across an increasingly the interdisciplinary field.

Now, when will celebrate the tenth years anniversary of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!

On behalf of the Editorial Board and Scientific Committees of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we would like to thank the many people who helped make this journal successful. We thank all authors who submitted their work to **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**.



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INVESTIGATION OF THE CHARACTERISTICS OF BIOGAS FUELS AND OPPORTUNITIES FOR THEIR DISTRIBUTION IN BULGARIA

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Abstract: In the article examined the characteristics of biogas fuels and presented opportunities for distribution in Bulgaria. For this purpose have been made studies on the composition of the biogas fuels derived from various starting materials. Analyzed the possibilities for use of biogas fuel, depending on the content of the various concentrations of methane and carbon dioxide. An in-depth analysis of the possibility of distributing raw materials to finished filling stations in Bulgaria, according to the application. Consider the possibility of distribution of finished materials and comply with the requirements for the transport of dangerous goods.
Keywords: Biogas, Algorithm, Distribution, Lower calorific value, Gas generators stations

INTRODUCTION

Road transport is one of the main sources of air pollution. When the full and insufficient combustion of fuels to generate complex mixture of gaseous and solid pollutants, many of which are dangerous to human health.

In addition to carbon oxides, nitrogen oxides, sulfur dioxide, hydrocarbons, particulate matter, etc., are emitted and many toxic pollutants such as benzene - carcinogenic by the International Agency for Research of Cancer (IARC), polycyclic aromatic hydrocarbons (PAHs), especially benzo [a] pyrene, which is used as an indicator of the carcinogenic properties of PAHs [1,2]. It necessary to looking for alternative fuels and to implement short- and long-term measures to reduce emissions from road transport as: reducing the volume of motorized traffic, improved traffic flow, promoting public transport, transfer of highly polluting cars to less sensitive places and others [3,4].

Currently in Bulgaria there are numerous farms of biogas. The first biogas plants are made in India in 1859 currently is estimated in Germany there are 1000 installations in Austria - 200 in Switzerland - 100 in Korea - 30,000 in India - and 500,000 in China - seven million. Biogas is a product of fermentation processes in organic matter by the action of methane bacteria. These microorganisms are strictly anaerobic. Their working range is in the range of 0 to 70°C.

The rate of fermentation processes, and hence the quantity of the product gas depends strongly on the temperature regime. The most common feedstock for biogas production is taken excrement of livestock and poultry. Nature provides, however many, some even unexpected as resources [5-8].

This publication examines the possibility of using biogas as a fuel for internal combustion engines and its application in transport. It is also analyzed the possibility of distributing biogas fuel in Bulgaria.

RESEARCH OF THE CHARACTE-RISTICS OF BIOGAS FUELS

The main component of biogas is methane, which is characterized by the following properties: burning cleaner, cheaper, and its octane number is greater. Because of these properties, in recent years, methane is becoming more widespread.

It is mainly used for heating in industry and households, but the most valuable application is in transport. Using natural gas allows toxic substances, soot and smoke exhaust gases to reduce about 3-4 times. The use of methane in the internal combustion engine is environmentally the cleanest technology (after

hydrogen). Table 1 reflects the relationship between the consumption of 100 km compared to other fuels [11].

Table 1. Relationship between the consumption of 100 km compared to other fuels

Fuel	Expense (litres/100 km)	Price (BGN)	Price of 100 km (BGN/100 km)
GASOLINE	8	1.99	15.92
PROPANE-BUTANE	10	1.01	10.10
METHANE	4.8	1.19	5.71

Biogas is a fuel gas, which is obtained by fermentation in anaerobic (without presence of oxygen) environment of organic products. Let us mention that in nature biogas is obtained in a natural way (so-called marsh gas). The composition of biogas, most often in the range shown in Table 2 [5].

Table 2. Composition of biogas

№	Ingredients	Content, %
1	METHANE (CH_4)	45 - 75
2	CARBON DIOXIDE (CO_2)	25 - 50
3	NITROGEN (N_2)	0 - 7
4	OXYGEN (O_2)	0 - 2
5	HYDROGEN (H_2)	0 - 1
6	HYDROGEN SULFIDE (H_2S)	0 - 1

With these parameters the energy value of biogas is 4,5 to 7,5 kWh/m^3. For comparison, the energy value of diesel is approximately 12 kWh/kg, the wood - 4,5 kWh/kg, briquettes - 5,5 kWh/kg, natural gas - 8,3 kWh/m^3.

Reconstruction of the petrol engine to work on gaseous fuel is relatively easy, since the engines are designed to work with external mixture formation and spark ignition. The main change that is made to provide an adequate system for mixing gaseous fuel with air. The management of this type of engine is done by changing the supplied fuel-air mixture, i.e. depending on the change of the angle of the throttle opening.

There are several reasons why using biogas as an alternative fuel. For example, the combustion process is quiet, non-exhaust emissions are less even during cold start, CO_2 emissions are significantly smaller, has a high octane rating, allowing it to be used in gasoline engines turbocharging. Compared to gasoline methane fuels have the following disadvantages: lower density, consumes an additional energy for their thickening, loss of gas production and transportation, and relatively few charging stations at the time.

The majority of all gas engines are internal combustion engines with spark ignition and fuel injection in manifold. In the gas engine, especially when working with biogas with a high content of CO_2 may reduce the amount of air, in order to enrich the gas-air mixture. The range of power reduction by a large degree depends on the value of the net calorific value of the used biogas. If biogas contains 15% CO_2, a lower calorific value Hu decrease with 33% [(Q^d_i) Hu value is between 45670 to 30806 kJ/kg], and this contributes to reducing the effective power of the engine with approximately about 30%.

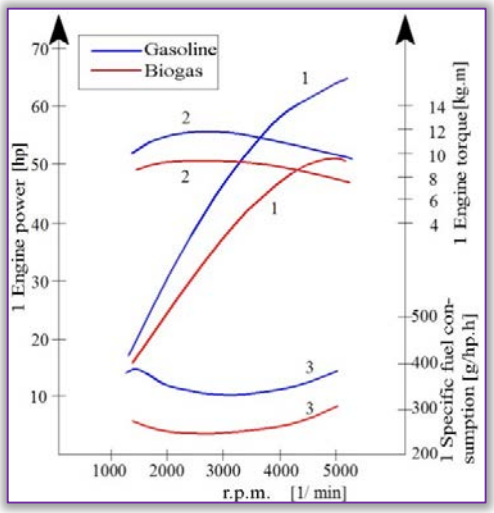

Figure 1. The change of engine power (1), torque (2) and specific fuel consumption (3) as a function of the rotational speed of the crankshaft for petrol and biogas

In comparison with the use of clean natural gas maximum power reduced by 20%, and LPG - 5%. The main conclusion from this is that you have well-considered choice of class power of the engine to cover the estimated needs. Figure 1 shows the change of engine power (1), torque (2) and specific fuel consumption (3) as a function of the rotational speed of the crankshaft for petrol and biogas.

The high content of H_2S in biogas is a major problem with the engines. During combustion it reacts and forms SO_2 and H_2O. After which SO_2 reacts with water to produce H_2SO_3 - sulfuric acid. SO_2 can also react with O_2 to obtain SO_3 and then with water to form H_2SO_4. The presence of these acids leading to severe corrosion and wear of parts in the engine. The presence of hydrogen sulphide in the biogas also leads to deterioration of the engine oil and to the destruction of the catalyst system of the vehicle. Siloxanes R_2SiO can form a thick layer of silica inside the combustion chamber and engine exhaust system. Are formed a large amount of silica particles responsible for the wear on the valve and valve seat.

Ammonia is another corrosive constituent element of the biogas. It reacts with water and forms NH_4OH, which has a corrosive effect on aluminum and copper parts (sliding bearings) of engine. The presence of a large amount of diluent in the biogas leads to a reduction of the calorific value. Some of the heat of combustion is taken from the diluent and this is the reason for a low flash point, which leads to a lower rate of combustion. CO_2 has a high heat capacity, which increases with increasing temperature. This means that at high combustion temperatures, large part of the heat is absorbed by CO_2, and as a result considerably reduces

the temperature of combustion which is also shown in Figure 2. However, the heating of the gas-air mixture leads to an increase of the combustion temperature but then dissociates CO_2 (apart) and many of CO emissions are emitted from the exhaust system.

To maximize the efficiency of the gasoline engine, redesigned to work with Biogas fuel should increase the angle of start of ignition, because that biogas has a lower rate of combustion than gasoline.

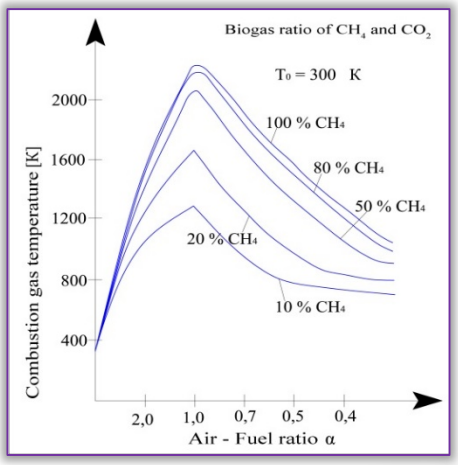

Figure 2. Temperature of combustion of biogas, depending on the concentration of CO_2

RESULTS AND ANALYSIS

To determine the appropriateness of the use of biogas as a fuel for internal combustion engines is an analysis of some parameters affecting work and a power-economic indices of the engines. The calculations were made for several Biogas fuel, depending on the raw material used to produce biogas. Calculated are: lower calorific value of fuel, the required amount of air for the combustion of 1 kg. fuel, the density of the gas at various rates of CH_4 and CO_2.

Table 3. Biogas from organic waste

CH_4 [%]	CO_2 [%]	CO [%]	N_2 [%]	O_2 [%]	H_2 [%]	H_2S [%]	C_6H_6 [%]
60	35.47	0.1	3.4	0.5	0.001	0.533	0.000066
65	30.47	0.1	3.4	0.5	0.001	0.533	0.000066
70	25.47	0.1	3.4	0.5	0.001	0.533	0.000066
75	20.47	0.1	3.4	0.5	0.001	0.533	0.000066
80	15.47	0.1	3.4	0.5	0.001	0.533	0.000066
85	10.47	0.1	3.4	0.5	0.001	0.533	0.000066
90	5.466	0.1	3.4	0.5	0.001	0.533	0.000066
95	0.466	0.1	3.4	0.5	0.001	0.533	0.000066
100	0	0	0	0	0	0	0

Hu [kJ/m³]	ρ [kg/m³]	M [kg/mol]	Hu [kJ/kg]	Air [kg]
21636	1.184	26.53	18278	10.3825
23427	1.122	25.14	20889	11.2122
25219	1.059	23.74	23806	12.042
27010	0.997	22.35	27088	12.8718
28802	0.935	20.95	30806	13.7016
30593	0.873	19.56	35055	14.5313
32385	0.811	18.17	39955	15.3611
34176	0.748	16.77	45670	16.1909
35830	0.716	16.05	50042	17.0954

Lower specific heat of combustion Hu is a quantity of heat which is removed by complete combustion of a unit of gas. The difference between the lower and upper limit of the calorific value of 1 m^3 gas is equal to the heat of vaporization (condensation) of the water which is produced by the combustion of the gas. Calculations were made according to the composition of the gas by the formulas shown in [9, 10] and the obtained results, with specialized software, are shown in Tables 3 to 5.

Table 4. Biogas from agricultural materials

CH_4 [%]	CO_2 [%]	CO [%]	N_2 [%]	O_2 [%]	H_2 [%]	H_2S [%]	C_6H_6 [%]
60	35.9	0.1	2.5	1	0.5	0	0
65	30.9	0.1	2.5	1	0.5	0	0
70	25.9	0.1	2.5	1	0.5	0	0
75	20.9	0.1	2.5	1	0.5	0	0
80	15.9	0.1	2.5	1	0.5	0	0
85	10.9	0.1	2.5	1	0.5	0	0
90	5.9	0.1	2.5	1	0.5	0	0
95	0.9	0.1	2.5	1	0.5	0	0
100	0	0	0	0	0	0	0

Hu [kJ/m³]	ρ [kg/ m³]	M [kg/mol]	Hu [kJ/kg]	Air [kg]
21565	1.18	26.46	18268	10.2166
23356	1.118	25.06	20886	11.0464
25148	1.056	23.67	23812	11.8762
26939	0.994	22.28	27105	12.7059
28731	0.932	20.88	30837	13.5357
30522	0.869	19.49	35104	14.3655
32314	0.807	18.09	40027	15.1952
34105	0.745	16.7	45773	16.025
35830	0.716	16.05	50042	17.0954

Table 5. Landfil biogas

CH_4 [%]	CO_2 [%]	CO [%]	N_2 [%]	O_2 [%]	H_2 [%]	H_2S [%]	C_6H_6 [%]
60	26.87	0.1	10	2.5	0	0.533	0.000066
65	21.87	0.1	10	2.5	0	0.533	0.000066
70	16.87	0.1	10	2.5	0	0.533	0.000066
75	11.87	0.1	10	2.5	0	0.533	0.000066
80	6.867	0.1	10	2.5	0	0.533	0.000066
85	1.867	0.1	10	2.5	0	0.533	0.000066
86.9	0	0.1	10	2.5	0	0.533	0.000066
86.9	0	0.1	10	2.5	0	0.533	0.000066
100	0	0	0	0	0	0	0

Hu [kJ/m³]	ρ [kg/m³]	M [kg/mol]	Hu [kJ/kg]	air [kg]
21636	1.126	25.24	19210	10.0507
23427	1.064	23.85	22016	10.8805
25219	1.002	22.46	25171	11.7103
27010	0.94	21.06	28744	12.54
28802	0.877	19.67	32823	13.3698
30593	0.815	18.27	37524	14.1996
31262	0.792	17.75	39469	14.5094
31262	0.792	17.75	39469	14.5094
35830	0.716	16.05	50042	17.0954

THE POSSIBILITY OF DISTRIBUTING RAW MATERIALS TO FINISHED FILLING STATIONS IN BULGARIA, ACCORDING TO THE APPLICATION

Currently in Bulgaria there are biogas plants producing raw biogas, but there is no built Methane stations using fuel - upgraded biogas. This raises the need to establish

an algorithm that can be used as in the case where at the biogas plant has added a system to enrich produced biogas and a case where there is none. The resulting upgraded biogas can be used as fuel for internal combustion engines. There is also the possibility next to the biogas installation has a charging station. Also upgraded biogas can be distributed in the already existing network of charging stations for methane in Bulgaria. Raw biogas can be used for the gas-generating stations producing electrical energy.

Algorithm for distribution of finished materials to filling stations in Bulgaria, depending on their application.

In connection with the distribution of the finished raw materials to filling stations in Bulgaria, according to the application they proposed algorithm (see Fig.3).

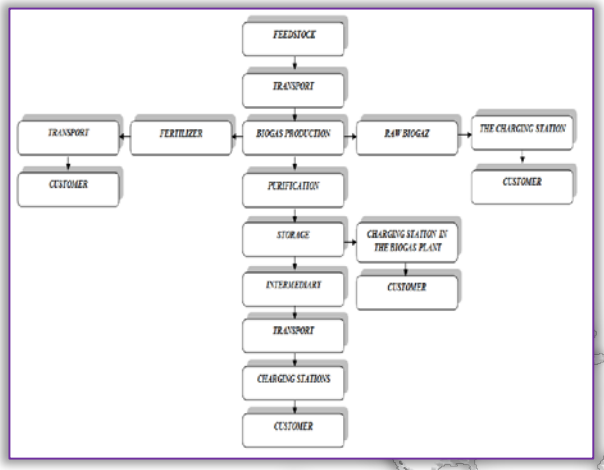

Figure 3. Algorithm for distribution of finished materials to filling stations in Bulgaria, depending on their application

The proposed algorithm enables full distribution of finished materials in various stages of production of biogas. It shows sample distribution capabilities biogas to filling stations and end users.

CONCLUSIONS

Based on the above study, and theoretical calculation can be made to the following conclusions:

- Using non-upgraded biogas as a fuel for internal combustion engines is inefficient. CO_2 concentration in the composition from about 15% decreased the net calorific value of the fuel with up to 33% (Hu vary from 45 670 to 30 806 kJ / kg).
- Vehicles using upgraded biogas have significant advantages over those with gasoline or diesel engines. Total CO_2 emissions are drastically reduced due to the use of gaseous fuel. Soot emissions are also drastically reduced, even compared with new diesel engines, which use appropriate filters. Emissions of NOx and non-methane hydrocarbons are also significantly reduced. It has been shown that upgraded biogas (biomethane) has the greatest potential as a fuel compared to other biofuels.
- The proposed algorithm enables full distribution of finished materials in various stages of production of biogas. Shows sample distribution capabilities biogas to filling stations and end users.

The above conclusions are grounds to assert that unfortified biogas can be used as fuel for gas-generating stations. Upgraded biogas (biomethane) can be used in vehicles as it has the greatest potential as a biofuel. The application of the proposed algorithm will doprine for full and effective use and distribution of finished materials and waste products in various stages of production of biogas.

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DEVICE FOR USE IN MANUFACTURING EQUIPMENT

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Abstract: The authors focus on modifying parts of the Rotational Universal Module joint system. The main task of the joint system is to create a solid bond between two adjacent modules. This is called the rotary coupling, because two adjacent modules rotate to each other. The main objective was to achieve improved locking system in comparison with the initial design. Also facilitate the assembly operation during the construction of kinematic structures. A detailed description of the adjustments made, see the following chapters.
Keywords: rotation universal module, rotary unit, locking pin, large flange of bearing

INTRODUCTION

Nowadays is possible to find in global markets tremendous number of robotic handling equipments that provide manipulations in space. It is recommended to use handling equipments which reach at least five degrees of movement freedom. This condition ensures successful manipulation in space.

Rotation Universal Module offers possibility of kinematic chains creation with such numbers of freedom degrees which are needed to fulfill the task [1]. The number of freedom degrees depends on number of modules that are connected to each other in the kinematic chain [2]. The first prototypes of Rotation Universal modules have been tested to detect inequalities, subsequently they were carefully analyzed and solved. Individual deficiencies and approaches how to remove them are described below.

ROTATION UNIVERSAL MODULE

Rotation Universal Module (URL) is a rotary module with an unlimited degree of rotational movement. URL is suitable for engines and equipment that need unlimited rotational movement freedom [3]. Rotation Universal Module is designed on modular principle that allows using one type of module to compile various combinations of engines.

If given solution is not suitable or is necessary to establish different kind of machine, it is possible thanks to modularity rebuild initial solution [4]. Other useless modules can be used in other applications. Proposed machines and equipment can achieve a huge variety of movement options and freedom degrees using the infinite rotation of adjoining modules that are joined together by motion joints.

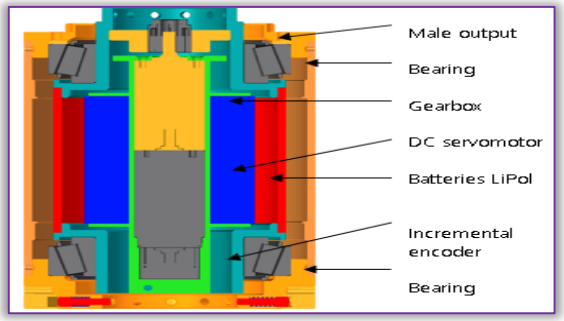

Figure 1. Cut the Rotation Universal Module flesh

Rotation Universal Module is designed to secure the unlimited rotation. That is reason why all components are placed in the body of the module (Figure 1). This makes the components protected against external influences. Each module is equipped with DC servo motor Faulhaber 3863 012C (204W, 12V, 85% efficiency) which is located in the middle of the module. The engine is equipped with an incremental encoder Faulhaber IE2-512 which can scan 102 400 positions per revolution. In the output of the engine is mounted reducer Faulhaber (38A, 200: 1, 20 Nm) with electro brake (6W, 12V 80Nm) which is located behind reducer. Module is equipped with leveling LiPo batteries 4in1 (14.8V) to secure permanent run also after power failure. [Skylight 2010b] The module is managed by PID

control servomotor. Output nominal speed of Rotation Universal Module is 30 revolutions / minute.

Final solution is a modular system which allows us to assemble modular robots that can be composed of identical type or typically identical Rotation Universal Module with limitless possibility of movement rotation. Engines and equipments that are built by these modules should ensure the best operating range and also the best achievement of desired location in the workspace [5].

THE MAIN COMPONENTS OF THE LOCKING SYSTEM

Primary part of the Rotation Universal Module locking system consists from twelve locking pins that are stored in milled grooves which are located around the perimeter of the large flanges of bearings. Rotary unit ensures the movement of the locking pin. Movement is secured by grooves that are milled inside of the rotary part. In order to ensure a smooth return movement of the locking pin, each locking pin have inside of housing stored spring. Restraint and tension adjustment of the rotary component is secured by four pins with spring-loaded ball. The pins are located on the outer periphery of the rotary part.

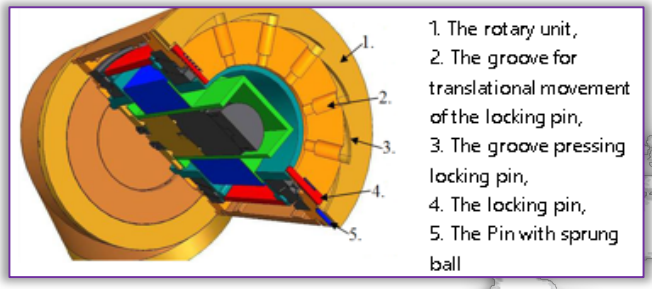

Figure 2. Components of the locking system

IDENTIFIED DEFICIENCIES OF THE LOCKING SYSTEM

Production of first three Rotation Universal Module prototypes enabled to perform a series of tests to identify deficiencies. These deficiencies in the design phase did not reveal to be critical, but during handling with Rotation Universal Module was clear that they need to be solved [6].

At the very act of locking the two adjacent modules, in which is needed to turned rotary unit clockwise. Twisting deteriorated into modules and thus undermines the achievement of the final position. In the final position, there is a protrusion of the locking pin and engagement with the aperture in the opposite parts. Finally it makes firm connection of two adjacent modules. The act of locking makes difficult also weight of one module that achieves 5 kg. To achieve the correct functionality of the device and facilitate locking action was needed to solve this problem. Acceded to the locking system modifies components namely large flange of bearings and a male output. Individual interventions are described below.

COMPONENTS MODIFICATION OF THE LOCKING SYSTEM

The entire locking system of Rotation Universal Module has been designed in a cylindrical shape (Figure 3). This shape makes it difficult to lock two adjacent parts, especially in cases where it is necessary to assemble complex devices. Given problem is also complicated because of weight of one module. The main problem occurs when is necessary to reach a final position in which the rotatable part is turned, and subsequently locking pins are inserted into the holes which are located in opposite parts. Result of this mechanism is really important - locking of two adjacent parts together. During rotation of rotary part there is an undesirable movement of connection module and this disrupts resultant position properly connection of two modules. This action is for an individual worker very difficult.

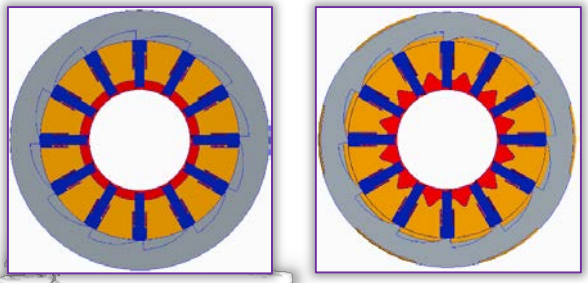

Figure 3. Cut the lock system before and after treatment

In order to resolve this issue we acceded to the adjustment of some parts of the Rotation Universal Module locking system - a large flange of bearings and a male output. As it is showed in Figure 4 both parts have had cylindrical shape in connection place. This causes slip recollection of modules and withdrawals to reach final position in the act of locking two modules together. It was necessary to propose a modification of given position that should be attained in each from twelve positions.

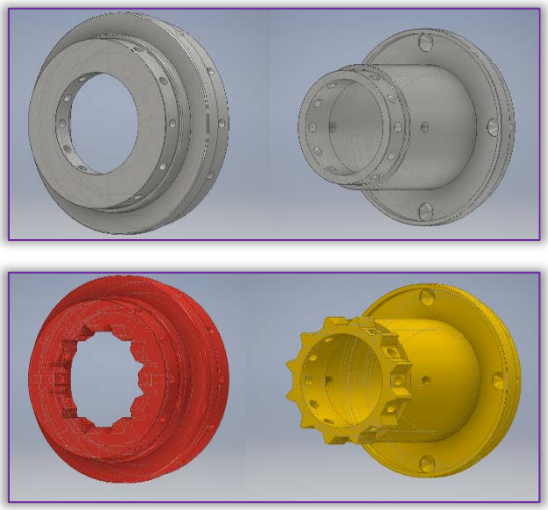

Figure 4. Large flange of bearing male and output before and after treatment

To meet this certain requirement we modified the shape of the parts of the original cylindrical shape to star-shape. Although this change is also problematic in manufacturing but in terms of installation and handling of the modules will bring great facilitate. As we can see from (Figure 4) into the large flange of bearings was needed to mill open triangular shape to achieve gear shape. Same approach has been designed also in males output. In this adjustment it was necessary to adjust one more component which has to achieve the same star-shape as in the previous two episodes. The change was necessary in order to fully prepare the module during its assembly. This procedure has no mechanical nature, but without it would be impossible to complete a module.

Thanks units adaption we have achieved the desired changes. Reassembly of engines and equipment with star-shaped Rotation Universal Module locking system (Figure 5) finally causes suitable grip during act of locking modules. The achievement of the final position is possible in all (twelve) positions.

CONCLUSIONS

Rotation Universal Module is a rotary module with unlimited rotation. Its main use is in construction of modular robotic devices with different movement freedom degrees. Thanks to testing and debugging of the prototype, deficiencies have been revealed. These have been adjusted according to the desired requirements. With a proactive approach and implementation of tests series in the future, we are able to remove all potential Rotation Universal Module shortcomings [7]. Finally the module will be tuned into the desired outcome with adjustments and debugging to get a satisfactory construction result.

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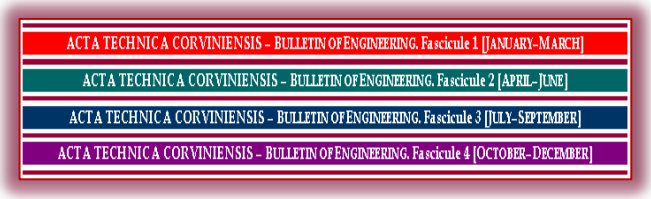
We are very pleased to inform that our international and interdisciplinary journal **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** completed its nine years of publication successfully [**issues of years 2008 –2016, Tome I–IX**].

In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm.

Every year, in four online issues (**fascicules 1 – 4**), **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** [e-ISSN: 2067-3809] publishes a series of reviews covering the most exciting and developing fields of science and technology. Each issue contains papers reviewed by international researchers who are experts in their fields. The result is a journal that gives the scientists and engineers the opportunity to keep informed of all the current developments in their own, and related, areas of research, ensuring the new ideas across an increasingly the interdisciplinary field.

Now, when will celebrate the tenth years anniversary of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!

On behalf of the Editorial Board and Scientific Committees of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we would like to thank the many people who helped make this journal successful. We thank all authors who submitted their work to **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**.



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DESIGN AND CONTROL OF FULL VEHICLE SUSPENSION SYSTEM

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Abstract: This paper deals with the design and control of vehicle suspension system for a full vehicle model with the aim to improve the ride comfort and to guarantee permanent contact between road and wheel. For the design of full vehicle active suspension system we will start by reduced model with 7 DOFs, this model contains all the basic elements to evaluate the ride comfort and tire load variations of the full model with 13 DOFs model. Full vehicle model with 7 DOFs contains 14 state variables which are very difficult and sometimes impossible to measure. These difficulties will be solved by using state estimator or Kalman filter. The selection of weighting factors is very important task to design an active vehicle suspension system, in such a way that during the process a defined goal function is minimized and provide the possibility to emphasize quantifiable issues of vehicle suspensions like; ride comfort and road holding for varying external conditions. Simulations are performed in SIMULINK/MATLAB for full vehicle model, both active and passive suspension system, linear and nonlinear models, while these systems are excited by the white noise disturbance and the linearization around the equilibrium point are performed in MathCAD.
Keywords: passive, active, suspension, optimal control, Kalman Regulator

INTRODUCTION

In order to improve the overall suspension performance, like; ride comfort and road holding for varying external exploiting conditions different authors have discussed various control solutions.

Except contemporary suspension systems, with fixed characteristics in case of an active suspension system it may be applied with great success the theory of optimal control. This theory may be applied both for full state feedback and for limited state feedback.

These analysis has shown that despite the presence of an active force generator, according to the information of the Suspension State which may generate the control force in any shape and mark in order to ensure the better performance, however the conflict between the ride comfort and road holding still remains.

For control system design of suspension it is important to specify an input control vector u. This force drives a system to a specified target state in such a way that during the process, a defined goal quadratic function J is minimized. During the determination of a quadratic goal performance index it is particularly important the selection of weighting matrices Q and R for different values of weighting factors (Likaj, 1998).

NONLINEAR DYNAMIC SYSTEM OF FULL VEHICLE MODEL

For the analysis of vertical oscillation, pitch and bounce of the body mass, suspension working space and dynamic variation of tire load, is used the full car model shown in Figure 1.

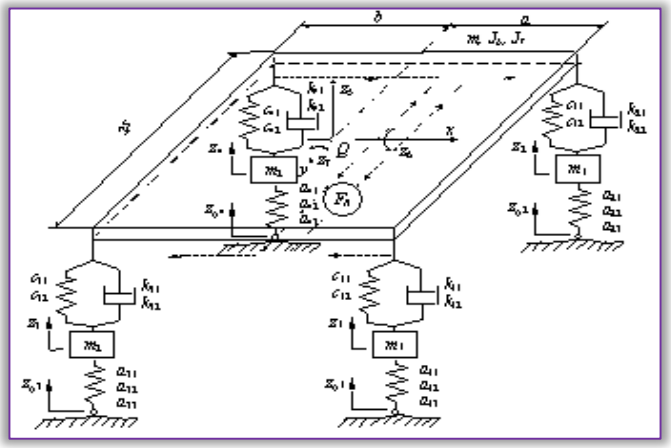


Figure 1. Full vehicle model

The general coordinates are taken in the following form (Demic 1997, Likaj 2005):

» z_1, z_2, z_3 and z_4 – displacement of unsprung mass (tires),

- z_5 – vertical displacement of sprung mass (body),
- z_6 – pitch of sprung mass,
- z_7 – roll of sprung mass,
- z_{01}, z_{02}, z_{03} and z_{04} – the amplitudes of the road excitation by the road microprofile, at each tire.
- a,b and s – the coordinates of the center of gravity for the body mass.,
- J_6 and J_7 – central moments of the inertia for the body mass.

Taking into account the possible displacements of the model with 7 DOFs, the following expressions can be defined:

a) Spring deflections:

$$\begin{aligned} z_{r1} &= z_5 + a\cdot z_7 - s\cdot z_6 - z_1 \\ z_{r2} &= z_5 + a\cdot z_7 + s\cdot z_6 - z_2 \\ z_{r3} &= z_5 - b\cdot z_7 - s\cdot z_6 - z_3 \\ z_{r4} &= z_5 - b\cdot z_7 + s\cdot z_6 - z_4 \end{aligned} \quad (1)$$

b) relative velocities:

$$\begin{aligned} \dot{z}_{r1} &= \dot{z}_5 + a\cdot \dot{z}_7 - s\cdot \dot{z}_6 - \dot{z}_1 \\ \dot{z}_{r2} &= \dot{z}_5 + a\cdot \dot{z}_7 + s\cdot \dot{z}_6 - \dot{z}_2 \\ \dot{z}_{r3} &= \dot{z}_5 - b\cdot \dot{z}_7 - s\cdot \dot{z}_6 - \dot{z}_3 \\ \dot{z}_{r4} &= \dot{z}_5 - b\cdot \dot{z}_7 + s\cdot \dot{z}_6 - \dot{z}_4 \end{aligned} \quad (2)$$

c) radial tire deformations:

$$\begin{aligned} z_{r5} &= z_1 - z_{01} \\ z_{r6} &= z_2 - z_{02} \\ z_{r7} &= z_3 - z_{03} \\ z_{r8} &= z_4 - z_{04} \end{aligned} \quad (3)$$

On the basis of written deformations, non-linear forces on elastomeric elements can be written as follows:

d) Tires:

$$\begin{aligned} F_1 &= a_{11}z_{r5} + a_{12}z_{r5}^2 - a_{13}z_{r5}^3 \\ F_2 &= a_{21}z_{r6} + a_{22}z_{r6}^2 - a_{23}z_{r6}^3 \\ F_5 &= a_{31}z_{r7} + a_{32}z_{r7}^2 - a_{33}z_{r7}^3 \\ F_6 &= a_{41}z_{r8} + a_{42}z_{r8}^2 - a_{43}z_{r8}^3 \end{aligned} \quad (4)$$

e) Springs:

$$\begin{aligned} F_3 &= c_{11}z_{r1} + c_{12}z_{r1}^3 \\ F_4 &= c_{21}z_{r2} + c_{22}z_{r2}^3 \\ F_7 &= c_{31}z_{r3} + c_{32}z_{r3}^3 \\ F_8 &= c_{41}z_{r4} + c_{42}z_{r4}^3 \end{aligned} \quad (5)$$

f) Shock absorbers:

$$\begin{aligned} F_9 &= k_{11}\dot{z}_{r1} + k_{12}\dot{z}_{r1}^2 \mathrm{sign}(\dot{z}_{r1}) \\ F_{10} &= k_{21}\dot{z}_{r2} + k_{22}\dot{z}_{r2}^2 \mathrm{sign}(\dot{z}_{r2}) \\ F_{11} &= k_{31}\dot{z}_{r3} + k_{32}\dot{z}_{r3}^2 \mathrm{sign}(\dot{z}_{r3}) \\ F_{12} &= k_{41}\dot{z}_{r4} + k_{42}\dot{z}_{r4}^2 \mathrm{sign}(\dot{z}_{r4}) \end{aligned} \quad (6)$$

Based on the full vehicle model with 7DOFs which is shown in the Figure 2, the differential equation for the passive system is applied, has been obtained using the D'Alamper principle, for the small vibrations around the equilibrium position, in this form:

$$\begin{aligned} m_1\ddot{z}_1 &= F_3 + F_9 - F_1 \\ m_1\ddot{z}_2 &= F_4 + F_{10} - F_2 \\ m_2\ddot{z}_3 &= F_7 + F_{11} - F_5 \\ m_2\ddot{z}_4 &= F_8 + F_{12} - F_6 \\ m\cdot\ddot{z}_5 &= -(F_3 + F_9 + F_4 + F_{10} + F_7 + F_{11} + F_8 + F_{12}) \\ J_6\ddot{z}_6 &= (F_3 + F_9 + F_7 + F_{11} - F_4 - F_{10} - F_8 - F_{12})\cdot s \\ J_7\ddot{z}_7 &= (F_7 + F_{11} + F_8 + F_{12})\cdot b - (F_3 + F_4 + F_9 + F_{10})\cdot a \end{aligned} \quad (7)$$

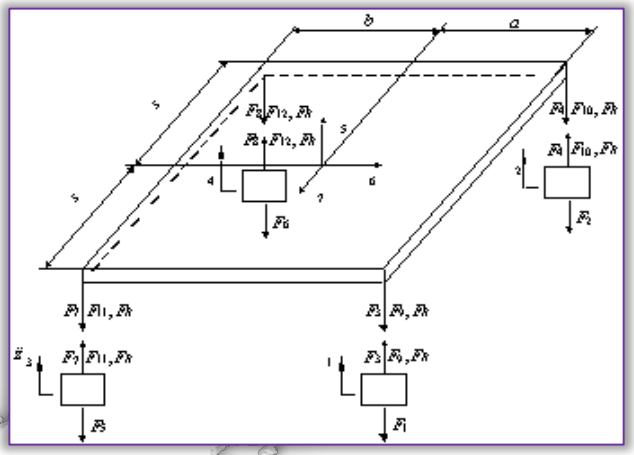


Figure 2. Acting forces in full vehicle model

SIMULATION RESULTS

In the following table are shown the values of the full vehicle model with 7 DOFs, vehicle that have been used for the simulation of the passive and active system:

Table 1. Model parameters of full vehicle model

m_1 = 40 kg	a = 1.8 m
m_2 = 35.5 kg	b = 1.0 m
m = 1460 kg	s = 0.75 m
I_6 = 2460 kg m^2	I_7 = 460 kg m^2

While in Table 2 are given the oscillatory parameters.

Table 2. Oscillatory parameters of full vehicle model

a_{11} = 80000 N/m	c_{22} = 6000 N/m^3
a_{12} = 40000 N/m^2	k_{21} = 4000 Ns/m
a_{13} = 20000 N/m^3	k_{22} = 800 Ns^2/m^2
a_{31} = 80000 N/m	c_{41} = 30000 N/m
a_{32} = 40000 N/m^2	c_{42} = 6000 N/m^3
a_{33} = 20000 N/m^3	k_{31} = 4000 Ns/m
c_{21} = 30000 N/m	k_{32} = 800 Ns^2/m^2

where:

$$a_{11} = a_{21} \quad a_{31} = a_{41} \quad k_{11} = k_{21} \quad c_{11} = c_{21}$$
$$k_{31} = k_{41} \quad c_{31} = c_{41} \quad a_{12} = a_{22} \quad a_{32} = a_{42}$$
$$k_{12} = k_{22} \quad c_{12} = c_{22} \quad k_{32} = k_{42} \quad c_{32} = c_{42}$$
$$a_{13} = a_{23} \quad a_{33} = a_{43}$$

For the full active vehicle model the following weighting factors have been used:

Table 3. Weighting factors

$q_1 = 0.1$
$q_2 = 9.0$
$q_3 = 3600$
$q_4 = 0.00000225$

The SIMULINK model for full vehicle model with 7 DOFs is shown in Figure 3.

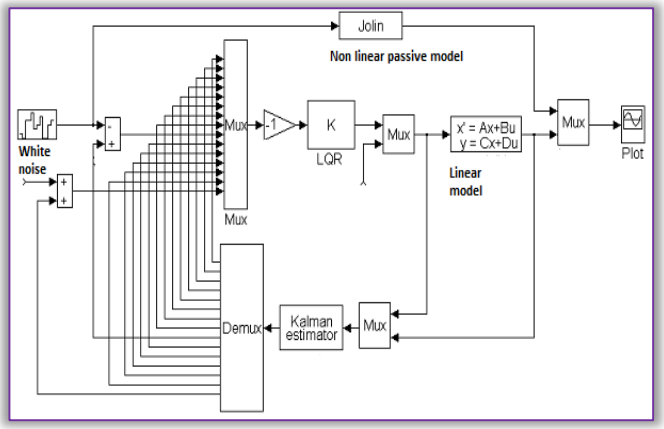
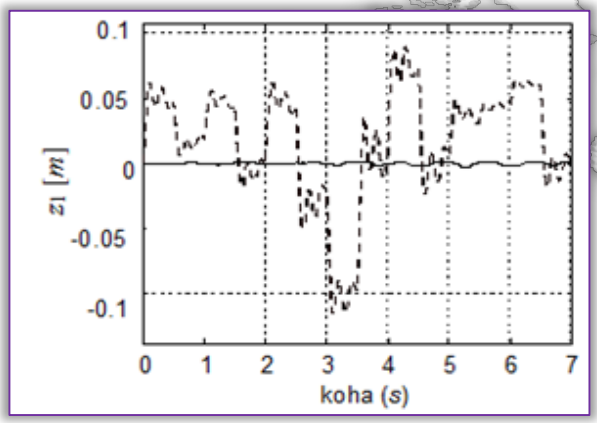
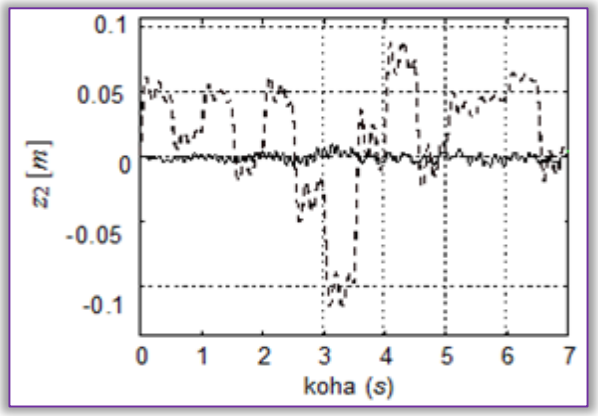


Figure 3. Simulink model for full vehicle system with 7 DOFs (14 state variables)

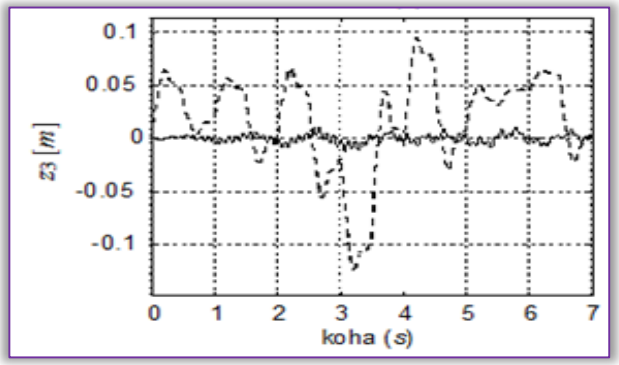
Simulation results for displacement of all DOFs are shown in the following figures.



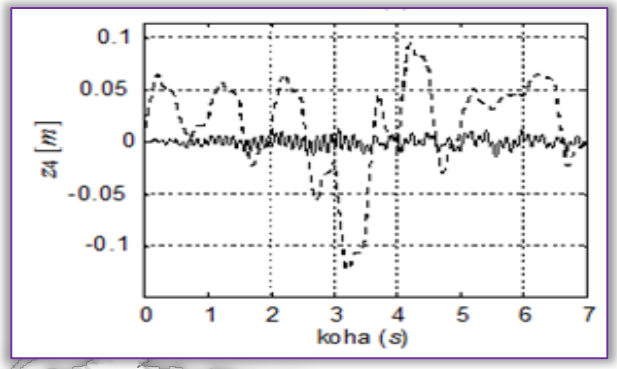
Figures 4. Displacement of z1 DOF for passive (---) and active (-) vehicle suspension system



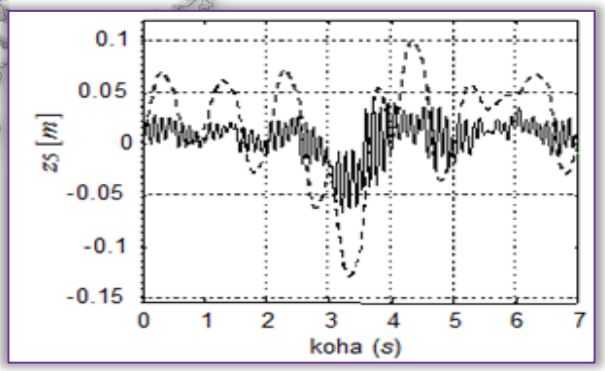
Figures 5. Displacement of z7 DOF for passive (---) and active (-) vehicle suspension system



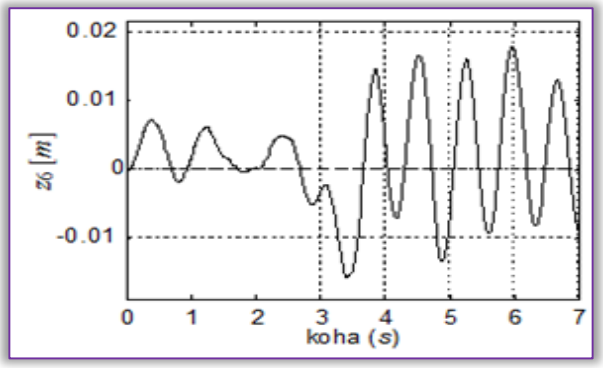
Figures 6. Displacement of z3 DOF for passive (---) and active (-) vehicle suspension system



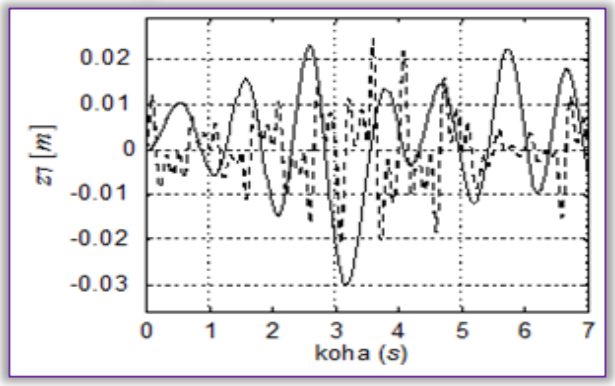
Figures 7. Displacement of z4 DOF for passive (---) and active (-) vehicle suspension system



Figures 8. Displacement of z5 DOF for passive (---) and active (-) vehicle suspension system



Figures 9. Displacement of z6 DOF for passive (---) and active (-) vehicle suspension system



Figures 10. Displacement of z7 DOF for passive (---) and active (-) vehicle suspension system

CONCLUSIONS

For the purpose of designing the performance of an active suspension system the model 7 DOFs model has been used, which is a universal model and can be easily modified to be applied to a wide range of vehicle models. Optimal output control (full feedback control) is performed by minimizing of the quadratic goal function. Through the quadratic performance index can be assigned a Kc matrix of the output feedback, which will obtain Jmin (Likaj, 1998) for the given weighting factors. Such acquisition of values for the weighting factors is based on the maximum allowed variance of the output variables. From the results obtained in the simulations can be concluded that the displacements of the full vehicle model for active suspension system are significantly smaller than the passive nonlinear suspension system.

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AGRICULTURAL FEEDSTOCK CHARACTERIZATION USED IN BIOGAS PLANTS

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Abstract: Anaerobic digestion is a biochemical decomposition process that is used for the treatment and energy recovery from biomass, like organic residues, agricultural and industrial wastes, animal manure and energy crops. The paper presents results of experimental research on the physico-chemical characteristics of the agricultural biomass (corn stalks, wheat straw and alfalfa) that can be used in co-digestion with animal manure in biogas plants. Parameters with a significant role in the process of anaerobic fermentation were assessed: total soluble solids (TSS%), the pH, the moisture content as well as the reducing sugars in the liquid fraction of the tested substrate.
Keywords: agricultural feedstock, corn stalks, wheat straw, alfalfa

INTRODUCTION

In the last period, the anaerobic fermentation of organic fraction has been recognized as a valuable method that can convert the substrate used into useful products such as biogas and digestate (*Khalid et al, 2011*).

The most commonly used substrate for biogas production by anaerobic fermentation process is the manure containing nutrients necessary for the growth of anaerobic microorganisms. However, due to the low concentration of total solids and a high concentration of ammonia present in the manure, it is a common practice to blend in various residues of crops and energy crops (*Regueiro et al, 2012*). The anaerobic digestion of agricultural wastes mixed with animal manure, in a co-digestion mode, can improve significantly the fermentation process and also the biogas production. The most important reason for using co-digestion of animal manure and agricultural biomass is the adjustment of the carbon and nutrient balance and also the quality and stability of the digestate (*Cestonaro et al, 2015; Parawira et al, 2004*). Moreover, agricultural wastes are a desirable material to co-digest with dairy manure because of its high biodegradability.

The final products of anaerobic fermentation process are the biogas that is a mixture of methane (CH_4), carbon dioxide (CO_2), hydrogen sulphide (H_2S), nitrogen (N), oxygen (O_2) and water vapors and the digestate that can be used as soil amendment (*Scano et al, 2014*). The biogas production resulted from the anaerobic fermentation of organic fraction is considerably influenced by the substrate composition (*Ahn H.K., 2010*). Even for the same species of the biomass used, its composition may vary according to geographical area, the season of harvest and the storage mode (*Templeton, D.W., 2009*). Thus, the characterization of substrate components used in anaerobic digestion process for obtaining biogas is very important to estimate the biogas production.

Lately, there were carried out a lot of experiments aiming determination of biogas production resulting from anaerobic fermentation of vegetal biomass, animal manure and other biodegradable wastes (*Cuetos et al, 2011; El-Mashad and Zhang, 2010; Xie et al, 2011*).

Zhang et al (2013) investigated biogas production by co-digestion of goat manure with three crop residues, namely, wheat straw, corn stalks and rice straw, under different mixing ratios. Results showed that the combination of goat manure with corn stalks or rice straw significantly improved biogas production at all carbon to nitrogen (C/N) ratios. Goat manure (GM)/corn stalks (CS) (30:70), GM/CS (70:30),

GM/rice straw (RS) (30:70) and GM/RS (50:50) produced the highest biogas yields after 55 days of fermentation.

In the present paper, there were tested the physico-chemical characteristics of the agricultural biomass consisting of corn stalks, wheat straw and alfalfa, in order to identify the most efficient substrate that can be used in co-digestion with animal manure in biogas plants. It is well known that the anaerobic digestion of organic matter is related to its composition, thus it is necessary to find out what the characteristics of the substrate to be fermented are. Parameters with a significant role in the process of anaerobic fermentation were assessed: total soluble solids (TSS%), the pH, the moisture content as well as the reducing sugar in the liquid fraction for corn stalks, wheat straw and alfalfa.

MATERIAL AND METHOD

Corn stalks, wheat straw and alfalfa plants used during experiment were obtained from a household located in the Teleorman County, Romania.

Regarding the biomass processing, grinding was done with the help of an electrical grinder for vegetable residues Viking GE150 and then with a laboratory mill Grindomix GM-200 for 1 minute at 5000 rpm (fig. 1).

Figure 1 – a) Laboratory mill Grindomix GM-200 and b) Grinder for vegetable residues Viking GE150

The proportion agricultural substrate – water is presented in Table 1. Each quantity of the tested substrate was placed in the same quantity of water in tightly closed Erlenmeyer flasks. After that, the Erlenmeyer flasks were placed in the bacteriological thermostat for 7 days at a temperature of 35 °C (fig. 2). During the experiment, liquid samples were collected for analysis. Assessment of the agricultural substrate was done by analysing and interpreting the following parameters: total soluble solids (TSS%), the pH and the reducing sugar.

The content of total soluble solids (TSS) was determined with a thermo-balance, after the centrifugation of initial samples at 5000 rpm followed by filtering through a membrane with pores of 0.45 µm. The pH of the liquid samples was determined using a pH meter type Hanna.

Figure 2 - Bacteriological thermostat and Erlenmeyer flasks with tested biomass

Table 1. The proportion of substrate used in experiments (w/w)

	Corn stalks (g)	Wheat straw (g)	Alfalfa (g)	Water (g)
Erlenmeyer flask 1	15	-	-	300
Erlenmeyer flask 2	-	15	-	300
Erlenmeyer flask 3	-	-	15	300
Erlenmeyer flask 4	5	5	5	300
Erlenmeyer flask 5	7,5	-	7,5	300
Erlenmeyer flask 6	7,5	7,5	-	300

In order to estimate the concentration of sugars in the samples taken, was used the method in which is used the 3.5-dinitrosalicylic acid (DNS) (*Miller G.L., 1959).* The absorbance was measured at 540 nm using the T92+ UV VIS spectrophotometer, PG Instruments.

The moisture content for each type of agricultural biomass was measured using a KERN RH 120-3 thermo-balance and the results were the following: corn stalks (14.49%), wheat straw (12.23%) and alfalfa (11.44%).

RESULTS

Based on the data obtained from experimental tests, were plotted the variation diagrams for each index analysed (TSS, pH and reducing sugar) as a function of digestion time (figures 3 - 5).

The total soluble solids contain soluble sugars, soluble proteins, mineral salts, pigments and water-soluble compounds that are used as nutritive substrate for different groups of microorganisms involved in anaerobic digestion and biogas production. TSS value refers to the amount of soluble compounds released into the fermentation medium from the vegetal material, mainly substances with low mass. In addition, soluble substances could be formed by the hydrolysis reactions due to the exoenzymes released by hydrolytic bacteria in order to degrade the macromolecular substrate at assimilable compounds with low mass.

The initial TSS values differ depending on the used substrate type. Analysing the data, it can be observed that in all cases TSS value tends to increase. For the milled corn stalks, the TSS values have increased from 0.5%, value recorded after 24 hours, to 2.5% after 168 hours of incubation.

During the experiment, all the TSS values increase because of substrate degradation, the highest value being 2.6% after 168 hours of incubation, for the mixture of corn stalks and alfalfa biomass. In time, the bacterial populations will consume nutrients from the medium and the TSS values will decrease significantly.

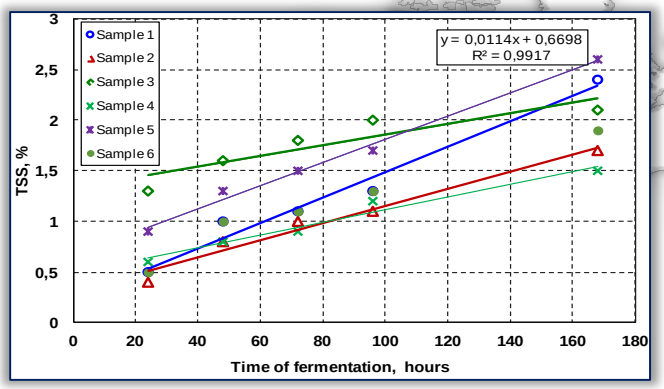

Figure 3 – The TSS variation during fermentation process

The evolution in time of the pH variation for each tested substrate is shown in Figure 4. The pH is a key parameter that provides significant information regarding the stability of anaerobic digestion process. In our case, the pH of analysed liquid samples had an ascending tendency, characteristic for this type of fermentation.

During the 168 hours of experiments, the pH values were maintained in the acid domain due to, probable, the fermentations that produce organic acids, such as acetic, propionic, butyric, fatty acids, alcohols etc.

For each the tested substrate, as well as in the case of thereof mixture, after 24 hours, the pH value start to increase, and at the end of fermentation period have values ranging from 5,8 to 6,5 units.

It can be considered that in this case takes place the first two phases of anaerobic digestion, namely hydrolysis and acidogenesis, where act hydrolytic and acidogenic microorganisms, like: *Streptococcus, Lactobacillus, Bacillus, Escherichia coli, Salmonella.* The highest pH values were recorded for the mixture of corn stalks and alfalfa, from 5.35 units after 24 hours and reaching 6.5 units at the end of the experiment.

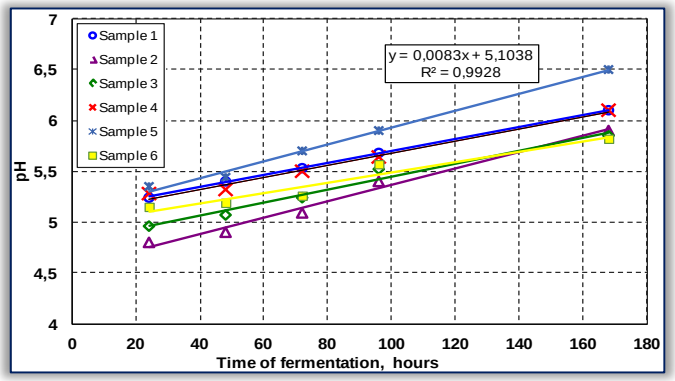

Figure 4 - The pH variation during fermentation process

Due to cellular multiplication and the fermentation produced by these, the reducing sugar concentration had a slightly increasing trend for all the tested substrates during the 168 h of incubation. In time, al the values increase due to saprophytic microorganisms activity with a degradation action of polysaccharides (cellulose and starch) in the plant cell.

During this phase, the sugar concentration is mainly due to extraction process of sugar in water and less to microorganisms' activity, beginning to adapt to the environment and multiply. The growth of microorganisms occurs approximately after the first 24 - 48 hours. They consume the substrate, and also reducing sugars; however, sugars accumulate in the medium at least in the first 168 hours of incubation.

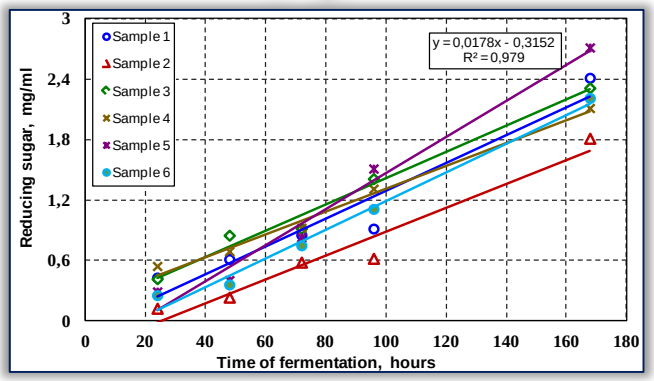

Figure 5 - The reducing sugar variation during fermentation process

After 24 hours the highest concentration of sugars was found in the case of substrate consisting of corn stalks, 0.420 mg/ml, while the lowest concentration was detected in the case of wheat straw, being about 0.115 mg/ml.

Compared to the first day, after 168 hours, for the mixture of corn stalks and alfalfa, sugar concentration increased about 10 times, reaching 2.7 mg /ml.

There is a close correlation between the concentration of sugars and total soluble solids concentration that increase almost simultaneously and are higher in the mixture of corn stalks and alfalfa biomass.

The lowest results were recorded from wheat straw having a siliceous coating, which does not allow microorganisms to access the polysaccharide vegetable wall.

CONCLUSIONS

The anaerobic fermentation is an effective biological process for treating the organic wastes derived from the agricultural and zootechnical sector. The biogas production resulted from the anaerobic fermentation is considerably influenced by the substrate composition.

The achievement of these experiments contributes to the optimization of anaerobic digestion process, in order to obtain biogas from biomass. The characterization of substrate components used in biogas plants is very important to estimate the biogas production.

From the experiments conducted, it was found that the concentration of sugars and total soluble solids increased almost simultaneously in the mixture of corn stalks and alfalfa biomass. After 168 hours, for the mixture of corn stalks and alfalfa, sugar concentration increased to 2.7 mg /ml. For the same substrate, the pH value reached 6.5 units at the end of the experiment.

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SUITABILITY OF THE LOW GRADE KALAMBAINA LIMESTONE DEPOSIT FOR GLASS MAKING

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Abstract: A study to determine suitability of the low grade Kalambaina limestone deposit for glass making has been carried out. Samples were collected from four different locations. The representative samples were analyzed and characterized to determine the chemical composition, mineral phase and microstructural morphology using X-ray fluorescence (XRF), X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) respectively. The results of the XRF showed thatthe deposit consists of 45.66 wt% CaO, 0.38 wt% MgO, 0.35 wt% Fe_2O_3, 0.22 wt% Al_2O_3, 1.13 wt% SiO_2, 0.19 wt% TiO_2 and the amount of material lost on ignition was 42.99% (LOI). Qualitative and quantitative XRD analyses revealed that calcite was the dominant mineral followed by quartz which occurred as the lesser phase. The percentages of calcite and quartz in the sample were99.23 wt% and 0.77 wt% respectively. SEM/EDS analysis depicted the major elemental composition of thedeposit and then the SEM-micrograph demonstrated the spherical calcite dust as dominant phase. The composition of the limestone deposit compared favorably with standard except for high concentration of iron oxide (0.35 wt%) which is objectionable but the concentration of iron oxide is still tolerable for making green container glass (0.96 wt%). Notwithstanding, low grade Kalambaina limestone can be upgraded through beneficiation to minimize the iron oxide concentration.
Keywords: Limestone; Kalambaina; low grade; Glassmaking; River Sokoto

INTRODUCTION

Limestone is a vital industrial raw material used in glass, ceramics, cement, pharmaceuticals, bricks, paint and adhesive industries [1]. Limestone makes up 10% of the total volume of all sedimentary rocks and composed principally of calcium carbonate (calcite) or the double carbonate of calcium and magnesium (dolomite). It is commonly composed of tiny fossils, shell fragments and other fossilized debris and also limestone is usually gray, but it may be white, yellow or brown. It is a soft rock and is easily scratched and effervesces readily in any common acids [2,3].

In the manufacture of high quality glass, limestone should have a maximum of 0.004% Fe_2O_3 and above this value may be unpleasant because its presence even in minute amount tends to color the glass [4]. Lime is one of the major constituents of glass and is introduced in glass in three different forms namely; limestone or marble burnt lime and slake lime [5].

In glass industry, limestone is used in varying proportions from 2.0-18 wt% of the batch and its divalent calcium ion increases the strength of structure network and hence improves the chemical durability, inhibits cord formation, improves fusibility and also smoothness and luster among others [4, 6].

The addition of lime to glass batch ordinarily acts as flux towards sand and also improves viscosity which results in greater durability and resistance to weathering [5]. The aim of the study is to determine the suitability of Kalambaina limestone for glass making.

Kalambaina limestone deposit occurs two miles in width along the Southern valley of River Sokoto. The formation is composed of white to whitish gray chalky limestone with nodules of hard crystalline limestone at the lower part which is about 4.5m thick and constitutes about 80% calcium carbonate and above. It was noted that the upper 5 meters of the formation was dominantly loose gray clayey limestone [7, 2]. Table 1 presented the standard limestone specifications for glass making.

Table 1: Standard Limestone Specifications for Glass Making (Source:[8])

OXIDE	Wt%
SiO_2	<2.0
TiO_2	<0.1
Al_2O_3	<0.3
Fe_2O_3	<0.1
Mn_3O_4	<0.1
MgO	<3.0
CaO	>54.3
Na_2O	<0.1
K_2O	<0.1
P_2O_5	<0.1
SO_3	<0.5
Cr_2O_3	<0.1
SrO	<0.2
ZrO_2	<0.1
BaO	<0.1
NiO	<0.1
CuO	<0.1
ZnO	<0.1
PbO	<0.1
LOI	42.7
Total	100.0

The limestone for this study was sourced from Kalambaina limestone deposit in Wamakko local government area of Sokoto State, Nigeria.

Samples of about 5 kg of the Kalambaina limestone were collected from four different locations, crushed and sieved to about 75 µm particle size distributions from which a representative samples were taken by coning and quartering method for conduct of various analyses.

METHODS / CHARACTERIZATION OF SAMPLE USING ANALYTICAL TECHNIQUES

Representative samples were subjected to various analytical techniques to ascertained chemical composition, dominant mineral present in the sample and microstructural morphology using XRF, XRD and SEM respectively. In addition, a small portion of the fourth sample was dried at 100°C, roasted at 1000°C and then Loss on Ignition (LOI) was determined.

The first sample was subjected to XRF to determine oxides of calcium, magnesium, sodium, potassium, manganese, iron, aluminium, titanium, silicon, phosphorus, chromium, nickel, vanadium, zircon and copper.

The second sample was subjected to identification of dominant minerals by XRD using a back loading method and then the third and fourth samples were used to study surface morphology and loss on ignition respectively.

RESULTS AND DISCUSSIONS

Chemical composition of Kalambaina Limestone Deposit is illustrated in Table 2 while qualitative and quantitative XRD results are given in Figure 1 and Table 3 respectively.

Table 2: Chemical composition of low grade Kalambaina limestone deposit

OXIDE	Wt.%
SiO_2	1.13
CaO	45.66
MgO	0.38
Al_2O_3	0.22
Fe_2O_3	0.35
Cr_2O_3	<0.01
P_2O_5	0.04
V_2O_5	<0.01
TiO_2	0.01
Na_2O	<0.01
K_2O	<0.01
MnO	0.08
NiO	<0.01
ZrO_2	<0.01
CuO	<0.01
LOI	42.99
Total	90.85

The result in Table 2 demonstrates that low grade Kalambaina limestone has 45.66 wt% CaO (lime) content which was far below industrial limestone specification for making quality colourless glass (Aliyu et al, 2013). But, Kalambaina low grade limestone is higher than Indian Shahabad low grade limestone which has 43.2 wt% CaO [9]. Loss on ignition is within the acceptable level [8]. Similarly, Kalambaina low grade limestone contains low concentration of magnesia (0.38 wt%) when compared with the standard [8].

Apart from relatively high percentage of lime, it was detected that the sample contains 0.35wt% Fe_2O_3 which is unpleasant in glass making due to its colouring effect. Although, 0.96 wt% is tolerable for making green container glass [10]. However, Kalambaina low grade limestone can be upgraded to meet the requirements for soda-lime silica glass manufacture through beneficiation.

The qualitative and quantitative analyses result in Table 3 and Figure 1 have revealed the presence of calcite as dominant mineral followed by quartz as lesser phase. The percentage of calcite in the low grade Kalambaina limestone is 99.23 wt% and quartz is accounting for the balance.

The SEM/EDS analysis in Figure 2 shows the major elemental composition of the low grade Kalambaina limestone and the SEM- micrograph given in Figure 3 demonstrates the dominant spherical calcite dust alongside the lesser phase.

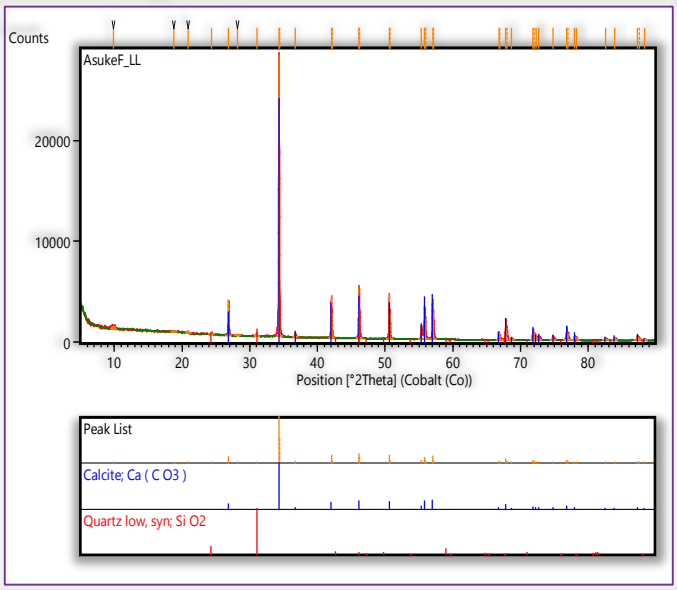

Figure 1: Qualitative XRD analysis of low grade Kalambaina limestone sample

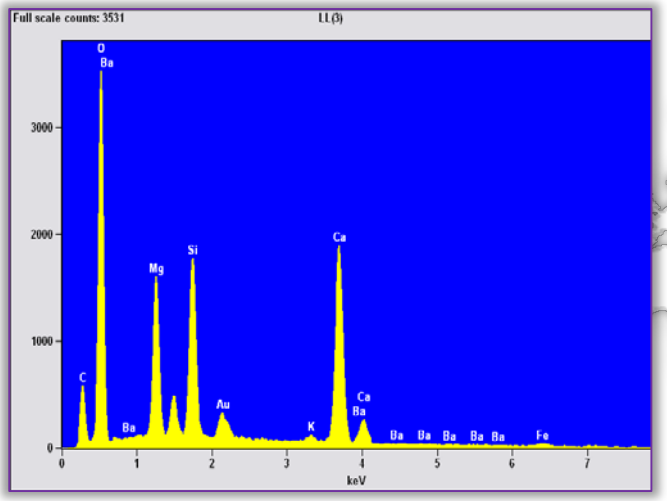

Figure 2: SEM/EDS analysis of low grade Kalambaina limestone

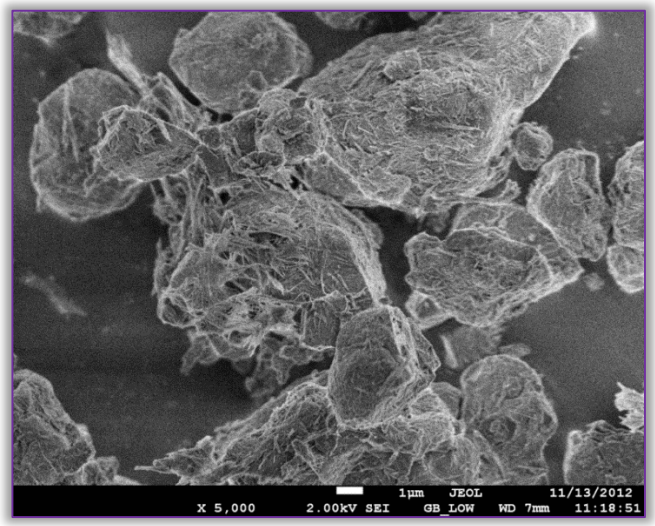

Figure 3: SEM-micrograph of low grade Kalambaina limestone sample at 5,000 Magnification Showing Spherical Calcite Dust.

Table 3: Results of quantitative XRD analysis of the low grade Kalambaina limestone sample

Mineral	Wt%	3α error
Calcite	99.23	0.17
Quartz	0.77	0.17

CONCLUSIONS

The low grade Kalambaina limestone has undergone instrumental analytical techniques and the results of the study revealed that it is suitable for making green container glass due to its relatively high calcite content and low iron oxide content.

Although, the sample can be upgraded by beneficiation to remove the iron oxide concentration so as to meet the industrial limestone requirements for making quality colourless glass.

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STUDY ON IRRIGATION SYSTEMS IN AREAS THREATENED BY DESERTIFICATION – REVIEW

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Abstract: Global climate change increases the areas subject to desertification, the greatest scourge that threatens Earth. One third of the globe is subject of aridity, affecting more than one billion people in 110 countries, including five countries in the European Union, including Romania. In this paper there are presented some modern methods of irrigation, applicable effective in areas threatened by desertification, namely: drip irrigation, with variants wetting the surface and water underground, irrigation by condensation of water vapor existing in the pores of the soil or the atmosphere and the complementary systems for irrigation by condensation, such as systems to optimize the temperature in the root zone of the plants.
Keywords: irrigation systems, desertification, condensation

INTRODUCTION

According to the United Nations Convention to Combat Desertification (http://www2.unccd.int), desertification is the degradation of land in arid, semi–arid and sub–humid areas, resulting from various causes, including climate and human activities.

The Fifth Report of the Intergovernmental Panel on Climate Change (IPCC, 2013) mentions that global average air temperature has increased by about 0,85ºC in the last 100 years (1850–2012), the period 2001–2013 is one of the warmest in the data stream recorded after 1850. Also, the number of hot days increased frequency of heat waves registering a growth trend evident in most of Europe, Asia and Australia. Over 90% of extreme events produced in Europe in the last 30 years are the dangerous hydro–meteorological phenomena (floods, storms) and climate (heat waves, droughts, forest fires) (EEA, 2010).

In this context, climate change is a major challenge for agriculture, water resources and ensuring stability crops being key priorities in policy of prevention and mitigation of extreme events.

Globalization demographic, economic and climatic factors exert great pressure in the agricultural sector to increase food production and reduce water consumption. Part of this pressure linked to the global need for water due to the livestock sector. Statistically, it is known that meat production requires 8–10 times more water than grain production. 70% of global water consumption goes on agriculture for irrigation. Irrigated agriculture accounts for 20% of total cultivated land (global average), but bring 40% of food (WWDR, 2016).

MATERIAL AND METHOD

In Romania, a change in the climate falls in the global context, but with specific geographic region in which our country is situated. Agricultural areas of Romania are affected by drought frequency (approx. 7 million ha), temporary excess of water (approx. 4 mil ha), water erosion and landslides (approx. 6.4 million ha), compaction (approx. 2.8 million ha), etc. It noted that drought is the limiting factor that manifests the largest agricultural area. In this context, the data indicate that most agricultural areas vulnerable to water scarcity in the soil are the Dobrogea, southern Romanian Plain, south–eastern and eastern Moldova and western Tisa Plain. These areas are mainly used in agriculture (approx. 80% of the total, of which approx. 60% is arable land) and forestry (approx. 8%), especially the Danube Meadow (National Strategy on reducing the effects of drought prevention and combating land degradation and desertification, short, medium and long – MARD, 2008).

Farmers apply two methods: dryfarming and agriculture through irrigation. Technology "dryfarming" is profitable for crop production without irrigation in areas receiving less than 500 mm rainfall annually or less. In areas with heavy rain, strong winds, uneven distribution of rainfall, the term "dryfarming" it is also recommended under irrigated crop in terms of annual rainfall between 601–700 l/sqm. The basic problems of the system "dryfarming" are so accumulation in soil of a small amount of annual rainfall, keeping moisture in the soil until it is used by plants, preventing evapotranspiration direct soil moisture during the growing season, adjust the quantity the plant extracts water from the soil, choice of crops suitable for arid, applying appropriate treatments to crops and evaluate products based on superior composition of plants that require small amounts of water (ANM, 2014).

In this paper there are presented some modern procedures of introducing water into the soil, applicable effective in areas threatened by desertification, namely: drip irrigation, consisting of watering through tubes or strips, the water being dispensed drop by drop, into the root zone, with variations in surface and water underground watering; irrigation by condensation of the water vapor existing in the soil pores (underground) or the atmosphere (air); complementary systems for irrigation by condensation (temperature optimization systems in the plant roots).

RESULTS

Drip irrigation systems

A drip irrigation system is based on distribution of water slowly and evenly, drop by drop, in an amount and with a frequency tailored to the needs of the plant, with offsetting strict evapotranspiration, with close supervision rules watering (Payero et al, 2008). Drip irrigation involves the distribution of water directly to plant roots, reducing water consumption by 70%, while achieving higher yields by up to 90%. Drip irrigation method introduced the concept of fertigation, irrigation, fertilization while using irrigation water as support (Phuntsho et al, 2012). They are using nutrients and stimulating total water soluble. They are managed in strict rules, without being scattered in the areas between the rows that does not require fertilization.

The surface drip irrigation presents a number of advantages over conventional systems (eg. sprinkler irrigation), namely: the ability to irrigate land irregularly shaped; soil moisture is maintained at field capacity, strictly in the root zone; it is reduced weeds, between rows of plants because the soil is dry; between rows is facilitated access to culture for mechanized or manual work; reduces soil erosion; plant leaves stay dry and thus reduce the risk of diseases and burns; pressures are much lower than in conventional systems, reducing pumping costs (energy saving).

A schematic diagram of a surface drip irrigation system is presented in Figure 1 (Bloomer et al., 2013).

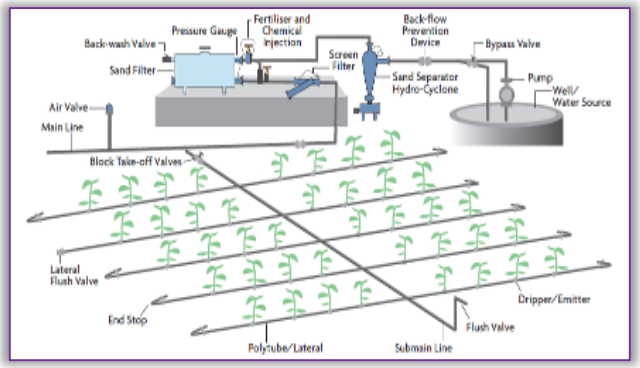

Figure1 – Components and layout of a drip irrigation system (Bloomer et al., 2013)

Subsurface drip irrigation

Compared to surface drip irrigation, the subsurface enables the execution of all agricultural mechanized (Gil et al, 2008). This system is especially advantageous as the soil surface remains dry, which leads to the decrease in the degree of weed. Also, the volume of wet soil in the root zone is larger compared with surface drip irrigation (Figure 2). The subsurface drip irrigation can be operated continuously or intermittently at a pressure of about 1 (one) atmosphere, at a dispensing flow rate between 0.4 and 10 l/h (http://www.eurodripusa.com).

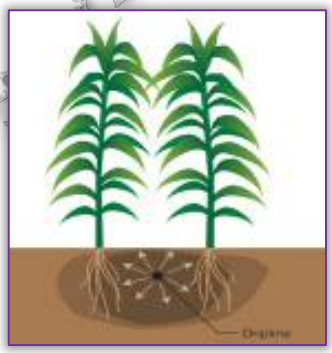

Figure 2 – The distribution of water in the roots area (http://www.eurodripusa.com)

IRRIGATION BY CONDENSATION SYSTEMS

Concept description

Condensation is the process by which water is transformed from gaseous into liquid. Condensation is important for water cycle because it forms clouds. They produce precipitation, which is the main way to return water to Earth (https://ro.wikipedia.org).

Water entering the first ground hygroscopic and capillary saturates all its particles and the pores of the capillary of a particular layer. The water which is under the force of gravity gradually penetrates in depth, continuously wetting the soil to a depth that ensures its saturation water absorbent, film and capillary. Soil water movement occurs in three forms: vapor movement, capillary movement, the gravity movement. The movement of the vapor occurs as a result of

differences in vapor pressure of water in the different layers of the soil. The movement takes place from the higher layers by the vapor pressure of the lower pressure layers (Kleps, 2002). Lebedeff (Lebedeff, 1927), studying the movement of water vapor in the soil, determined that, in a year, about 72 mm of water condensed from the vapor in the atmosphere in a soil type mold. Water condensation in the atmosphere increases as the difference between absolute humidity and water vapor pressure is higher. In Romania, Botzan (Botzan 1966) found the process in research on water balance in soils irrigated Dobrogea on the Black Sea coast and on the terrace of the Danube at Braila. Studies in this area are of practical importance, both in terms of the water balance in the soil and in the study of crop resistance to drought conditions unfavorable intervals during the growing season.

State of the art

Irrigation by condensation is an inexhaustible resource of water for irrigation, the combination of high relative humidity, the air temperature and the low temperature of water circulating through a closed loop system. Irrigation by condensation is designed primarily to arid and semi–arid areas, where groundwater is deep and fresh water sources are rare.

Worldwide, studies on irrigation by condensation were made over time by several researchers (Widegren, 1986; Nordel, 1987; Ruess and Federer, 1990; Gustafsson and Lindblom, 2001).

Absorption of water by plants is very effective in moderating the distribution of daily water, as demonstrated in the plant irrigation condensation built in 1993 by Swiss Company Ingenieurbüro (Hausherr, 1993), the condensation stream of moist air in underground pipes of halved consumption of water at tomato crop. The temperature into the soil has been decreased by increasing the distance between the pipes or decreasing the burial depth, although in both cases the condensation rate increased.

Other theoretical and experimental studies of the irrigation by condensation system were carried out in Adana, Turkey (Gustafsson et al., 1999), resulting in the possibility of irrigation 4.6 mm/day with an energy consumption of 1.6 kWh/m^3.

In 1987, Nordell built a small–scale plant in a greenhouse cucumbers in Övertorneå, Northern Sweden. The air conditioning system was intended to reduce the temperature difference between night and day. During the day, moist air was circulated through underground pipes for heating and cooling ambient soil. When designing an irrigation by condensation system, underground piping configuration such that the critical temperature is reached by the pipe walls and not in the soil between two parallel pipelines. In this way, the roots will grow freely in the space between the pipes. Pipes diameter, depth of burial and pipe spacing is chosen depending on water availability and temperature distribution in the soil (Figure 3) (Lindblom, 2006).

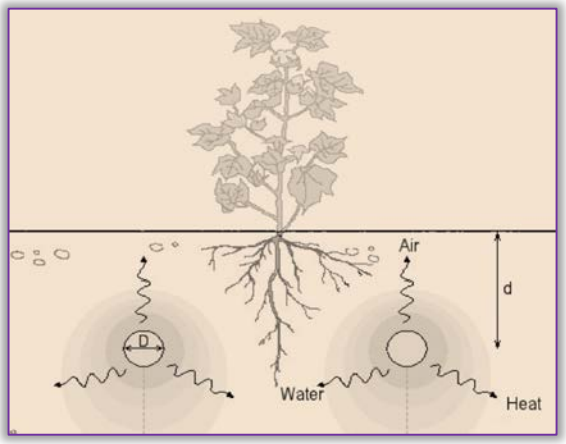

Figure 3 – Section through pipes buried into the soil (Lindblom, 2006)

The length of the pipes affects the efficiency of the dehumidification of air, since the rate of condensation decreases along the pipe. Small depths of burial of the pipeline can increase the rate of condensation resulting in a superficial layer of the water distribution in the soil, water that accumulates on top of the pipe. If one takes into account sunlight, shallow burial depth leads to a lower production of water at a rate of greater evaporation surface due to additional heating of the soil surface. The power consumption of the fan necessary to drive the flow of air through a perforated pipe was 0.4 kWh per 1 m^3 of the condensed water (Lindblom & Nordell, 2006).

Constructive solutions

The document US 4459177 (O'Hare, 1984) relates to a system for the transfer of moisture in the soil horizontally (Figure 4), which can be used in the production of drinking water or irrigation in arid zones. The system uses solar energy for extracting moisture from the soil by heating soil water evaporation and subsequent condensation of water vapor.

Convection column 1 is a black box type solar collector rectangular form, vertically arranged. In its interior, the heated air flows from the entrance to the exit located at the bottom of the upper part, the lower part forming the circulation. This edition pulls warm air from the solar evaporation pipe 2 by 4 in the condensation pipe 3. The pipe 4 has small holes through which soil moisture enters through capillarity and soaking. The water is evaporated by hot air stream in line 4 and transferred to the pipe 3 is cooled by the soil around, which condenses. The water formed by condensation in the pipe 3 can be extracted using a pump or by removing the cap 5 from the outlet pipe 7. The outlet pipe in place of the porous material can be used for drainage into the soil. In this way the water is transferred from a wet to a dry area.

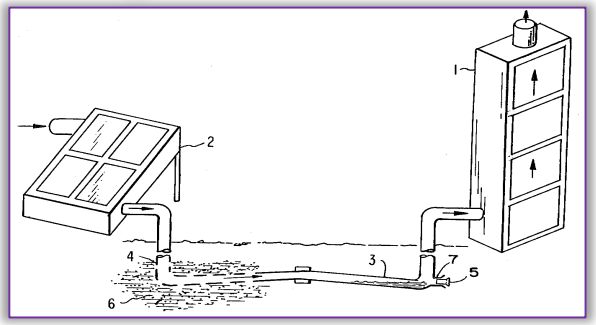

Figure 4 – System for the transfer of moisture into the soil, horizontally (O'Hare, 1984): 1 – convection column; 2 – solar collector; 3 – condensation pipe; 4 – evaporation pipe; 5 – cap; 6 – moist soil; 7 – exit pipe

National Institute for Research in Rural Engineering, Water and Forestry (INRGREF) of Tunisia built in 2004 a pilot plant for underground irrigation by condensation and air irrigation (Figure 5 and Figure 6), in a region characterized by climate variable and minimal rainfall (Lindblom and Nordell, 2006). The pilot plant includes the following main parts:

- a hot water storage tank heated by solar energy, which takes place humidifiers;
- a network of underground pipes with a length of 13 m and a diameter of 63 mm, placed at different depths (0.25 m and 0.4 m);
- an air irrigation system (dew induced irrigation) with vertical pipes;
- a monitoring system of parameters: current air and soil temperature, moisture etc.

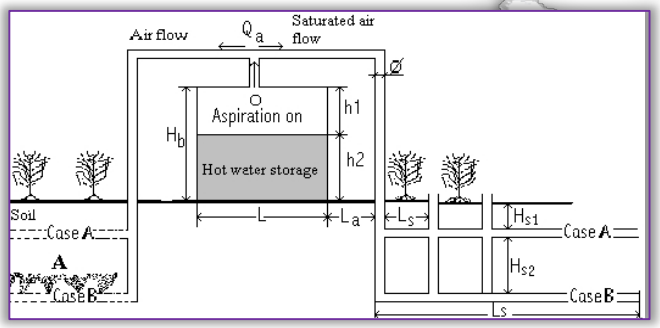

Figure 5 – Sketch of pilot plant (Lindblom and Nordell, 2006): irrigation by condensation (right side); air irrigation (left side); H_{s1}=0.25 m; H_{s2}=0.4 m

Figure 6 – The pilot plant located in the experimental field (Lindblom and Nordell, 2006)

According to experimental research carried out in the pilot plant, underground irrigation by condensation provides a quantity of water that ensures more than 50% of the water needs of vegetable crops in arid areas of Tunisia (Table 1) (Chaibi, 2013). This amount of water can be doubled by the 20% increase of the water temperature in the storage tank.

Table 1. Coverage degree (production/demand) for the irrigation by humid air condensation (Chaibi, 2013)

Daily water production (mm/day)	Rate of satisfaction in water needs (%)				
	Green beans	Peas	Tomato	Potatoes	Onion
2.8	51–56	69–71	57–64	61–68	74–81

Dew induced irrigation

The dew induced irrigation system is an alternative of the irrigation by condensation and was first introduced in 2003, at the International Conference ICEE in Brack, Libya. Dew induced irrigation is obtained by placing the horizontal lines of vertical pipes buried with the top end above the soil surface, which allows the evacuation of the air flow in hot and humid atmosphere. Because of the difference in temperature between the flow of air from the underground pipe and the ambient air, the vapors form a cloud of condensed water droplets falling to the ground in the form of dew. This system can also be used to protect crops from frost, because the latent heat released by steam condensed prevent sudden drop in temperature during the night (Figure 7) (Lindblom, 2003).

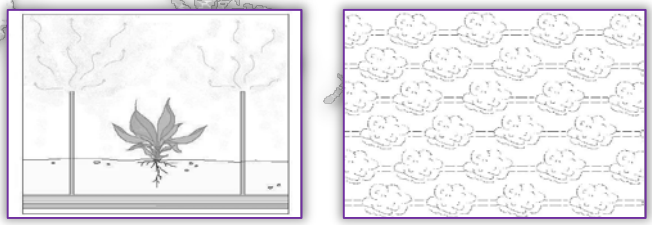

Figure 7 – The principle of the dew induced irrigation system (Lindblom, 2003)

Since the amount of water extracted from the atmosphere increases with increasing temperature difference between ambient air and the air in the pipes, the best performance can be achieved when the hot water tank is stored during the day and at night used for irrigation.

The irrigation device Airdrop (Figure 8) (Dolasia, 2011; Kaja, 2012) uses the process of condensation to collect moisture from the air. Through the air intake system of the turbine, the air is channeled into the underground through a copper coil and the temperature is brought quickly to the ground. This process creates an environment with a humidity of 100%, from which the water is then collected and stored in an underground tank to be pumped into the underground irrigation system.

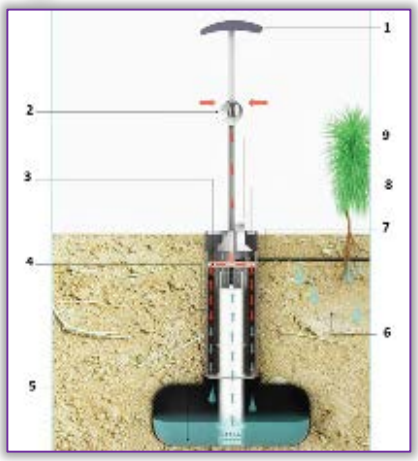

Figure 8 – The irrigation device Airdrop (Dolasia, 2011)
1 – photovoltaic panel with spherical surface; 2 – turbine; 3 – the direction of air flow; 4 – condensation process; 5 – tank; 6 – water distribution in the soil; 7 – semipermeable pipe; 8 – battery; 9 – air out

Air flow regime inside the copper coil can be laminar or turbulent (Figure 9) (http://bustler.net/news). In the case of laminar flow, air passes directly through the tube and condensate is formed only on the inner wall of the tube, which is only cold area with warm air comes into contact. Turbulent flow of air was carried out by placing a spiral coil of copper, to increase the contact surface between the air and the pipe and when the air temperature falls to the ground temperature. Copper coil acts as a resistance to the air and creates the effect of turbulent flow.

Figure 9 – Flow regimes through the copper coil (http://bustler.net/news): laminar (left); turbulent (right)

TEMPERATURE OPTIMISATION SYSTEMS IN THE ROOTS AREA – CONCEPT DESCRIPTION

The principle underlying the temperature optimizing system in the plants roots area is that the temperature gradient between the soil surface and a certain depth is maintaining approximately constant throughout the year. In other words, the temperature of the soil to a certain depth is greater than the temperature of the surface of the soil during the cold season and less than that in the hot season. Within the context of current climate change, this temperature difference became significant, reaching and even exceeding 10°C (http://rootssat.com).

Due to the cooling effect of the root area during the summer, is maintained soil moisture and evaporation rate is reduced. System energy requirements are minimal and are assured of unconventional energy sources, such as solar. It is a simple and reliable system that requires a low initial investment and low maintenance costs (Figure 10).

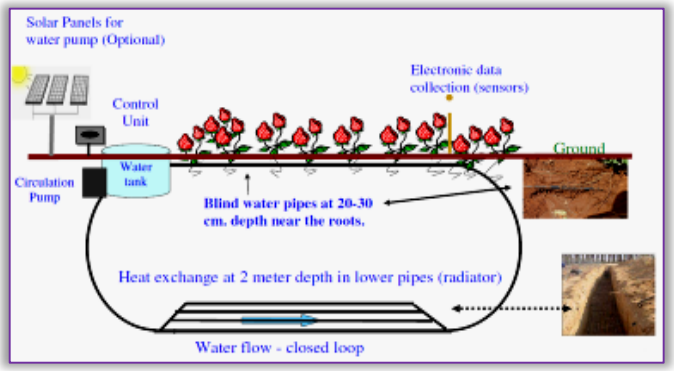

Figure 10 – The scheme of temperature optimization system in the area of plant roots (http://rootssat.com)

CONSTRUCTIVE SOLUTIONS

In US 6148559 patent document (Monte, 2000) are presented a system and a method for preventing the formation of premature buds of fruit trees during the transition period between seasons, when take place sudden temperature increases. The method consists of maintaining the temperature in the plant roots area to a value lower than the temperature at which the buds are formed under normal circumstances. Through a network of underground pipes circulates a cooling agent which, under normal conditions of pressure and temperature, is in gaseous state (eg. hydrocarbons, CO_2, noble gases, anhydrous ammonia); in the pipework there is an area of high pressure (10 – 17 bar) in which the cooling agent is in liquid state and an area of low pressure (2 – 2.7 bar in which the cooling agent is in gaseous state. Root area temperature control system is shown in Figure 11.

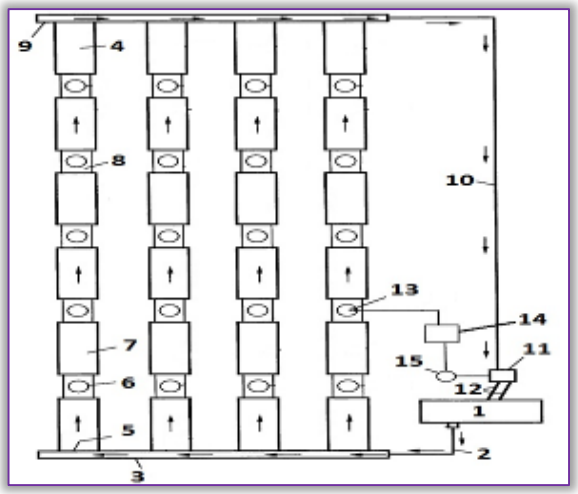

Figure 11 – The scheme of the temperature control system in the area of plant roots (Monte, 2000). 1 – reservoir; 2 – transfer pipe; 3 – high pressure collector; 4 – distribution lines; 5 – regulator; 6 – roots area; 7 – isolated area; 8 – area without insulation; 9 – low pressure collector; 10 – return pipe; 11 – compressor; 12 – heat exchanger; 13 – sap flow sensor; 14 – microprocessor; 15 – solenoid valve

The high pressure area comprises tank 1 in which the cooling agent is in liquid state, the pipe 2 for transferring of the cooling agent to the high pressure collector 3, to which are connected the distribution lines 4, each line having a regulator 5, which allows the adiabatic expansion by Joule–Thomson effect.

In general, the plant roots configuration includes a central spherical zone. Distribution lines of the cooling agent are located in the immediate vicinity of this zone, so that the cooling affect about one–third of the zone. To maximize cooling efficiency and to avoid its propagation in areas where there are no roots, distribution lines are provided at equal intervals with fiberglass insulations. The cooling agent in gaseous state is taken away from the low pressure collector 9 and sent to the compressor 11, passing again in liquid state and goes into the storage tank after previously passing through the heat exchanger 12 on freon basis. To monitor the sap flow departing from the plant roots to buds it is used a special sensor that sends an electrical signal to a microprocessor. The microprocessor drives a solenoid valve which controls the compressor so that when the sap begins to rise, the compressor is turned on and the root zone is cooled to stop the sap flow.

For a total length of the distribution lines of about 75 m and a diameter of 1/2 inch, buried at a depth of 13 cm, the flow rate of the cooling medium is 267 g/min, at a pressure of 2.3 bar. In these conditions, when the ambient temperature is between 10...44°C, the temperature of the soil at a distance of 20 cm from the distribution line is maintained in the range of 3...6°C. At a distance of 10 cm from the distribution line, the ground temperature is between –5...–1°C. It is recommended that the depth of burial of the distribution lines is between 13...20 cm. The flow rate of the cooling agent is between 84...300 g/min. In the US 4577435 patent document (Springer, 1984) is shown a device for both heating/cooling of the plant root system and for heating/cooling the air surrounding the plants (Figure 12). The power supply system is both from unconventional sources (solar, geothermal) and from conventional sources (boilers, chillers, wood or coal burners). The temperature control device is adaptable to a wide range of applications and operating conditions, it is easy to install and maintain and has improved efficiency in operation. The device is designed mainly to heat the root system of the plants in the pots, but can be used in germination beds, the heat transfer tubes being buried in the ground. The input/output collectors are located on the same side of the array of tubes which form U–shaped loops. This location mode enables the temperature gradient between the inlet collector and U loop have the opposite direction of the temperature gradient between the U loop and the output collector. In other words, adjacent tubes have temperature gradients with opposite directions, which leads to uniform temperature in the root zone.

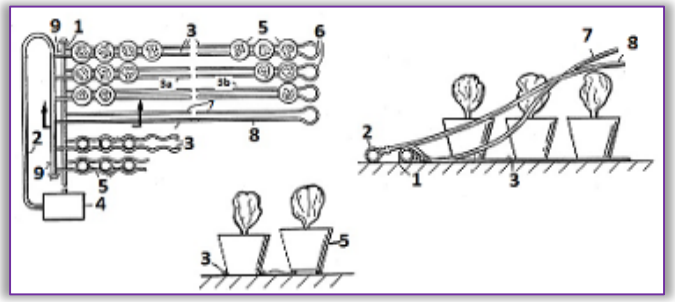

Figure 12 – Device for heating/cooling of the plant root system (Springer, 1984). 1,2 – inlet/outlet collector; 3 – heat transfer pipes; 4 – liquid pumping station; 5 – plant pots; 6 – terminal loop; 7 – portion of the pipe to the outside; 8 – the top portion of the tube; 9 – ventilation valves

The heat transfer tubes have circular section and are made of flexible plastic material (polypropylene, elastomeric polymers of ethylene, diene monomer – EPDM), capable of sustaining the weight of the pots with plants and to support temperatures from –45°C to 150°C. For a length of the transfer pipes of 30 m, water temperature in the inlet collector is 40°C, and those of the output collector reaches 32°C. The optimal distance between the tubes is between 2.5…7.6 cm.

When it's necessary heating the air around the plants during the cold season or cooling it down in hot season, transfer pipes can be removed and placed above the plant height. The loop can be supported in this position by some special supports. In this way, the system is not only used in the root area temperature control, but also to control the ambient air temperature.

The experiments described below were made by the company Netafim (http://www.netafim.com) and placed in three different climate zones in Israel (South – arid, Central and North).

- **Pilot installation for heating/cooling the melons (Arava melons) culture root area** (Figure 13), located on an area of 1000 m^2 in the South.

Figure 13 – Pilot installation for growing melons (http://www.netafim.com)

- **Pilot installation for growing cucumbers in a greenhouse** (Figure 14) (http://www.netafim.com), located in the North. Planting took place in December, and harvesting was carried out from February to May. It has been observed an increase in production of up to

240% with the optimization system of root zone temperature.

Figure 14 – Pilot installation for growing cucumbers in greenhouses: comparison between control culture and culture created with optimization system root zone temperature (http://www.netafim.com)

- **Pilot installation for growing strawberries in greenhouses in suspended layers** (Figure 15) (http://rootssat.com, http://www.netafim.com), the greenhouse being located in the central area. The experiment was carried out in winter, the temperature difference between the unheated soil of the control culture and the heated soil of the experimental culture was 10.8°C at an ambient air temperature of 1.2°C. It has been observed an increase in production between 20...25% and an early maturity of the fruit compared to the control culture, when using the temperature optimizing system in the root zone.

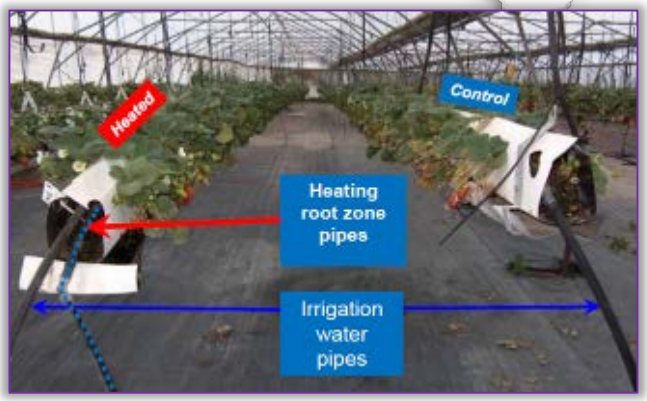

Figure 15 – Pilot installation for growing strawberries in greenhouses (http://rootssat.com, http://www.netafim.com)

CONCLUSIONS

If until recently drought was considered an accident climatic, weather conditions in the last 20 years shows that due to the global climate changes, drought tends to be a state of fact.

To prevent this, irrigation systems are needed in all areas with danger of desertification. It is also necessary to educate farmers in applying technologies appropriate to this crisis, which preserve water in the soil. Relative effectiveness of different methods of irrigation, traditional or new, must be reported also to soil characteristics, climate, hydrology, which can radically alter the terms of comparing a method to another.

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ADSORPTION OF PHOSPHATE AND ORGANIC MATTER FROM MEAT INDUSTRY WASTEWATER BY ACTIVATED CARBONS NORIT SA2, HYDRODARCO AND ZEOLITE ZSM–5

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Abstract: This paper presents the ability of new and not previously studied commercial activated carbons Norit SA2, Hydrodarco C and Zeolite ZSM-5 to remove phosphate ions and reduce the organic load, after the secondary treatment of the meat industry wastewater. The influence of pH, contact time and initial concentrations are studied. Adsorbent Hydrodarco C shows substantial capacity to adsorb phosphate ions, as well as organic matter from meat industry wastewater (removal efficiencies of 81.20% and 84.92%, respectively). The best fit of the experimental results with theoretical models was obtained for the Langmuir and Freundlich's equilibrium models, while the kinetics was the best described by the pseudo second-order model. This study proved the effectiveness of commercial activated carbons for removal of phosphate ions and organic matter and their possibility to be used for tertiary treatment of meat industry wastewater.
Keywords: phosphate, organic matter**,** meat industry wastewater, adsorption kinetics, commercial adsorbents

INTRODUCTION

The wastewaters of meat industry are characterized by large organic load and high content of phosphorus and nitrogen as dominant pollutants that cause the degradation of water bodies of rivers and lakes [1-4]. The discharge of untreated or insufficiently treated wastewater with high concentration of phosphorous stimulates the growth of algae and other photosynthetic organisms in recipients and coastal areas and leads to eutrophication and disturbance of the natural balance of water bodies due to the reduction of dissolved oxygen [5, 6].

Increasingly stricter directives and regulations in the field of environmental protection require a lower concentration of phosphorus and organic load in wastewater streams, where their removal by conventional wastewater treatment systems represents a problem that has not been fully resolved. Quite often, the primary and secondary treatment processes in the wastewater treatment are not sufficient, therefore tertiary treatment of municipal and industrial wastewater treatment has become a necessity which can meet the requirements that are in accordance with the stringent regulations on the issue of environmental protection [5].

The process of adsorption is one of the most effective methods for the treatment of wastewaters. The benefits of adsorption technology are reflected in high efficiency, easy operation, availability and cost-effectiveness of various adsorbents [2]. Activated carbon, natural and modified clays are used as adsorbents for the removal of pollutants from wastewater [7-12]. Natural clay has proven as a good adsorbent for the removal processes of cations of different metals and organic compounds [8, 13, 14].

Despite the large number of cited studies that describe adsorption processes on various adsorbents as a possible way of treating the municipal and industrial wastewaters [15, 16], studies on using commercial activated carbons as adsorbents for the removal of phosphorus compounds and reduction of organic load in the real samples have not been conducted in large

numbers. Therefore, it is necessary to conduct a research on adsorption capacity and characteristics of commercial activated carbons, as well as the possibilities of their use in tertiary treatment of meat industry wastewater.

The aim of this study was to assess the ability of commercial active carbons Norit SA2, Hydrodarco C and Zeolite Socony Mobil-5 (ZSM-5) to remove phosphate ions and reduce the organic load expressed as the chemical oxygen demand, after the secondary treatment of purification of the meat industry wastewater. During experimental research, the kinetics and adsorption equilibrium of commercial activated carbons in real samples in the pH range from 2 to 11 have been examined. In defining the adsorption equilibrium, Langmuir, Freundlich and Temkin equations have been used. Kinetics has been quantitatively determined by using models of pseudo-first- and pseudo-second-order.

MATERIALS AND METHODS

Adsorbents

Commercial activated carbons Norit SA2, Hydrodarco C and Zeolite ZSM-5 (manufacturer Acros Organics, Geel, Belgium) were used as adsorbents.

Activated carbon Hydrodarco C is a powdered activated charcoal with mesh pore structure and 1-150 μm particle size. It is obtained from lignite, after activation by water vapor. It is used for the removal of organic substances from industrial and municipal wastewaters. Activated carbon Norit SA2 is produced from peat rich in organic carbon. It contains neither substances that can be harmful to the environment, nor compounds susceptible to bioaccumulation. Activated carbon Norit SA2 is not soluble in water (Table 1).

Table 1. Norit SA-2 and Hydrodarco C general characteristics

Property	Norit SA-2	Hydrodarco C
Methylene blue adsorption (g/100g)	15	9,3
Iodine number	850	550
Total surface area (BET) (m^2/g)	950	545
Apparent density (tamped) (kg/m^3)	460	388
Particle size D_{10} (μm)	3	2
Particle size D_{50} (μm)	20	13
Particle size D_{90} (μm)	140	165
Ash content (mass %)	9	17.7
Moisture (as packed) (mass %)	2	5

Zeolite ZSM-5 is a type of a "high-silica"-Zeolite, which is responsible for most of its special properties. Zeolite ZSM-5 can be moderately hydrophilic to highly hydrophobic (depending on the Si/Al ratio). Zeolite ZSM-5 has a very high temperature and acid stability (>1000°C and down to pH=3, respectively). It is synthesized at high temperatures and pressures in an autoclave coated with Teflon and is characterized by low water solubility (Table 2).

Table 2. Zeolite ZSM-5 general characteristics

Property	Zeolite ZSM-5
Si/Al	37
S_{meso} (m^2/g)	40
Total surface area (BET) (m^2/g)	390
Apparent density (tamped) (kg/m^3)	250
Particle size D10 (μm)	4.5
V_{micro} (cm^3/g)	0.17
V_{meso} (cm^3/g)	0.09

Wastewater samples

In four sampling campaigns during the spring, summer and autumn 2013 and the winter 2014 wastewater samples from the meat processing plants in the Province of Vojvodina, Republic of Serbia, were collected. Determination of their physico-chemical characteristics was conducted in order to get deeper insight into the current quality issues and to evaluate the efficacy of the applied treatment methods [1]. Only one of the selected meat processing industries has installed wastewater treatment plant. Hence, the meat industry wastewater collected after the secondary treatment of purification at a slaughterhouse in Vojvodina (Serbia) was used for adsorption experiments in our study.

The slaughterhouse has a modern system of wastewater treatment (Figure 1). The equipment installed in the purification system facilitates the treatment of the wastewater generated by the washing of slaughterhouses, meat processing plants, laboratories and vehicles for the transport of livestock and meat. The plant capacity is about 300 m^3 of wastewater per day. Pretreatment of wastewater in the plant involves the removal of burly material with coarse grid and the leveling of flow and composition of wastewater in the equalization tank (D and I). After the burly content removal, wastewater is transfered from the equalization tank to the flotation device by pumps (A and B). During the flotation process, suspended and floating particles are removed from the wastewater (oils, greases, emulsions). At the output of the flotation device, moderately purified water is separated from the waste sludge (F). Separated foam is removed from the surface of the flotation device by skimmers and is then transported to the waste sludge tank, while the incompletely purified water is transferred to the next tank for further treatment (G). The next step of the process is the biological treatment of wastewater (E and E1). During the biological treatment nitrification occurs. Nitrification is the biological oxidation of ammonia nitrogen to nitrite, followed by the oxidation of the nitrite to nitrate. After nitrification, the denitrification process follows, i.e. the biological reduction of nitrate to

molecular nitrogen (C). After the biological treatment, the disinfection of the effluent is carried out.

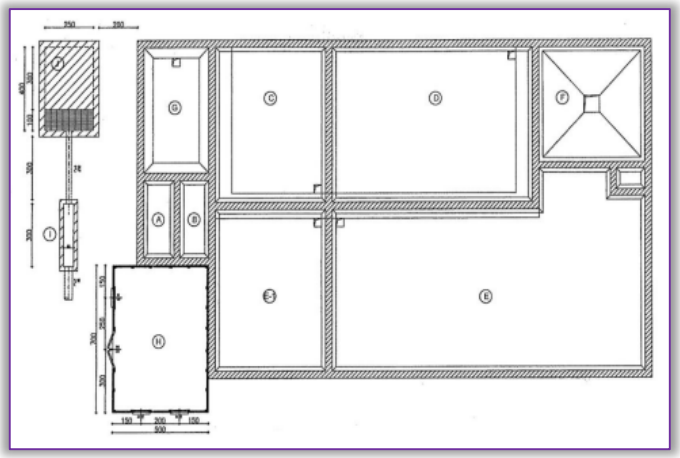

Figure 1. Scheme of the system for wastewater treatment – A – Balancing tank, B – Flotation tank, C – Denitrification, D - Flow equalization tank, E and E1– Biological oxidation, F - Sedimentation tank, G – Sluge processing, H - Technical premises, I - Grid with channel, J - Pumping station

Reagents and adsorbates

For the purposes of the experiment, standard solutions of potassium dihydrogen phosphate (KH_2PO_4) and ADDISTA LCA 703 (Hach Lange GMBH, Dusseldorf, Germany) standards have been used. The initial concentrations of phosphate ions and organic load were 10 and 50 mg L^{-1}, respectively. All solutions were prepared by diluting with a real sample of the meat industry wastewater collected after the secondary treatment of purification. Adjustment of pH value, before the start of and during the experiment was carried out by adding small volumes of 0.1 M NaOH or 0.1 M HCl with a micropipette.

All parameters were determined by using the standard Environmental Protection Agency (EPA) methods (EPA 365.3 for phosphate anions and EPA 410.4 for COD). The concentrations of phosphate ions and Chemical Oxygen Demand (COD) values were measured by Ultraviolet-Visible (UV-Vis) spectrophotometer DR 5000 (Hach Lange, Germany).

The influence of pH value

The pH of the solution affects the total surface charge of activated carbon and Zeolite. In the acidic solution, the area is protonated and therefore positively charged. In an alkaline solution protons are removed from the surface, and therefore it becomes negatively charged. Hence, it is very important to investigate the effect of pH on removal efficiency of selected contaminants typical for the wastewater pollution.

Multiparameter device, Multi 340i (WTW Germany), was used for measuring the initial pH value of suspension obtained by adding 0.2 g of the adsorbent, in the form of commercial activated charcoal, in 50 mL of experimental samples, additionally spiked with KH_2PO_4 and ADDISTA LCA 703 to obtain final concentrations of 10 mgL^{-1} and 40 mgL^{-1}, respectively. The initial pH values of suspensions spiked with phosphate ions and organic matter were: 8.30, 8.48 and 8.21, respectively. In order to examine the characteristics of adsorbents in acidic, basic and neutral media, pH value was adjusted by titration using hydrochloric acid or sodium hydroxide. During examining the adsorption characteristics of adsorbents in relation to phosphate ions, pH value was set at the following levels: pH=2, pH=4, pH=7, pH=9 and pH=11. In the case of testing of the reduction of organic load, pH value was adjusted by titration to levels: pH=3, pH=5, pH=7 and pH=9.

Kinetics of adsorption

The adsorption kinetics of organic matter was evaluated for the initial concentration of 40 mgL^{-1}. In neutral conditions (pH = 7), 0.2 g of commercial activated carbons (Norit SA2 and Hydrodarco C) was used in different contact time. The phosphate ions adsorption kinetics was studied for activated carbons Norit SA 2, Hydrodarco C and Zeolite ZSM-5. Wastewater from the meat processing industry was spiked with standard solution of KH_2PO_4, to a concentration of 10 mg L^{-1}, 0.2 g of the adsorbent was added, and the pH value was adjusted to 9.

The mixing procedure was carried out at a Heidolph shaker Unimax 1010 with fixed speed (140 rpm) for the periods of 5, 10, 20, 30 and 40 minutes. Adsorbed amount, q_e (mg g^{-1}), was calculated via the equation:

$$q_e = \frac{(C_0 - C_e) \times V}{m} \quad (1)$$

C_0-the initial concentration of adsorbate,
C_e-the residual concentration of adsorbate,
V-the volume of solution,
m-the mass of adsorbent.

The removal efficiency is defined by the equation:

$$R_e\ (\%) = \frac{(C_0 - C_e)}{C_0} \times 100 \quad (2)$$

In order to determine the kinetics and mechanism of adsorption, different initial concentrations of organic matter (5-50 mg L^{-1}) and phosphate ions (1-20 mg L^{-1}) were used. Two kinetic models were tested: pseudo first-order model and pseudo second-order model. Kinetic models of pseudo-first- and pseudo second-order together can provide a simple and satisfactory explanation of the adsorption process. Linearized forms of the equations of pseudo first- and pseudo second-order kinetic models can be used to calculate the values of characteristic kinetic parameters. Pseudo first-order model is the oldest model which describes the speed of adsorption based on the adsorption capacity. This model in a real system corresponds mainly to the adsorption at low adsorbate concentrations and it is presented by the equation:

$$\log (q_e - q_t) = \log q_e - (K_1 t / 2.303) \quad (3)$$

where K_1 (mg g^{-1}) presents adsorption constant of pseudo first-order kinetic model and can be determined by the graph log (q_e - q_t) as a function of t.

Pseudo second-order model is based on the assumption that the adsorption could be explained by the second order chemisorption processes:

$$t / q_t = 1 / (K_2 q_e^2) + t / q_e \quad (4)$$

from graph t/q_t versus t.

Adsorption equilibrium

The data on the influence of different initial concentrations of pollutants on the residual concentrations in a solution is the basis for obtaining the data on the adsorption equilibrium. In the experiments, 0.2 g activated carbon samples were mixed for 30 min with 50 mL solutions of various organic matter and phosphate ion concentrations ranging from 5 mg/L to 50 mg/L. Langmuir, Freundlich and Temkin adsorption isotherms were used in this paper to define the adsorption equilibrium. The parameters were obtained by linear regression.

The linear form of the Langmuir isotherm is represented by the equation:

$$C_e / q_e = C_e / q_{max} + (1 / K_L q_{max}) \quad (5)$$

where C_e is the equilibrium concentration of adsorbate (mg L^{-1}), q_e equilibrium adsorption capacity (mg g^{-1}), K_L the Langmuir constant (L mol^{-1}) related to the free energy of adsorption and q_{max} (mg g^{-1}) theoretical monolayer saturation capacity.

Freundlich's isotherm model is empirical and based on the existence of heterogeneous energy adsorption centers on the surface of the adsorbent. The linear form of this isotherm is represented by the equation:

$$\log q_e = \log K_f + (1 / n) \log C_e \quad (6)$$

where K_F (L g^{-1}) presents Freundlich's constant, and n is Freundlich's exponent which shows how adsorption is favored. The linear form of Freundlich isotherm and its graphical representation log q_e to log C_e are needed to determine the values of K_F and n. Ratio of 1 / n ranges from 0 to 1 and the intensity of adsorption is greater when this value is lower.

Linear form of Temkin isotherm is represented by the equation:

$$q_e = B \ln A_T + B \ln C_e \quad (7)$$

where A and B are constants which could be determined by graphical presentation of isotherm.

RESULTS AND DISCUSSION

Applied pre-, primary and secondary treatmnet of wastewater within the meat processing plant improved the quality of water by reducing COD and BOD_5 (Biochemical Oxygen Demand 5-day test) values from 96% to 98.6%, while phosphorus concentrations were only partially removed from 15.29% to 68.48%. Even after treatment, concentration levels of phosphorus were eight times higher than the maximum allowed value prescribed by the Regulation of the Republic of Serbia (No. 67/2011) [17]. Therefore, special attention was focused on removal efficiency of phosphate anions from meat industry wastewater effluent.

Effect of pH

Influence of pH on removal efficiency of organic matter and phosphate ions by adsorption on commercial activated carbons Norit SA2, Hydrodarco C and Zeolite ZSM-5 were presented in Figure 2 and 3.

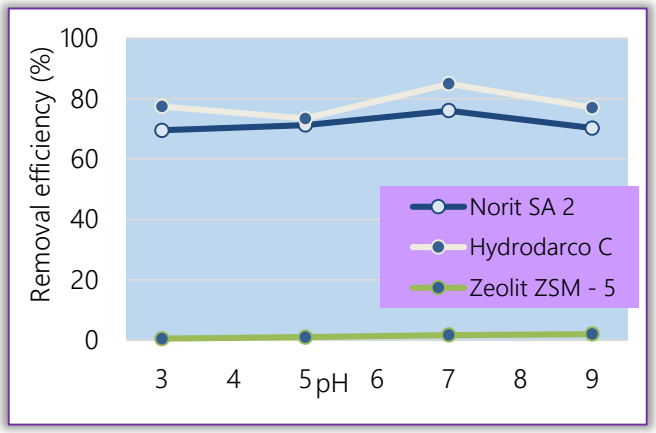

Figure 2. Effect of pH on removal efficiency of organic matter adsorption on different types of activated carbons and Zeolite

The results presented in Figure 2 indicate that the removal efficiency of organic matter was 69.50% and 84.92% for commercial activated carbon Norit SA 2 and Hydrodarco C, respectively. pH value didn't influence significant changes in adsorption capacity. However, the adsorption was most favored in neutral solution with the effiency of adsorption 76.00% and 84.92% for Norit SA2 and Hydrodarco C, respectively. Therefore, the further studies of organic matter adsorption were performed at pH=7. During the adsorption process, the pH should be constant. In the practical use, it would be necessary to pay special attention on setting the pH value of the suspension.

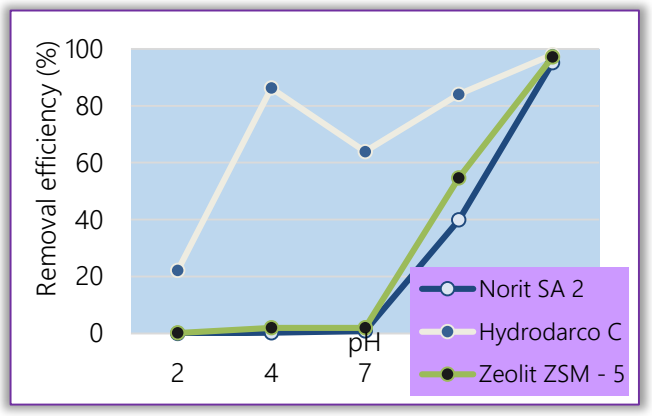

Figure 3. Effect of pH on removal efficiency of phosphate anions by adsorption on different types of activated carbons and Zeolite

Organic matter removal on Zeolite ZSM-5 was 2%, which indicates that ZSM-5 cannot be applied for the reduction of organic matter from aqueous solutions.

The highest removal efficiency of phosphate anions was achieved on pH = 11 for adsorbents Norit SA 2, Hydrodarco C and ZSM-5 (Figure 2).

However, due to cost effectiveness and commercial viability of adsorption process, pH = 9 was used for further adsorption studies. In basic solution (pH=9), removal efficiency of phosphate anions was 39.90%, 84.00% and 54.70%, respectively for above mentioned adsorbents. The results indicated that Hydrodarco C was the most efficient adsorbent for phosphate anions removal from meat industry wastewater. High specific surface area, wide range of different sizes pore distribution and a hydrophobic surface of activated carbon are the main features that make this adsorbent more efficient than Zeolite for removing phosphate anions from water.

Adsorption kinetics of organic matter

The organic matter adsorption results (Figure 4 and Figure S11 - appendix) showed that a rapid uptake takes place on activated carbon Norit SA 2 within the first 30 min. After this time, the rate of organic matter uptake was reduced as the equilibrium approached. The removal efficiency of organic matter amounts to 80.80% on activated carbon Norit SA2 and 81.68% on activated carbon Hydrodarco C.

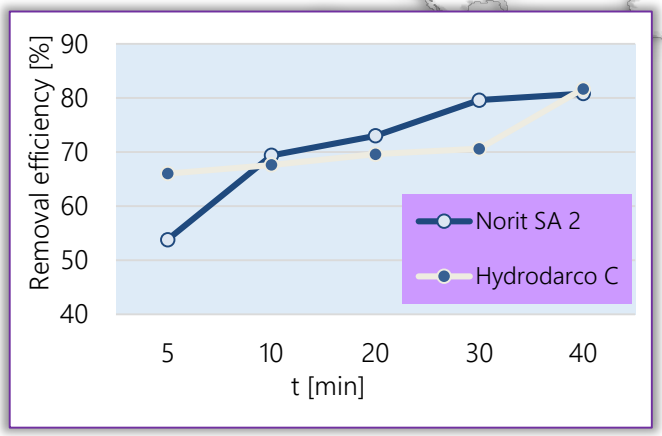

Figure 4. Effect of contact time on removal efficiency of organic matter by adsorption on activated carbons Norit SA 2 i Hydrodarco C

Table 3. The kinetic parameters of organic matter adsorption on activated carbons Norit SA 2 and Hydrodarco C

Pseudo first-order model			
Activated carbon type	R^2	k_1 [gmg^{-1} min^{-1}]	q_e [mg g^{-1}]
Norit SA2	0.9281	0.1142	5.8492
Hydrodarco C	0.9702	-0.0138	2.0500
Pseudo second-order model			
Activated carbon type	R^2	k_2 [gmg^{-1} min^{-1}]	q_e [mg g^{-1}]
Norit SA2	0.9989	32.4940	10.8450
Hydrodarco C	0.9834	24.3400	10.2450

The data presented in supplementary (see Figure S1 and S2) were used to determine kinetic parameters in the kinetic models tested (Table 2).

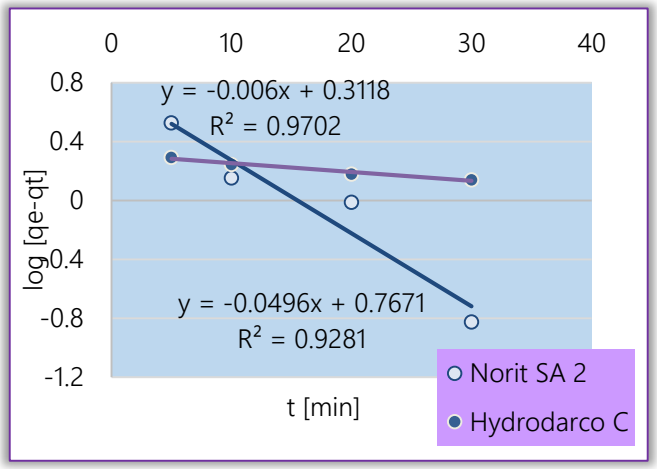

Figure S1. Kinetic pseudo – first order model for adsorption of organic matter on different types of activated carbons

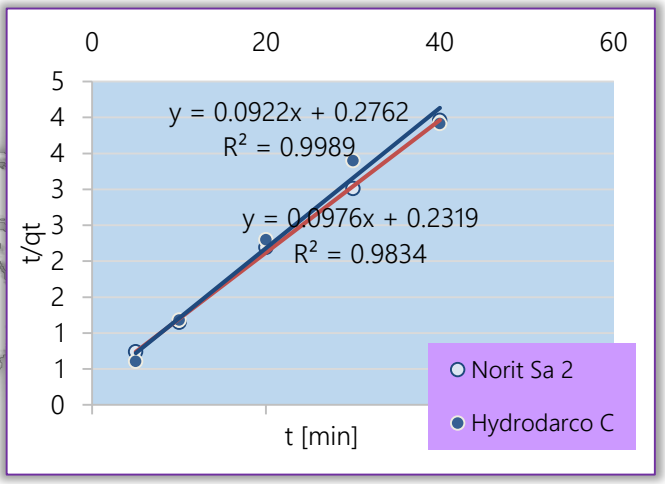

Figure S2. Kinetic pseudo – second order model for adsorption of organic matter on different types of activated carbons

Based on the values of the kinetic parameters shown in Table 3, it can be concluded that the adsorption kinetics of organic matter on activated carbons Norit SA 2 and Hidrydarco C could be better explained by the pseudo second-order kinetic model.

It is confirmed by the excellent agreement between experimental values obtained for the adsorption capacity (q_e=10.100 mg g^{-1}) with a calculated maximum adsorption capacity for pseudo second-order model (q_e=10.845 mg g^{-1}).

Adsorption kinetics of phosphate anions

The phosphate adsorption results showed that within the first 30 min a rapid uptake of phosphate ions takes place (Figure 5 and Figure S12 - appendix). The same conclusion was obtained by Benyoucef and Amrani (2011).

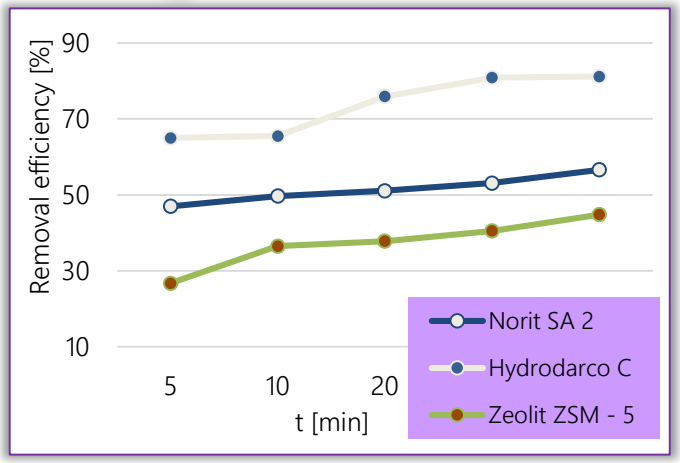

Figure 5. Effect of contact time on removal efficiency of phosphate anions by adsorption on activated carbons Norit SA 2, Hydrodarco C and Zeolite ZSM-5

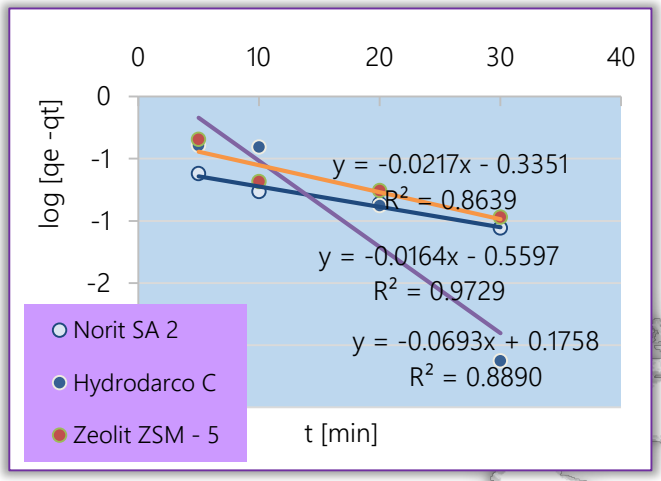

Figure S3. Kinetic pseudo – first order model for adsorption of phosphate anions on activated carbons Norit SA 2, Hydrodarco C and Zeolite ZSM - 5

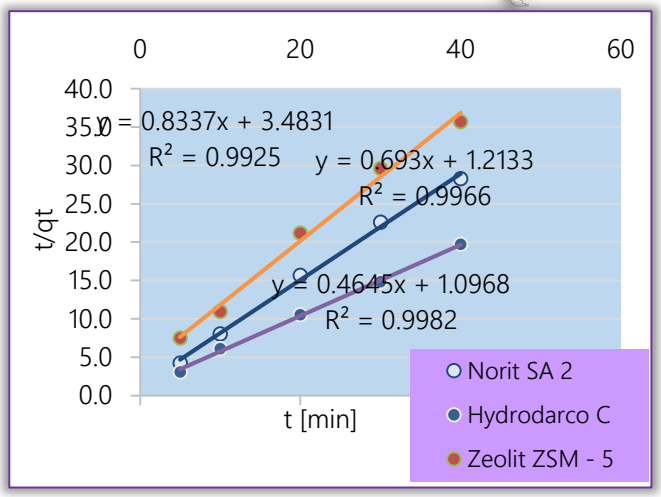

Figure S4. Kinetic pseudo – second order model for adsorption of phosphate anions on activated carbons Norit SA 2, Hydrodarco C and Zeolite ZSM – 5

The highest degree of phosphate ions reduction was achieved for activated carbon Hydrodarco C, and amounted to 81.20% after the equilibrium was achieved. The removal efficiency of phosphate ions in the case of Norit SA2 slightly raised during time, and amounted to 56.60% after 40 min. Adsorption of phosphate ions on Zeolite ZSM-5 showed the lowest removal efficiency, and amounted to 44.80%.

According to the data shown in supplementary (see Figure S3 and S4), kinetic parameters were calculated and presented in Table 4.

Table 4. The kinetic parameters of phosphate anions adsorption on activated carbons Norit SA 2, Hydrodarco C and Zeolite ZSM-5

Pseudo first-order model			
Adsorbent type	R^2	k_1 [gmg^{-1} min^{-1}]	q_e [mg g^{-1}]
Norit SA 2	0.9729	-0.0377	0.2756
Hydrodarco C	0.8890	-0.1596	1.4990
Zeolite ZSM-5	0.8639	-0.0500	0.4623
Pseudo second-order model			
Adsorbent type	R^2	k_2 [gmg^{-1} min^{-1}]	q_e [mg g^{-1}]
Norit SA 2	0.9966	0.3958	1.4431
Hydrodarco C	0.9982	0.1968	2.1526
Zeolite ZSM-5	0.9925	0.1996	1.1994

Correlation coefficients presented in Table 3 confirmed that adsorption kinetics of phosphate anions on activated carbons Norit SA 2, Hidrydarco C and Zeolite ZSM-5 fit to the pseudo second-order model, indicating that binding of the adsorbate to the adsorbent surface occurs by chemical bonding.

Adsorption isotherms of organic matter on activated carbons Norit SA 2 and Hydrodarco C

Removal efficiency and q_e of organic matter on the activated carbons Norit SA2 and Hydrodarco C for different initial concentrations of organic matter at pH =7 is presented on Figure 6 and Figure S13 (appendix).

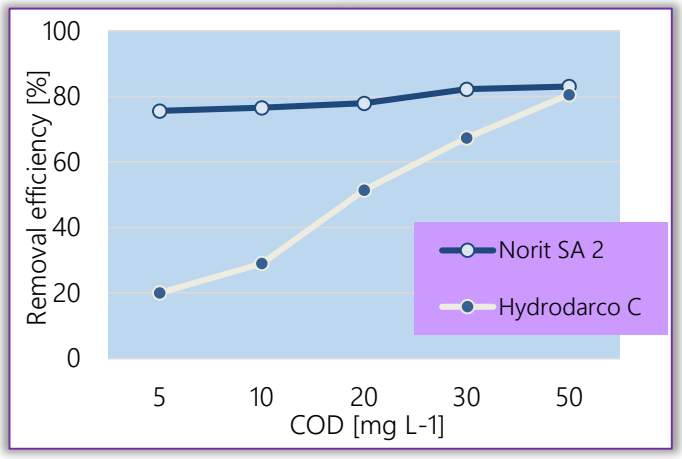

Figure 6. Effect of initial concentration of organic matter on its removal efficiency by adsorption on activated carbons Norit SA 2 and Hydrodarco C

Increase of initial concentration of adsorbate caused better removal efficiency on activated carbon Hydrodarco C, while removal efficiency remained constant (about 80%) for whole range of organic matter initial concentrations on activated carbon Norit SA2.

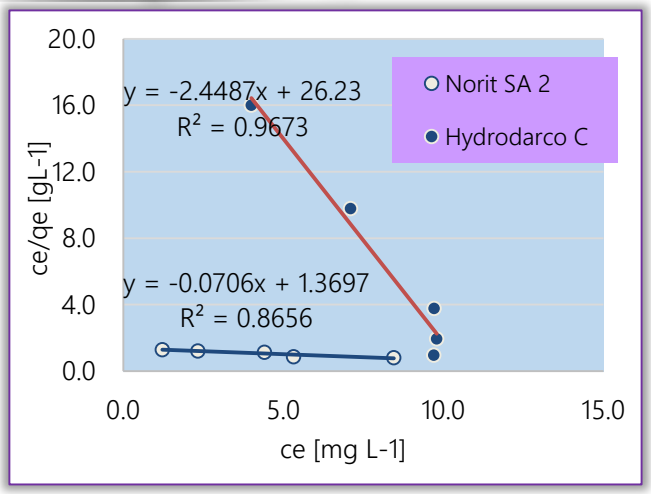

Figure S5. Langmuir isotherm of organic matter adsorption on activated carbons Norit SA 2 and Hydrodarco C

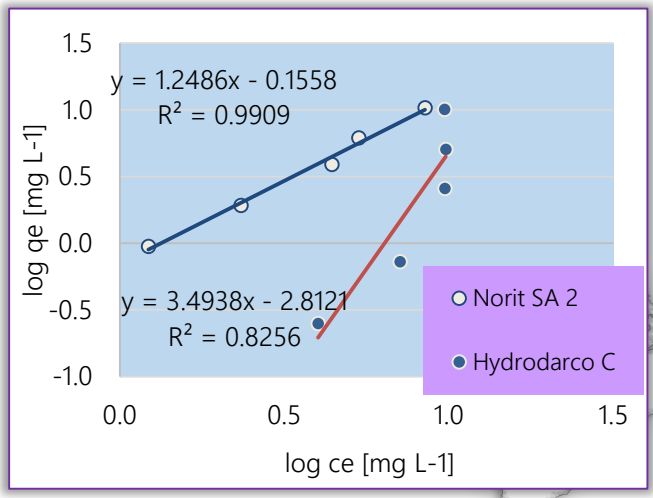

Figure S6. Freundlich isotherm of organic matter adsorption on activated carbons Norit SA 2 and Hydrodarco C

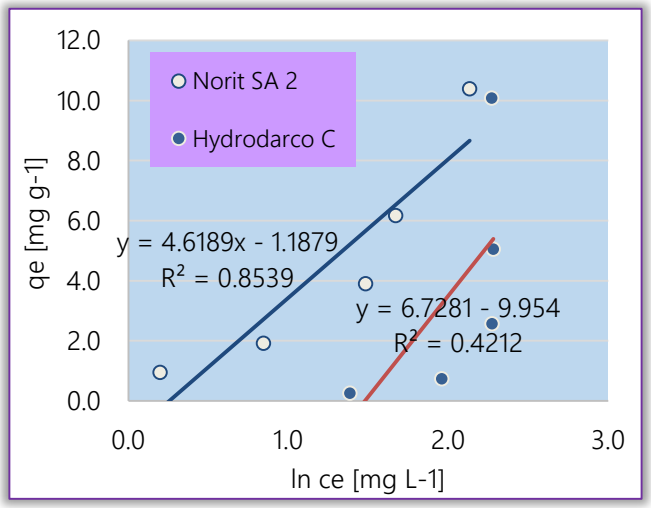

Figure S7. Temkin isotherm of organic matter adsorption on activated carbons Norit SA 2 and Hydrodarco C

Linear forms of Langmuir, Freundlich and Temkin equations are presented in supplementary data (see Figure S5-S7). Correlation coefficients are calculated and presented in Table 5.

Table 5. Isotherms used for description of organic matter adsorption onto Norit SA 2 and Hydrodarco C, including the calculated correlation coefficients

Langmuir	Activated carbon type	K_L [L mol^{-1}]	q_o[mg g^{-1}]	R^2 [-]
	Norit SA 2	0.730	14.17	0.865
	Hydrodarco C	0.038	0.410	0.967
Freundlich	Activated carbon type	K_F [L g^{-1}]	n [-]	R^2 [-]
	Norit SA 2	0.699	10.373	0.991
	Hydrodarco C	0.002	1.840	0.826
Temkin	Activated carbon type	A [L g^{-1}]	B [Lg^{-1}]	R^2 [-]
	Norit SA 2	-1.187	4.618	0.854
	Hydrodarco C	-9.954	6.728	0.421

Adsorption of organic matter on activated carbon Norit SA 2 is the best explained by Freundlich equilibrium model (R^2=0.991). High correlation coefficient indicates that the physical adsorption predominates in the total adsorption of organic substances on activated carbon Norit SA 2. Freundlich exponent n is 10.73, which indicates the energy heterogeneous surface. As n> 1, with increasing concentration of adsorbate, free energy for further adsorption increases, proving physical adsorption as dominant process.

Adsorption of organic substances on activated carbon Hydrodarco C best fit to the Langmuir isotherm (R^2=0.967). The relatively high value of the correlation coefficient indicates that the Langmuir model provides relatively good agreement with the experimental data and therefore it can be concluded that the chemisorption is dominant process.

- **Adsorption isotherms of phosphate ions on activated carbons Norit SA 2, Hydrodarco C and Zeolite ZSM-5**

Removal efficiency and q_e of phosphate ions for different initial concentrations and pH=9 is presented on Figure 7 and Figure S14 (appendix).

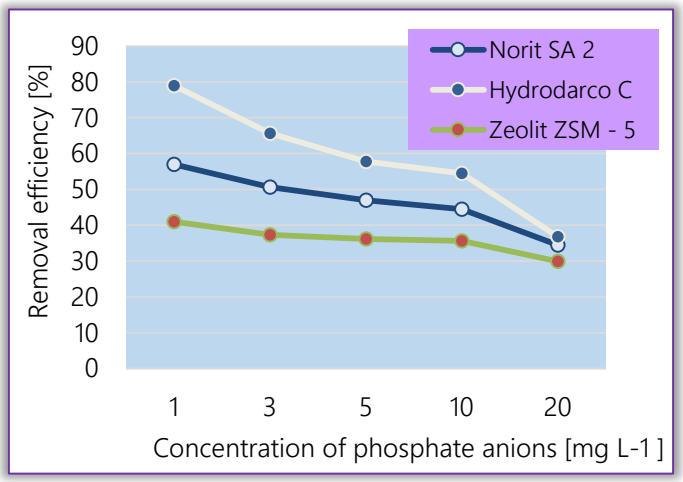

Figure 7. Effect of initial concentration of phosphate ions on their removal efficiency by adsorption on activated carbons Norit SA 2, Hydrodarco C and Zeolite ZSM-5

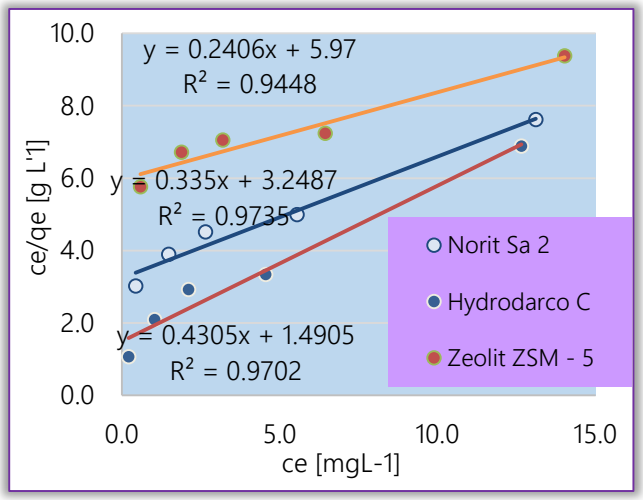

Figure S8. Langmuir isotherm of phosphate ions adsorption on activated carbons Norit SA 2, Hydrodarco C and zeolite ZSM-5

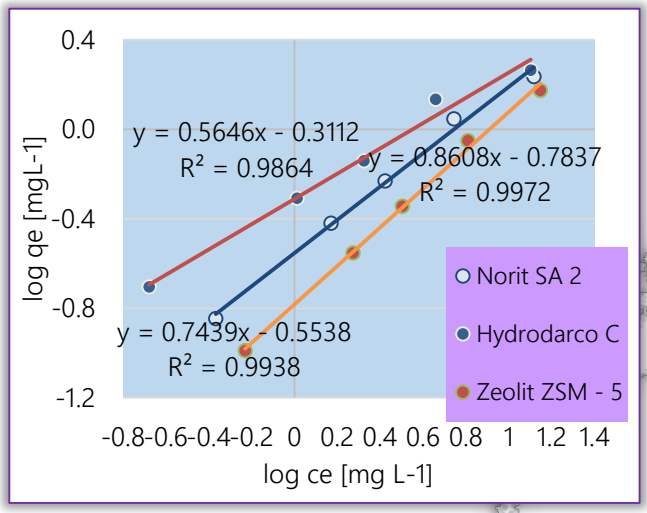

Figure S9. Freundlich isotherm of phosphate ions adsorption on activated carbons Norit SA 2, Hydrodarco C and zeolite ZSM-5

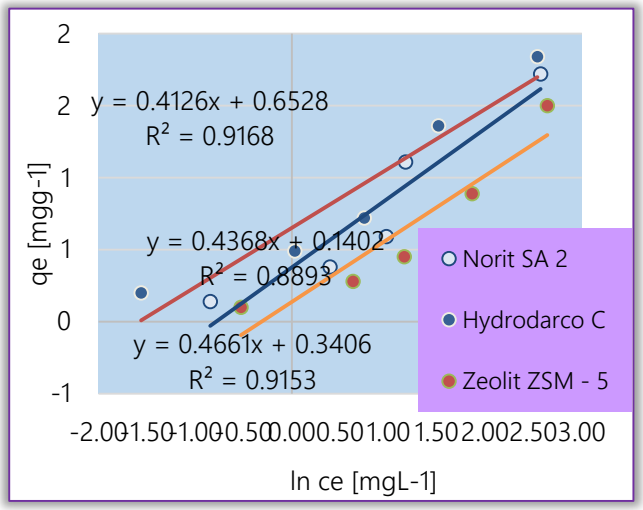

Figure S10. Temkin isotherm of phosphate ions adsorption on activated carbons Norit SA 2, Hydrodarco C and zeolite ZSM-5

The efficiency of phosphate ions removal decreases with the increase of their initial concentrations in all cases. The highest reduction was obtained for adsorption on Hydrodarco C and it ranges from 37% to 79%, while the lowest removal was achieved for Zeolite ZSM-5 in the range from 30% to 41%.

Linear forms of Langmuir, Freundlich and Temkin equations are presented in supplementary data (Figure S8-S10). Correlation coefficients are calculated and presented in Table 6.

Table 6. Isotherms used for description of phosphate ions adsorption onto Norit SA 2, Hydrodarco C and Zeolite ZSM-5, including the calculated correlation coefficients

	Adsorbent type	K_L [L mol^{-1}]	q_o [mg g^{-1}]	R^2 [-]
Langmuir	Norit SA 2	0.308	2.98	0.973
	Hydrodarco C	0.671	2.32	0.970
	Zeolite ZSM-5	0.168	4.16	0.944
	Adsorbent type	K_F [L g^{-1}]	n [-]	R^2 [-]
Freundlich	Norit SA 2	0.279	1.344	0.994
	Hydrodarco C	0.488	1.771	0.986
	Zeolite ZSM-5	0.165	1.162	0.997
	Adsorbent type	A [L g^{-1}]	B [L g^{-1}]	R^2 [-]
Temkin	Norit SA 2	0.341	0.466	0.915
	Hydrodarco C	0.653	0.413	0.917
	Zeolite ZSM-5	0.140	0.437	0.889

Adsorption of phosphate ions could be explained the best by Freundlich equilibrium model for all adsorbents. Similar results have been reported for the adsorption of phosphate by modified sawdust [18, 19]. High correlation coefficients indicate that the physical adsorption predominates in the phosphate ions adsorption on activated carbons and Zeolite ZSM-5.

CONCLUSIONS

This study showed that commercial activated carbons Norit SA2 and Hydrodarco C can be used for organic matter removal from real samples of waste water from the meat industry after the secondary treatment.

High removal efficiency of organic matter is achieved in neutral conditions (pH = 7) for activated carbons Hydrodarco C (84.92%) and Norit SA2 (76.00%). Extremely low level of organic matter separation on the Zeolite ZSM-5 in acidic, neutral and alkaline conditions indicates that aforementioned adsorbent can not be applied for the separation of organic matter from real aqueous solutions.

The kinetic modeling studies show that adsorption kinetics of organic matter follow pseudo second-order model. The equilibrium studies proved that Freundlich isotherm model best describes the adsorption of organic matter on the activated carbon Norit SA2, while the adsorption equilibrium of organic matter on activated carbon Hydrodarco C could be best described by the Langmuir isotherm model.

Adsorbent Hydrodarco C proved to be very effective in the reduction of phosphate ions from meat industry wastewater (removal efficiency of 81.20%). The effectiveness of adsorption process decreased with increasing initial concentration of phosphate ions. The kinetic modeling studies showed that kinetics of phosphate ions on Norit SA2, Hydrodarco C and the Zeolite ZSM-5 follow the model of pseudo - second order. Freundlich isotherm model the best describes the equilibrium of phosphate ions adsorption on above mentioned adsorbents.

Our study proved the effectiveness of commercial activated carbons for removal of phosphate ions and organic matter and their possibility to be used for tertiary treatment of meat industry wastewater.

APPENDIX

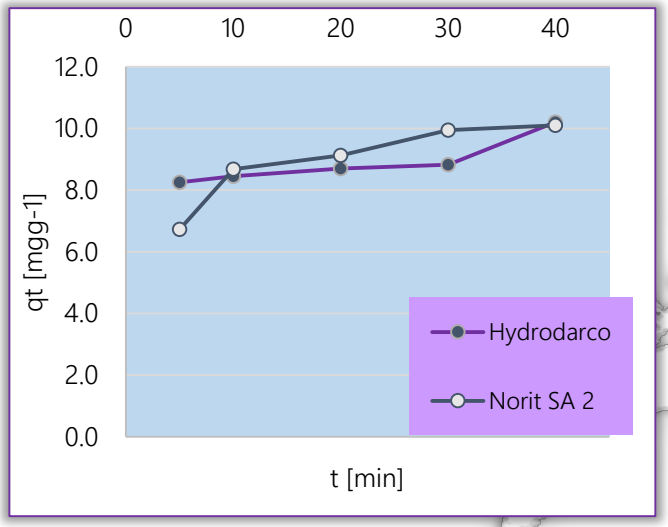

Figure S11. The kinetic data for organic matter adsorption on activated carbons Norit SA 2 and Hydrodarco C

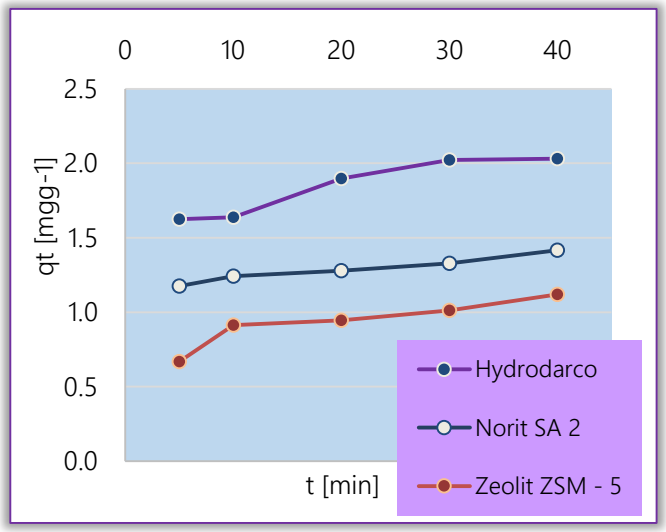

Figure S12. The kinetic data for phosphate ions adsorption on activated carbons Norit SA 2, Hydrodarco C and zeolite ZSM-5

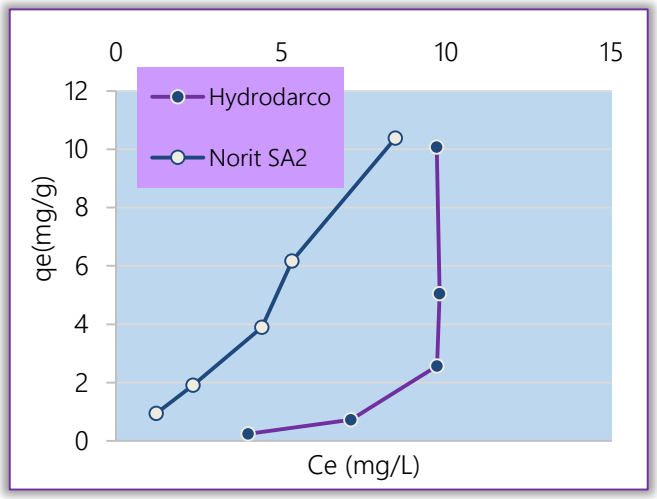

Figure S13. Adsorption isotherms for organic matter adsorption on activated carbons Norit SA 2 and Hydrodarco C

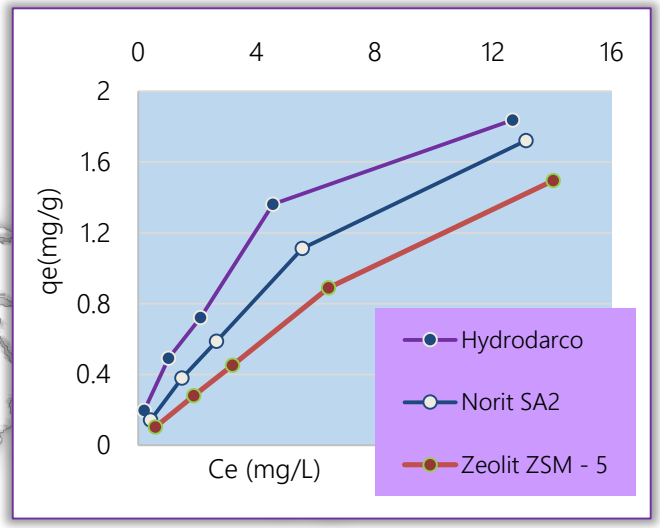

Figure S14. Adsorption isotherms for phosphate ions adsorption on activated carbons Norit SA 2, Hydrodarco C and zeolite ZSM-5

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IMPROVEMENT OF GEOTECHNICAL PROPERTIES OF LATERITIC SOIL USING WALNUT SHELL ASH

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Abstract: This study assesses the improvement of geotechnical properties of lateritic soil stabilized using walnut shell ash. Three natural soil samples A, B and C were collected from different locations in Akure and subjected to the preliminary tests for purposes of classification and identification. Engineering property tests such as California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS) and Compaction tests were performed on the three natural soil samples and thereafter the soil samples were treated with walnut shell Ash (WSA) at varying proportions of 2, 4, 6, 8 and 10% by weight of soil. The results showed that the addition of WSA improved the strength of the three soil samples. The unsoaked CBR values of the three samples increased to 15.85% at 8% WSA, 28.45% at 8% WSA and for sample C, it increased to 26.90% WSA by weight of soil at 6%. The Unconfined Compressive Strength (UCS) of samples A, B and C increased from 148.70 to 320.76 kN/m^2, 153.42 to 381.28 kN/m^2 both at 8% WSA and from 185.23 kN/m^2 to 490.67 kN/m^2 at 6% WSA respectively. It can therefore be concluded that WSA can effectively stabilize poor lateritic soil.
Keywords: Geotechnical properties; lateritic soil; stabilization; strength; walnut shell ash

INTRODUCTION

Laterites, according to Ola [1], has been defined as the products of tropical weathering with red, reddish brown and dark brown with or without nodules or concreting and generally (but not exclusively) found below hardened ferruginous crust or hard pan. Lateritic soils are generally construction materials and are mostly used in construction. In this tropical part of the world, lateritic soil are used as a road making material and they form the subgrade of most tropical roads, they are used as subbase and bases for low cost roads and these carry low to medium traffic [2].

Ogunribido [3], affirms that lateritic soil is generally used for road construction in Nigeria. Lateritic soil in its natural state generally have low bearing capacity and low strength due to high content of clay. When lateritic soil consists of high plastic clay, the plasticity of the soil may cause cracks and damage on the pavement, road ways, building foundation or any other civil engineering construction projects, hence, the need for soil improvement by way of stabilization or modification or both. Soil modification is the addition of a modifier (cement, lime etc.) to change its index properties, while soil stabilization is the treatment of soils to enable their strength and durability to be improved such that they become totally suitable for construction beyond their original classification [4]. According to Joel and Edeh, [5], modification refers to soil improvement that occurs in the short term during and after mixing (within hours). It is aimed at reducing plasticity of the soil to the desired level, short term strength gain, soil modification may or may not lead to strength increase but results in alteration of soil properties to enhance workability as evidenced in textural changes that accompany consistency improvements.

According to Amu et al. [6], soil stabilization may be defined as any process by which a soil material is improved and made more stable. Soil stabilization is the treatment of natural soil to improve its engineering properties. The ability to blend naturally occurring lateritic soil with some chemical additives to give it better engineering properties in both strength and water proofing is very important.

Ogunribido [3], opined that the over dependent on the utilization of industrially manufactured soil improving additives (cement, lime etc.) have kept the cost of

construction of stabilized road financially high, thereby making the provision of good roads for citizens of third world countries like Nigeria, quite difficult especially in the rural areas that are mostly agriculturally dependent. The cheap locally available materials can be classified as either agricultural or industrial wastes.

Walnuts

Walnuts are rounded, single-seeded stone fruits of the walnut tree commonly used for meat after ripening. Following full ripening, the removal of the husk reveals the wrinkly walnut shell, which is usually commercially found in two segments (three-segment shells can also be formed). During the ripening process, the husk will become brittle and the shell hard. The shell encloses the kernel or meat, which is usually made up of two halves separated by a partition. The seed kernels-commonly available as shelled walnuts are enclosed in a brown seed coat which contains anti-oxidants. The anti-oxidants protect the oil-rich seed from atmospheric oxygen, thereby preventing rancidity [7].

The worldwide production of walnut has been increasing rapidly in recent years with the largest increase coming from Asia. The world produced a total of 2.55 million metric tonnes of walnut in 2010. The average worldwide walnut yield was about 3 metric tonnes per hectare in 2010.

Among the major producers, Eastern Europe has the highest yield. According to the Omics International [8], the most productive farms in 2010 were in Romania, with yields above 23 metric tonnes per hectare. Walnut shells are versatile soft abrasive media with unique physical and chemical properties. These properties make them ideal for a variety of applications, such as walnut shell blasting, tumbling, cleaning, polishing, filtration, non-skid flooring as well as soaps and cosmetics. Walnut shell blasting, wheel blast or air blast equipment is used to drive walnut shell media to remove paints and coatings from buildings, cars, boats, furniture etc. [9].

Location and Geology of the Study

According to Ogunribido [3], Akure, the study area lies Longitude 70 18' N and 70 16' North of equator and between Latitude 50 11.5' E of Green Winch meridian. The study area occurred within the pre-cambrian crystalline rocks of the basement complex of Southwestern of Nigeria. The predominant rock types in the study area are, charnockites, granite gneiss and migmatitic rocks. In some places in the study area, these rocks have undergone deep weathering.

AIM OF STUDY

This study examines the improvement of geotechnical properties of lateritic soil using with the additive-walnut shell ash.

MATERIALS AND METHODS

Materials

- Three soil samples A, B and C were collected at three different locations in Akure, Nigeria at a depth not less than 1.2 meters from the ground surface. The soil samples were air-dried for two weeks at the Geotechnical Laboratory of the Federal University of Technology, Akure before analysis were carried out on them.
- Walnut shells were collected from stores and outlets of traders that sell walnuts. The walnuts shells were sun-dried for one week to remove moisture from it and were thereafter subjected to uncontrollable combustion using open air burning. The burnt ash was collected and sieved through 200 microns sieve.
- Potable water was gotten from the running taps in the laboratory.

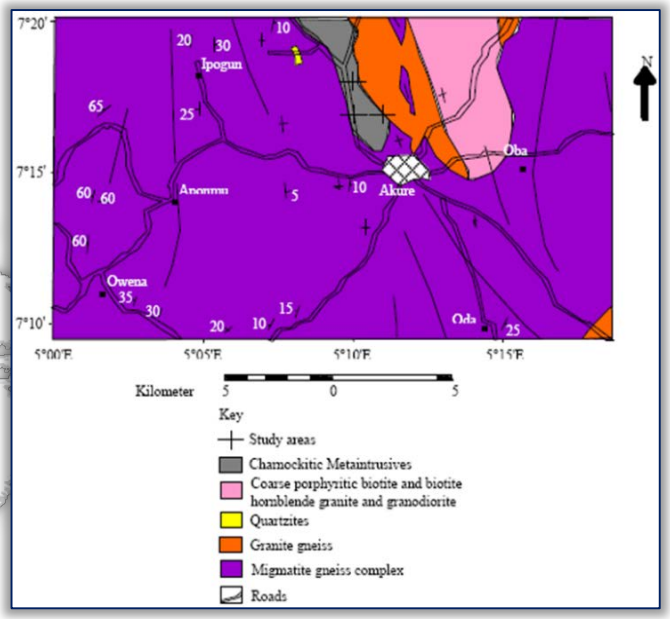

Figure 1: Study Area-Akure, Nigeria. Source: [10]

Methods

The preliminary tests such as natural moisture content, specific gravity, particle size analysis and Atterberg limits for purpose of detecting the index properties of the three natural soil samples were carried out. This, was followed by the engineering tests carried out on the mixtures of each of the three natural soil sample with walnut shell ash at proportions of 2, 4, 6, 8 and 10% by weight of soil respectively. These tests include the Atterberg limits, compaction, California bearing ratio and unconfined compressive strength tests.

RESULTS AND DISCUSSIONS

The results of the chemical analysis, the presence of some oxides which are found in the ordinary Portland cement were also found in the walnut shell ash, such as CaO, which is capable of reacting with the fine particles of soil to enhance stabilization by forming silicates and aluminates of calcium.

SiO_2 required to form dicalcium and tricalcium silicate, also, for improving of strength of the soil. Fe_2O_3 imparts into chemical reaction with calcium and aluminium to form tricalcium aluminoferrite. Al_2O_3 imparts quick setting properties to cementitious materials [12]. While the P_2O_5 has the potential to act as a binding agent to cement particles of soil together, thus increasing its stability [13].

Table 1: Chemical composition of Walnut Shell Ash (WSA), Source: [11]

Elemental Oxides	Weight Composition (%)
SO_3	2.20
P_2O_5	6.20
SiO_2	9.90
Fe_2O_3	1.50
Al_2O_3	2.40
CaO	16.60
MgO	13.40
Na_2O	1.00
K_2O	32.90
TiO_2	0.10

Table 2: Chemical composition of Ordinary Portland Cement, Source: [5]

Elemental Oxides	Weight Composition (%)
CaO	64.0
MgO	1.94
Al_2O_3	5.75
Fe_2O_3	2.50
SiO_2	20.40
MnO	-
TiO_2	-
K_2O	0.61
Na_2O	0.40
SO_3	2.73
LOI	1.20

Table 3: Summary of the preliminary tests results of the three soil samples

Property	Sample A	Sample B	Sample C
Percentage passing BS No 200 Sieve	45.00	42.00	46.00
Natural Moisture Content (%)	19.70	17.50	22.80
Specific gravity	2.72	2.78	2.69
Liquid Limit (%)	56.20	54.20	45.10
Plastic Limit (%)	20.10	22.80	24.10
Plasticity Index (%)	36.10	31.40	21.00
AASHTO Classification	A-7-6	A-7-6	A-7-6

The results from the preliminary tests are presented in table 3, the three soil samples are classified to be A-7-6. According to Garber and Joel [14], for a soil sample to be classified into the A-7 group; it must have a minimum Liquid Limit value of 41%, a minimum Plasticity Index value of 11% and the percentage of materials passing No 200 Sieve must be of minimum value of 36%. Furthermore, the plasticity index of Sample A (36.10) > (LL) 56.20 - 30=26.20. Plasticity Index of Sample B (31.40) > (LL) 54.20 – 30= 24.20. Plasticity Index of Sample C (21.00) > (LL) 45.10 – 30= 15.10. Therefore the three soil samples all belong to the A-7-6 groups.

The results of the Atterberg limits test Liquid limits (LL), Plastic Limits (PL) and Plasticity Index (PI) on the soil samples are shown in table 4. If a soil sample has Liquid Limits value which is less than 35%, it indicates low plasticity. If it is between 35% and 50%, it indicates intermediate plasticity. If it is between 50% and 70%, it indicates that the soil has high plasticity. If it is between 70% and 90%, the soil has very high plasticity and if it is greater than 90%, it is of extremely high plasticity [5].

Table 4: Atterberg limit tests results

Soil Sample	Walnut Shell Ash (%)	LL (%)	PL (%)	PI (%)
A	0	56.20	20.10	36.10
	2	55.20	20.80	34.20
	4	53.90	21.50	32.40
	6	52.50	22.20	30.30
	8	51.40	23.10	28.30
	10	50.40	23.80	26.60
B	0	54.20	22.80	31.40
	2	52.90	23.30	29.60
	4	51.60	23.70	27.90
	6	50.40	24.30	26.10
	8	49.30	24.90	24.40
	10	48.10	25.40	22.70
C	0	45.10	24.10	21.00
	2	43.80	25.00	18.80
	4	43.10	26.10	17.00
	6	42.30	27.60	14.70
	8	41.60	28.60	13.00
	10	40.80	29.10	11.70

Based on the foregoing, soil samples A and B have high plasticity, while sample C has intermediate plasticity. The addition of Walnut Shell Ash (WSA) in proportions of 2, 4, 6, 8 and 10% by weight of soil reduced the plasticity indices of the three soil samples. The reduction in plasticity indices indicates soil improvement [2].

The general decrease in LL at all the soil-WSA combination is attributed to the fact that the WSA reaction forms compounds possessing cementitious properties such as Calcium silicate with soil particles [15].

Table 5: Summary of the Unsoaked CBR and Unconfined Compressive Strength (UCS) results

Soil Sample	Walnut Shell Ash (%)	Unsoaked CBR (%)	UCS (kN/m²)
A	0	6.50	148.70
	2	10.20	220.85
	4	11.65	265.16
	6	12.82	300.45
	8	15.85	320.76
	10	11.90	265.33
B	0	7.90	153.42
	2	16.85	193.42
	4	18.90	270.87
	6	24.62	292.33
	8	28.45	381.28
	10	27.82	284.49
C	0	18.80	185.23
	2	19.90	240.74
	4	23.20	390.92
	6	26.90	490.67
	8	13.85	462.40
	10	16.22	392.58

Table 5 shows results of Unsoaked California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) following the addition of Walnut Shell Ash (WSA) in proportions of 2, 4, 6, 8 and 10% to each of the three natural soil samples. Variations of the UCS with increase in WSA from 0% to 8% for Sample A, 0% to 8% for Sample B and 0% to 6% for Sample C, after which it dropped in each case. The subsequent increase in UCS is attributed to the formation of cementitious compounds between the CaOH present in the soil and WSA and the pozzolans present in the WSA. This decrease in the UCS values after the addition of 8%, 8% and 6% of WSA to Samples A, B and C respectively may be due to the excess WSA introduced to the soil [15]. The explanation for the observed trends in CBR in each of the three soil samples is also applicable in the case of the Unconfined Compressive Strength. Unsoaked CBR values for Samples A, B and C, at optimum contents were 8%, 8% and 6% respectively with corresponding values of 15.85%, 28.45% and 26.90%.

Figure 2: Effects of WSA on the Maximum Dry Density of the samples

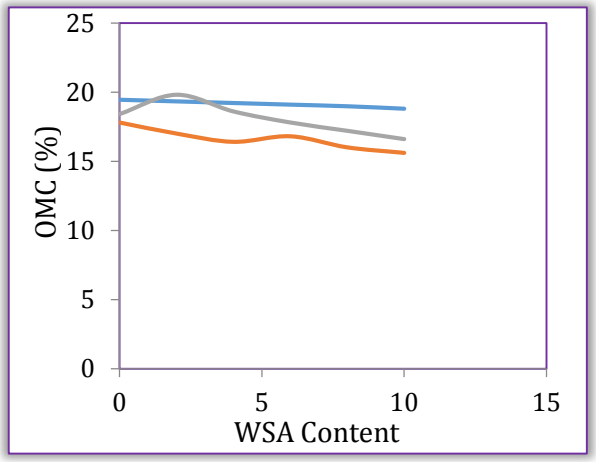

Figure 3: Effects of WSA on the Optimum Moisture Content of the samples

Figure 2 shows gradual increase in values of Maximum Dry Density (MDD) for soil samples A, B and C. Soil sample A has its MDD values increased from 1490 Kg/m³ at 0% WSA to 1560 Kg/m³ at 10% WSA. Sample B, as well witnessed gradual increase in values of MDD from 1400 Kg/m³ at 0% WSA to 1480 Kg/m³ and for soil sample C, the MDD value at 0% WSA was 1420 Kg/m³ which increased to 1495 Kg/m³ at 10% WSA by weight of soil. Figure 3, shows a general reduction in values of Optimum Moisture Content (OMC) with the gradual addition of Walnut Shell Ash (WSA) for the three soil samples. In soil sample A, values of OMC decreased from 19.46% at 0% WSA to 18.80% at 10% WSA. OMC reduced from 17.80% at 0% WSA to 15.60% at 10% WSA in soil sample B. In soil sample C, the OMC reduced from 18.40% at 0% to 16.60% at 10% WSA by weight of soil. According to Lambe and Whiteman [16], the lower the optimum moisture content (OMC), the better its workability and that increase in dry density is an indicator of improvement.

CONCLUSIONS

The procedure for the various tests were carried out in accordance with that stipulated in BS 1377 [17] and British Standards (BS) 1924 [18].

The three soil samples were classified into the A-7-6, A-7-6 and A-7-6 subgroups using AASHTO classification system, under the general system, the three samples all fall within Silt-Clay materials.

Walnut Shell Ash improved the soil samples by reducing their plasticity indices drastically, which are indicators of soil improvement.

Results show that the strength properties of the three natural soil samples improved upon the addition of Walnut Shell Ash. The unsoaked CBR values of the three soil samples at 8, 8 and 6% WSA for samples A, B and C respectively were 15.85%, 28.45% and 26.90% a marked improvement from their values at natural states. The UCS values also increased as well.

The study therefore concluded that Walnut Shell Ash (WSA) can effectively stabilize poor lateritic soil.

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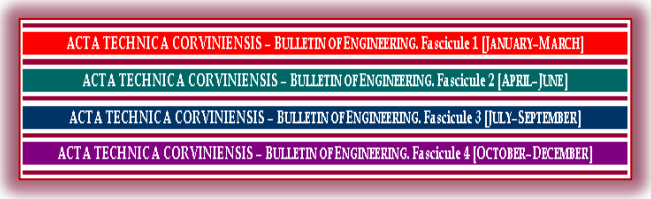
We are very pleased to inform that our international and interdisciplinary journal **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** completed its nine years of publication successfully [**issues of years 2008 –2016, Tome I–IX**].

In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm.

Every year, in four online issues (**fascicules 1 – 4**), **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** [**e-ISSN: 2067-3809**] publishes a series of reviews covering the most exciting and developing fields of science and technology. Each issue contains papers reviewed by international researchers who are experts in their fields. The result is a journal that gives the scientists and engineers the opportunity to keep informed of all the current developments in their own, and related, areas of research, ensuring the new ideas across an increasingly the interdisciplinary field.

Now, when will celebrate the tenth years anniversary of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!

On behalf of the Editorial Board and Scientific Committees of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we would like to thank the many people who helped make this journal successful. We thank all authors who submitted their work to **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**.



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MECHANICAL TESTING OF COMPOSITE MATERIALS WITH ORGANIC FIBRES FOR AUTOMOTIVE BRAKE PADS

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Abstract: Society is directed to use composite materials reinforced with natural fibers due to ecological catastrophes and the exhaustion of natural resources. Natural fibers have low mechanical properties, but these have some advantages such as:low density, low price of raw material and biodegradability. Thanks to these advantages, organic composite materials are appreciated in areas where material weight plays an important role, such as automotive. The weight of the materials used in the construction of automotive influences the amount of CO_2 emitted in the atmosphere with adverse effects on the environment. The paper presents some experimental research results from mechanical testing of new organic composite materials for automotive brake pads without any harmful effect. In this sense, four different laboratory formulations were prepared with varying percentage of coconut fiber, friction modifiers, abrasive material and solid lubricant using powder metallurgy technique. The results obtained provide useful information's about the behavior of these materials in operations.
Keywords: mechanical, organic, composites, pads, test, sample

INTRODUCTION

The environment holds a very important place in society. On the one hand, ecological catastrophes and on the other hand, the exhaustion of natural resources, have led to population awareness regarding to the impact of products and services on the environment. [1] So, it is aimed at designing products with low impact on the environment, but with maintaining a level of performance and similar functionality. For these problems, society is directed to use composite materials reinforced with natural fibers. Although natural fibers have low mechanical properties, these have some advantages such as: low density, low price of raw material and biodegradability. Thanks to these advantages, composites materials reinforced with natural fiber are appreciated in areas where material weight plays an important role, such as automotives. The weight of materials used in the construction of automotives influences the amount of CO_2 emitted in the atmosphere with adverse effects on the environment. [2]

In this regard, has been designed and built a family of organic composite materials. For these materials will be studied the behavior by determining the physico-mechanical and tribological characteristics. In the paper are presented four recipes of organic composite materials and the sequence of operations in manufacturing technology intended for making brake pads for small and medium vehicles.

The main objective of the paper is to present the results obtained from the mechanical tests (tensile, bending and compression) of new organic materials reinforced with coconut fiber. These results are necessary for the complete characterization of composite materials designed.

COMPOSITION OF MATERIALS AND MANUFACTURING TECHNOLOGY

New composite materials proposed and achieved have the chemical composition shown in Table 1. [3,4,5]

Table 1. Chemical composition of the developed composite materials

Samples / Components	C 1	C 2	C 3	C 4
Aluminium (%)	25	20	15	10
Graphite (%)	10	10	10	10
Zirconium oxide (%)	2	2	2	2
Silicon carbide (%)	10	10	10	10
Titanium oxide (%)	13	13	13	13
Phenolic resin (%)	40	40	40	40
Coconut fibre (%)	0	5	10	15

In establish the recipes it was considered the study realized in paper [6] referring to automotive brake pads formulations. All materials were prepared in powder

form. The method used in fabrication of new developed composites was powder metallurgy technique. The prime reason for using the powder metallurgy is the possibility of obtaining uniform parts and reducing tedious and expensive machining processes. [7, 8]

Parameters of manufacturing technology used in obtaining the samples were: heating temperature 200^{0}C, heating time 15 min, retention time 45 min, pressing force at cold (before the samples are placed in the oven) 5 KN, pressing force at hot 5 KN, cooling medium: air, cooling time 10 hour.

The sequence of operations in the manufacturing technology of the samples was:

- the phenolic resin is put into the mixing tank;
- homogenize the constituents with a mechanical mixer;
- constituents homogenized are introduced in the phenolic resin; the composition is homogenized with a mixer;
- place a layer of aluminium foil on the base of the mold and on the active surface of the piston;
- place a layer of graphite on the based mold;
- the mixture is introducing into the mold; the piston of the mold is take up;
- performing a cold pressing force on a hydraulic press;
- the assembly sample-mold is insert in the oven.

Fifthineen minutes after the introduction into the oven, the mold assembly is removed from the oven and is performed a hot pressing force. After that, the sample is return in the oven and maintained for 30 minutes. At the end the samples are cooled in air for 10 hours after which they are extracted from the mold (Figure 1).

Figure 1. Specimen of composite material using for mechanical tests

In order to characterize the new composites materials, were achieved tests to determine mechanical properties. The samples for each test were carried out by cutting in concordance with actual standards, [2].

TESTING METHODS

Mechanical test methods for composite materials must be appropriate to the type of composite analyzed as well as the structure of the product to be achieved. [9], [10]

For composite materials is considered to be necessary a minimum of testing on the basis of which the material can be characterized satisfactorily. Characteristics of materials, especially of composites, must also be determined experimentally. Samples may be subject to various requests: tensile, compression, bending, etc. The type of request is chosen depending on the role of the piece in the assembly. [1]

In this case, the purpose of composites materials is to make brakes pads for small and medium vehicles. The main request to which they are subject is compression. Fora complete characterization of the newly created composite materials, tensile and bending tests will also be performed. These results are necessary in the simulation using mathematical modeling.

The mechanical tests will be carried out in the Materials Resistance Laboratory of the Department of Mechanics and Resistance of Materials in Timisoara, on a Zwick / Roell Z005 equipment. The technical characteristics of the equipment are: maximum test force 5 KN, maximum test speed 3000 mm/min, test temperature: 0-250^{0}C, maximal pressure in the contact area: 300 N/mm^2. [11]

The test equipment works with the testXpert II software, which uses a programming language specific to physical-mechanical testing ZIMT (Zwick Interpreter for Materials Testing). This program offers maximum power and flexibility to operator, it provides a unique data export interface to the most popular systems or programs. These include Word, Excel, Adobe, Access, Oracle, SAP, MySQL and others. The software is designed in a modular system and can be used for several Zwick / Roell test tools. [11]

RESULTS

Figure 2 shows the assembly of the equipment Zwick / Roell Z005 for mechanical tests. Before performing each test, were measured the dimensions of the cross-section of each sample. The dimensions being entered as input in the computer connected to the test equipment. After making the measurements the samples were mounted in series on the equipment assembly. Both the tensile test, as well as bending and compression were performed on a number of ten samples. In the paper are presented the average values of the results obtained.

Figure 2. Assembly of Zwick / Roell Z005 equipment prepared for mechanical tests

At the tensile test the samples were elongated along its main axis with a constant speed, until break or until the load or deformation has reached a preset value. Figure 3 shows a sample made of one of the composite material

mounted in the equipment in order to perform the tensile test. Table 2 shows the values of the samples parameters subjected to the tensile test.

Figure 3. Sample mounted in the equipment to perform the tensile test

Figure 4. Sample broken after tensile test

Table 2. Values of the samples parameters subjected to the tensile test

Parameters	C1	C2	C3	C4
Length of the calibrated portion[mm]	60	60	60	60
Width [mm]	10	10.1	10	10.2
Thickness [mm]	6	5.9	6	5.8
Area of cross section [mm^2]	60	59.59	60	59.16
Loading speed [mm/min]	20	20	20	20

When fitting C1 and C4 samples, in the testing equipment, they crumbled due to a large porosity. These did not allow for mechanical tensile tests. Samples C2 and C3 did not raised problems when they are fitting in the equipment. Table 3 shows the mean values of mechanical tensile test.

Table 3. Average values of tensile tests

Characteristics	C1	C2	C3	C4
Breaking force [N]	Sample broken when the jets crash	3000	2430	Sample broken when the jets crash
Breaking voltage [MPa]		5.0344	4.0500	
Elongation		0.0123	0.0211	

Figure 4 shows the sample made of composite C2 at the end of the mechanical tensile test. Due to the breakage of the samples made of C1 and C4 composites comparative assessments cannot be made for the tensile behavior of the composites materials designed.

The samples subjected to the bending test were taken from disk samples presented in Figure 1. The thickness of disks were between 6 and 10 mm. Table 4 shows the average values of sample subjected to the bending test.

Table 4. Average values of sample parameters subjected to the bending test

Parameters	C1	C2	C3	C4
Length[mm]	100.01	100.02	100	100.01
Width [mm]	15	15	14.99	15
Thickness [mm]	7.2	7.5	7.4	7.5
Area of cross section [mm^2]	108	112.5	110.926	112.5

Figure 5 shows a sample mounted in the Zwick/Roell Z005 equipment for bending test. The distance between the supports of equipment is 48 mm, the loading speed was 20 mm/min and the temperature was constant, T=28°C. Bending test results are shown in Table 5.

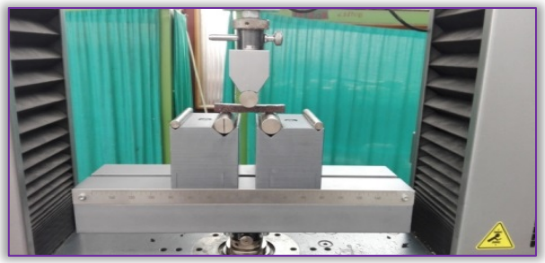

Figure 5. Sample mounted in the equipment to perform the bending test

Table 5. Average values of bending tests

Caracteristics	C1	C2	C3	C4
Breaking force [kN]	0.023	0.0842	0.0362	0.0723
Breaking voltage [MPa]	2.148	7.185	3.1752	6.1696
Elongation	0.1221	0.2114	0.1143	0.2345

The minimum breaking force was recorded for the C1 sample which does not contain coconut fiber and the maximum value of this force was obtained for sample C2 with 5% coconut. If in material exist internal stresses higher than admissible values during their use, even at a reduced load, there is the possibility of irreversible damage of composite material. [12] This shows the importance of reducing the risk of cracks in manufacturing technology.

Table 6. Average values of the parameters of the samples subjected to the compression test

Characteristics	C1	C2	C3	C4
Length [mm]	27.05	30.20	30.26	28.96
Width [mm]	26.49	30.16	31.33	31.43
Height [mm]	8.48	11.8	9.76	9.72
Loading speed [mm/min]	20	20	20	20
Area of cross section [mm^2]	716.55	910.83	948.04	910.21

The samples subjected to the compression test are parallelepiped and were taken from disk samples presented in Figure 1. Table 6 presents the values of the parameters of the samples subjected to the compression test, and the test results are shown in Table 7. Figure 6 shows the sample made of C2 composite with 5% coconut fiber at the time of compression.

Figure 6. Sample mounted in the equipment to perform the compression test

Table 7. Average values of bending tests

Characteristics	P7	P8	P9	P10
Breaking force[N]	2270	1620	3200	899
Breaking voltage [MPa]	3.1679	1.7785	3.3756	0.9876
Elongation	0.03	0.02	0.11	0.1

The values of the forces at which compression is produced for the test samples are between 899 N and 3200 N. At compression tests, the C3 composition with 10% coconut fiber has the best behavior. The evolution of compressive behavior of C2 and C4 composites was similar.

The mechanical behavior of the composite materials tested is satisfactory. To improve these will be followed: optimizing the proportion of raw materials and adding new constituents. One of them would be hexametayltetramine which has the role of transforming thermoplastics into thermosets. This will result in higher values of mechanical characteristics resulting in better mechanical behavior of the composites designed.

CONCLUSIONS

The study shows the results obtained from the mechanical tests which provide useful information in behavior of this composites materials intended for making brake pads for small and medium vehicles.

The results obtained allow to change the proportion of constituents in order to improve operating behavior.

The conclusions obtained from the experimental determinations are:

- C3 composition with 10% coconut fiber have the best behavior followed by C2 and C4 which has a similar evolution;
- the composite materials analyzed have a satisfactory behavior and have increased potential for their use in the manufacture of brake pads;
- the study offers possibilities to improve the mechanical properties by adding new constituents to the recipe and optimizing the proportion of materials for given operating conditions.

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ANALYTICAL-GRAPHICAL ANALYSIS OF VARIOUS INFLUENCES IN THE CARRYING ABILITY OF V-BELTS WITH NARROW PROFILE

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Abstract: In this paper is analyzed in detail influential that have important role in carrying ability of transmitters with trapezoid belts, better known as V-belts with narrow profile. While belt is determinate element for power, which V-belt transmitters can carry, then in detail is analyzed all constructive influential in their carrying ability. For analysis purpose are taken V-belts of type: SPA, SPB and SPC. In the work are given analytical formulae for the calculation of nominal and corrected carrying ability for these types of belts manufactured with coating. Corrected carrying ability is gained when nominal carrying ability is corrected through addition of Power, as a result of influential of these parameters: contact angle between belt and guiding wheel (α_1), transmission ratio (i) and length of belt (L). These influential are presented in this work in analytical and graphical form.
Keywords: V- belt, Nominal ability, Belt drive, Graphic analysis

INTRODUCTION

V-belt transmitters have high application for carrying of power in all types of machines. Main criterion for belt selection is nominal carrying capacity. It represents power, which can be carried by determined profile of belt in laboratory conditions for long time, and transmission ratio i =1. While conditions in field are different from laboratory conditions, then nominal carrying capacity needs to be corrected according to concrete conditions. This carrying ability is known as corrected carrying ability.

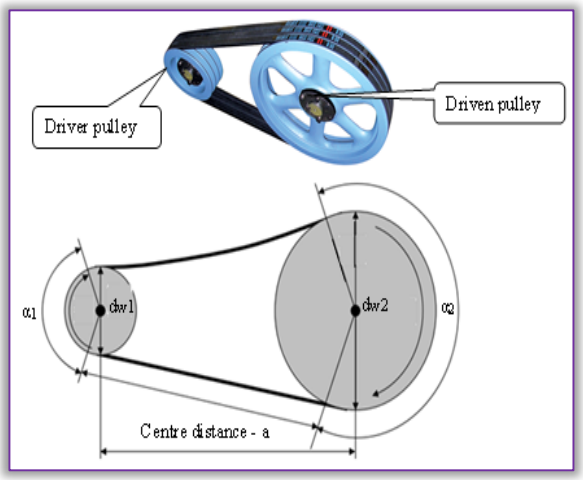


Figure 1. Belt drive

NOMINAL CARRYING ABILITY

Various manufacturers of V-belts give empirical expressions for calculation of power that can be carried by the belt, depending in type of belt, materials used, and forms of production and other parameters of technological process.

Mathematical expression for calculation of nominal carrying ability is:

$$P_{n1}(n_1) = d_{w1} \cdot n_1 \cdot \left[K_1 - \frac{K_2}{d_{w1}} - K_3 \cdot (d_{w1} \cdot n_1)^2 - K_4 \cdot \log(d_{w1} \cdot n_1) \right] \quad (1)$$

According to expression (1), it can be concluded that nominal carrying ability P_n depends on kinematic diameter (d_{w1}), number of rotations of guiding wheel (n_1) and coefficient of carrying ability K_x (x=1,2,3,4), which depends on: physical-chemical properties of materials as main components of belt, recipes of manufacturing and technological process of manufacturing.

CORRECTED CARRYING ABILITY

In practice, conditions in which transmitter with belt works are greatly different from testing conditions (in the laboratory). Therefore, in this work will be analyzed corrected carrying ability for 5 cases with various input data of: kinematic diameter of transmission wheels (d_{w1i}, d_{w2i}). Changing of these two geometrical parameters

with high importance results in change of other parameters that determines geometry and kinematics of transmitter, such as: angle of contact between belt and guiding wheel (α_{1i}), angle that create branches of belt with line that passes through centers of transmitter wheels (β_{1i}), length of belt (L), transmission ratio (i_i)(i = 1,2,3,4,5).

Carrying ability of belt in practice is different from nominal calculated with expression (1). This difference appears due to influential in carrying ability of:

- Angle of contact of belt with guided wheel (α_1),
- Transmission ratio (i),
- Length of belt (L)

Carrying ability that takes in consideration influential of mentioned parameters is called corrected carrying ability, and it represents power that can be carried by transmitter with trapezoid belts in the relevant conditions. It is calculated with expression:

$$P_1 = K_\alpha \cdot (P_{n1} + \Delta P_i + \Delta P_L) \quad (2)$$

Influential of contact angle between belt and guiding (traction) wheel

Expression for nominal carrying ability is achieved for the angle of embrace between belt and guiding wheel of value 180°. In practice this angle has various values, depending on concrete case. Influential of contact angle in carrying ability is considered through factor of contact angle, which is calculated with formula:

$$K(\alpha) = 1.25 \cdot (1 - 5^{\frac{-\alpha}{180}}) \quad (3)$$

Influential of transmission ratio

In practice are used belt transmitters that have transmission ratio i≠1. Additional power that is added to nominal carrying ability, because of transmission ratio, is calculated with formula:

$$\Delta P(i) = d_1 \cdot n \cdot K_4 \cdot \log\left(\frac{2}{1 + 10^{x(i)}}\right) \quad (4a)$$

$$x(i) = \frac{K_2}{d_1 \cdot K_4} \cdot \left(\frac{1}{i} - 1\right) \quad (4b)$$

Influential of belt length

For every belt profile is defined length of belt by manufacturer, for which is determined nominal carrying ability. This length is called *Basic Length* and has symbol L_o. For other values of belt length, influential of belt length in carrying ability I calculated with formula:

$$\Delta P(L) = d_1 \cdot n \cdot K_4 \cdot \log\left(\frac{L}{L_o}\right) \quad (5)$$

If all the influences mentioned above appear in analytical way in expression (3.1), then mathematical model for the calculation of power which can be carried by the transmitter with trapezoid belts will be:

$$P_1(n_1) = 1.25 \cdot \left(1 - 5^{\frac{-\alpha}{180}}\right) \cdot \left\{ \begin{array}{l} d_{w1} \cdot n_1 \cdot \left[K_1 - \frac{K_2}{d_{w1}} - K_3 \cdot (d_{w1} \cdot n_1)^2 - K_4 \cdot \log(d_{w1} \cdot n_1)\right] + \\ + d_{w1} \cdot n_1 \cdot K_4 \cdot \log\left(2 \cdot \left(1 + 10^{\frac{K_2}{d_{w1} \cdot K_4} \cdot \left(\frac{1}{i} - 1\right)}\right)^{-1}\right) \\ + d_{w1} \cdot n_1 \cdot K_4 \cdot \log\left(\frac{L}{L_o}\right) \end{array} \right\} \quad (6)$$

Based on expression (6), it can be noticed that in mathematical model for calculation of power that can be carried by the V-belt transmitter, besides technological factors K_x, other constructive parameters have also influence. These parameters in this work are classified as: *primary* and *secondary.* As a constructive parameters are named geometrical and kinematic parameters that have great influence in the power carried by transmitter, which are: angle of contact between belt and guiding wheel (α_1), kinematic diameter of guiding wheel (d_{w1}) and its number of rotations (n_1). Secondary Constructive parameters are geometric and kinematic parameters that appear partially in the mathematical model given by expression (6), such us: transmission ratio (i) and length of belt (L).

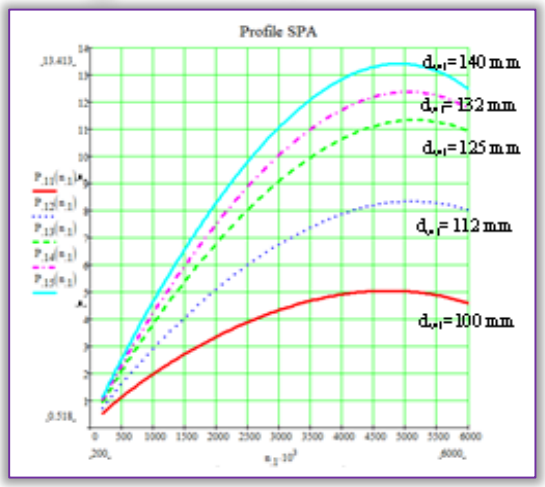
GRAPHICAL REPRESENTATION OF CARRYING POWER OF TRANSMITTER

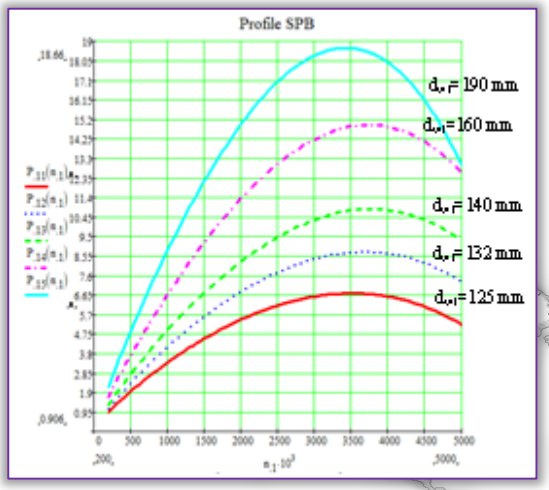
Influential of kinematic diameter of the guiding wheel

Using expression (6) and with the help of Mathcad Software is represented carrying power of transmitter with 3 different profiles of trapezoid belts (SPA, SPB and SPC) and for 5 various combinations of parameters qw define transmitter. Analysis of Geometric and kinematic parameters represented in Figure 2 are given in Table 1.

Table 1. Geometric and kinematic parameters of transmitter analyzed on trapezoid belts SPA, SPB and SPC

	d_{w1} (mm)	d_{w2} (mm)	a (mm)	L (mm)	α_1 (°)	β (°)	i (-)
Profile SPA							
1.	100	224	300	1122	156.146	11.927	2.286
2.	112	200	600	1693	171.589	4.205	1.822
3.	125	180	900	2280	176.498	1.751	1.469
4.	132	160	1000	2459	178.396	0.802	1.237
5.	140	150	1200	2856	179.523	0.239	1.093
Profile SPB							
1.	125	355	600	1976	157.9	11.05	2.898
2.	132	315	800	2313	166.865	6.568	2.435
3.	140	236	1000	2593	174.497	2.751	1.72
4.	160	224	1200	3004	176.944	1.528	1.429
5.	190	200	1400	3413	179.591	0.205	1.074
Profile SPC							
1.	224	630	800	2993	150.601	14.70	2.870
2.	250	560	1000	3296	162.166	8.917	2.286
3.	265	500	1200	3613	168.762	5.619	1.925
4.	280	450	1500	4151	173.503	3.249	1.640
5.	355	400	1800	4786	178.568	0.716	1.150





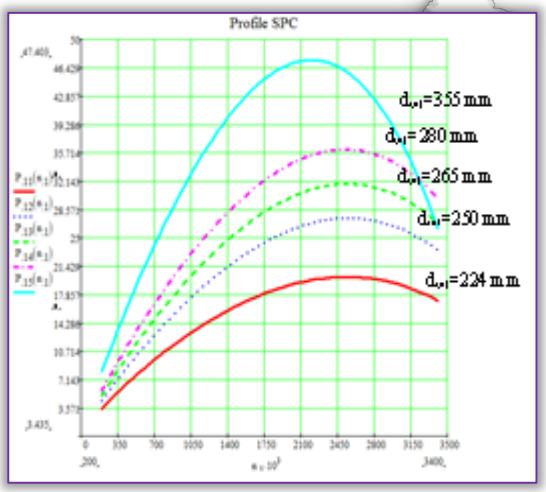
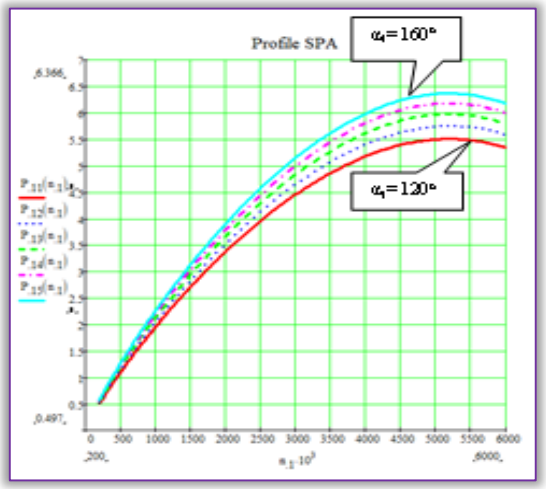
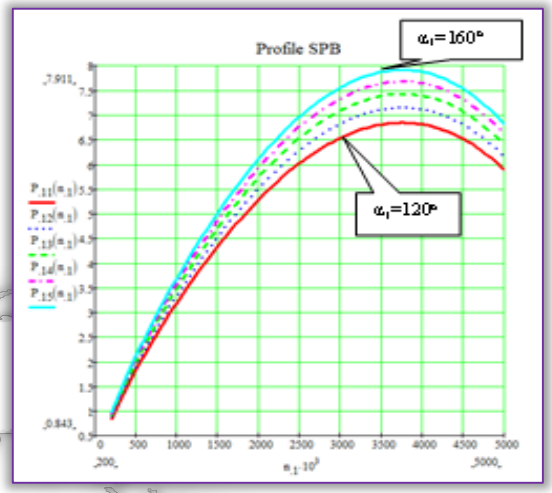


Figure 2. Graphical representation of power P_{1i} (kW) for the trapezoid belt transmitter SPA, SPB and SPC depending on the number of rotations of guiding wheel n_1 (min^{-1}).





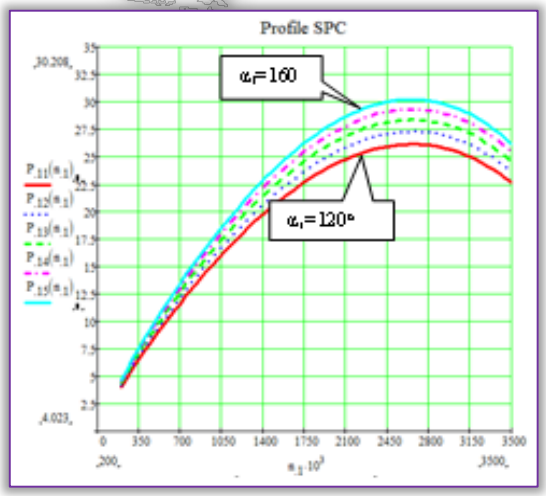


Figure 3. Graphical representation of power P_{1i} (kW) for the trapezoid belt transmitter SPA, SPB and SPC depending on the number of rotations of guiding wheeln_1 (min^{-1}) for various contact angles between belt and guiding wheel

Influential of contact angle between belt and guiding (traction) wheel

According to expression (6), for the values of angle of contact: α = 120°, 130°, 140°, 150°and 160°, in Figure 3 are shown curves of power which can be carried by transmitter with trapezoid belts of the profile SPA with guiding diameter of wheels d_{w1} = 100 mm.

According to Figure 3, it can be noticed that increase of contact angle between belt and guiding wheel results with increase of power that can be carried by transmitter. This increase is higher expressed with higher number of wheel 1 rotations.

Influential of transmission ratio

In order to see the influential of transmission ratio in the power that can be carried by transmitter, in the expression (6) are given these input values: kinematic diameter d_{w1} = 100 mm, α_1 = 140°, n_1 = 1000, 1500, 2000, 2500 and 3000 min^{-1}. Results are shown in forms of diagrams in Figure 4.

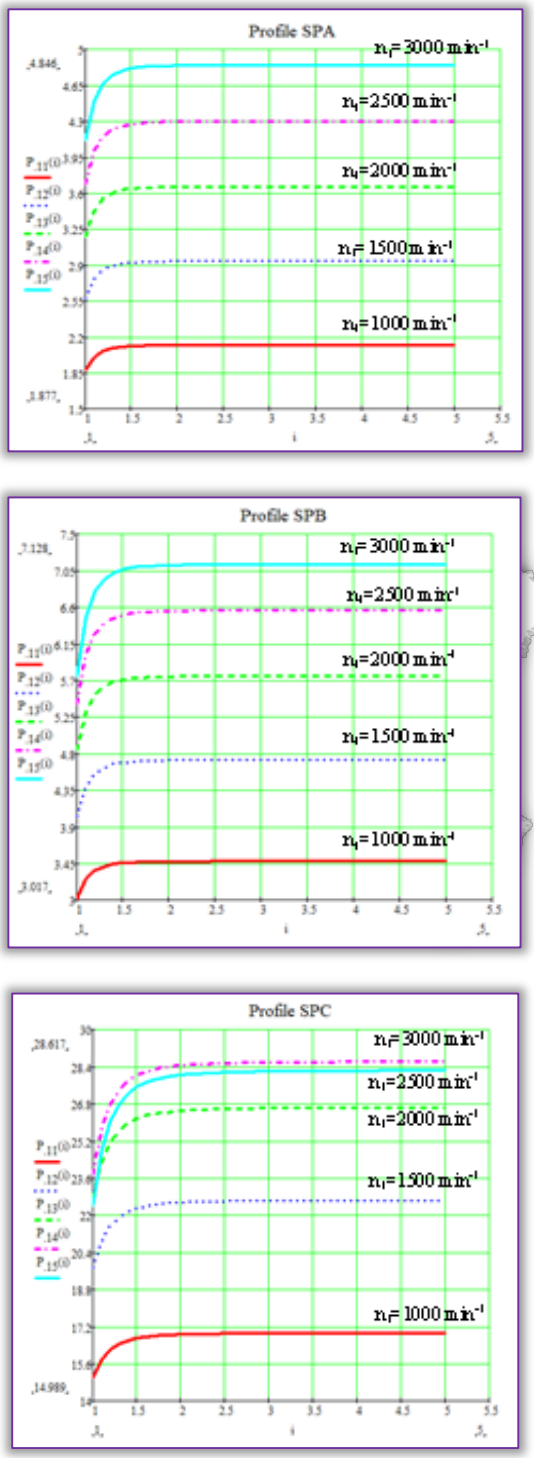


Figure 4.Graphical representation of power P_{1i} (kW) for the trapezoid belt transmitter SPA, SPB and SPC depending on the transmission ratio i (-), for various number of rotations of guiding (traction) wheel

Based on Figure 4, it can be noticed that transmission ratio has high influence in power that is carried by transmission with trapezoid belts for the values between 1...2. After the value i=2 this influence is constant.

Influence of belt length

For the belt profiles SPA, SPB and SPC, in the expression (6) are given input data: d_{w1} = 100 mm; α_1 = 140°; n_1 = 1000, 1500, 2000, 2500 and 3000 min^{-1}; i = 1.633; L_o = 2240 mm- SPA; L_o = 3150 mm – SPB; L_o = 5000 mm – SPC. Results are shown in forms of diagrams in Figure 5.

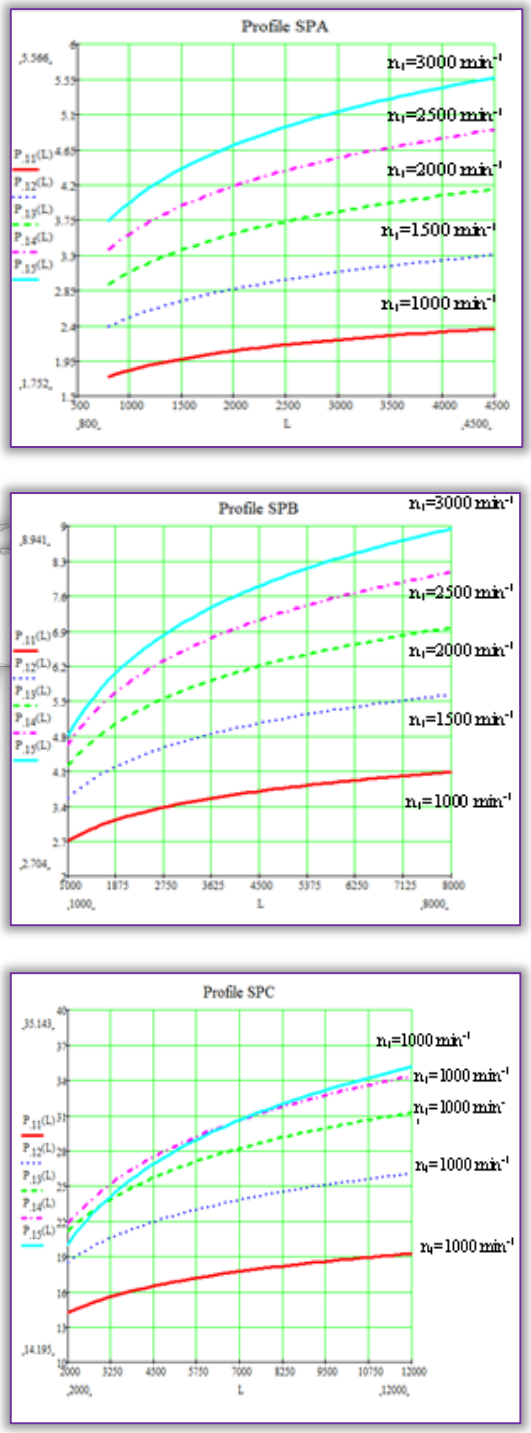


Figure 5. Graphical representation of power P_{1i} (kW) for the trapezoid belt transmitter SPA, SPB and SPC depending on the belt length (L), for various number of rotations of guiding (traction) wheel.

CONCLUSIONS

Based on mathematical expression given in this work, and diagrams gained based on these expressions, can be concluded as follows:

- Nominal carrying ability of trapezoid belts depends on technological factors which are represented through coefficients K_i (i=1,2,3,4) and other constructive coefficient, represented through kinematic diameter of guided wheel d_{w1} and number of rotations n_1.
- Corrected carrying ability, respectively the power that can be carried by the transmitter in the field, besides mentioned factors depends also from: contact angle between belt and guiding wheel α_1, transmission ratio i and length of belt L. These 3 factors have secondary importance, while kinematic diameter d_{w1} and number of rotations n_1 have primary importance.
- With the increase of embrace angle between belt and guiding wheel, carrying ability will increase.
- Increase of transmission ratio in the interval i=1…2 impacts significantly in the carrying ability.
- With the increase of belt length for ($L>L_o$), will increase carrying ability. This increase is more expressed for higher numbers of rotations.
- Length of belt can have negative impact in carrying ability if $L<L_o$.
- Graphical representation of these influences in the power that is carried by the transmitter with V-belts has practical importance for designer, because it enables him to make right selection of kinematic and geometric parameters of the transmitter to carry required power.
- During this selection should be used only the first part of curves – up to the point where power curve gains maximal value.

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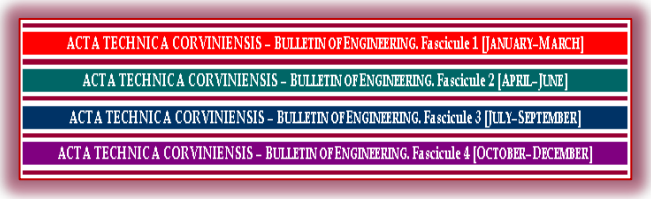
We are very pleased to inform that our international and interdisciplinary journal **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** completed its nine years of publication successfully [**issues of years 2008 –2016, Tome I–IX**].

In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm.

Every year, in four online issues (**fascicules 1 – 4**), **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** [**e-ISSN: 2067-3809**] publishes a series of reviews covering the most exciting and developing fields of science and technology. Each issue contains papers reviewed by international researchers who are experts in their fields. The result is a journal that gives the scientists and engineers the opportunity to keep informed of all the current developments in their own, and related, areas of research, ensuring the new ideas across an increasingly the interdisciplinary field.

Now, when will celebrate the tenth years anniversary of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!

On behalf of the Editorial Board and Scientific Committees of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we would like to thank the many people who helped make this journal successful. We thank all authors who submitted their work to **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**.



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EFFECTS OF TITANIA AND SINTERING TEMPERATURE ON THE PHASE DEVELOPMENT AND PROPERTIES OF SINTERED MULLITE-CARBON COMPOSITE SYNTHESIZED FROM OKPELLA KAOLIN

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Abstract: The effects of the addition of titania and sintering temperatures on the phases developed, physical and mechanical properties of sintered ceramic composite produced from kaolin and spent graphite electrode was investigated. The kaolin and graphite of known mineralogical composition were thoroughly blended with 2 and 4 (vol.) % titania. From the homogeneous mixture of kaolin, graphite and titania, standard samples were prepared via uniaxial compaction. The test samples produced were subjected to firing (sintering) at 1300˚C, 1400˚C and 1500˚C. The sintered samples were characterized for the developed phases using x-ray diffractometry analysis, microstructural morphology using ultra-high resolution field emission scanning electron microscope (UHRFEGSEM) various physical and mechanical properties were determined. It was observed that microstructural morphology of the samples revealed the evolution of mullite, cristobalite and microcline. The mineralogical phase of the samples revealed the increments in the evolution of mullite and also the variation in other phase attained as the sintering temperature was raised from 1300˚C to 1500˚C for the sample having the same composition. It was concluded that the optimum mechanical property of the ceramic samples produced was achieved with sample that contain 4 (vol.) % titania and sintered at 1300˚C.
Keywords: titania; kaolin; carbon; sintering temperatures; phases developed; sintered ceramic composite

INTRODUCTION

Mullite-carbon composites find increasing applications as refractories in the context of recent developments in ceramic industry for high temperature applications [1]. These refractories exhibit in general a complex microstructure characterized by crystalline phases of different thermal expansion coefficients, physical and mechanical property. There is a current limited understanding about the effect of microstructural features, including residual thermal stresses, on the overall performance of mullite-carbon ceramic composite at high temperature.

Previous researches have exploit mullite-zirconia and the addition of various additives which have been widely used for high-temperature applications due to their superior physico-mechanical properties [2]. This composite will compete with the existing mullite-zirconia in its area of applications. Recently, many researchers have focused their investigations on how to improve the properties of ceramics for various applications; Rendtorff *et al*. (2008) [3] used two different processing routes: for the preparation of zirconia-mullite composites, which are reaction sintering of alumina and zircon and direct sintering of mullite-zirconia grains by slip casting and sintered at 1600˚C for 2 hours. Badiee *et al.* (2001) [4] studied the effect of CaO, MgO, TiO_2, and ZrO_2 on mullitization of the Iranian and alusite located in Hamedan mines. They found out that the first three of these additives encouraged mullite formation from and alusite. Ebadzadeh and Ghasemi, (2002) [5] prepared zirconia-mullite composites using α-alumina and aluminium nitrate and zircon powder with TiO_2 as additive. Aramide *et al.* (2014) [6] synthesized mullite-zirconia composites containing yttria as additive. Chandra *et al.* (2013) [7] prepared zirconia-toughened ceramics with a mullite matrix based on the quaternary system ZrO_2-Al_2O_3-SiO_2-TiO_2 in the temperature range 1450-1550˚C using zircon-alumina-titania mixtures. Aksel and Komicezny, (2001) [8] studied the influence of zircon on the mechanical properties and thermal shock behaviour of slip-cast alumina-mullite refractories.

Furthermore, Jiang *et al.* (2011) [9] demonstrated that the role of additives can be rationalized in terms of promotion of sintering process, formation of new phases and influence on lattice constant of aluminum titanate ceramics. Dong *et al.* (2008) [10], specified the effect of both single additives (MgO, SiO_2, Fe_2O_3 and ZrO_2) and compound additives on the mechanical and thermal properties of aluminum titanate ceramics, and finally pointed out that the compound additives of MgO and Fe_2O_3 have an excellent improvement on the stability of aluminum titanate. Aramide *et al.* (2016) [11] had synthesized mullite-carbon composite from the same materials without any additive. The objective of the present work is to improve the properties of the mullite-carbon ceramic composite through the use of titania.

MATERIALS AND METHODS

RAW MATERIALS

Clay sample used for this study (as mine Kaolin sample) was sourced from Okpella, Edo State southern part of Nigeria, Graphite and titania (TiO_2) were sourced from (Pascal Chemicals, Akure), this were used to maintain the granulometry of the mixture.

METHOD

» **Processing of raw materials (Graphite & Kaolin)**

The raw materials (Spent graphite electrode and kaolin) were crushed into a coarse particle size, of about 10 mm for graphite and less than 2mm for kaolin; the crushed samples were further reduced by grinding using Herzog rod mill. The powdered samples were sieved using 600µm sizes aperture according to ASTM standards in an electric sieve shaker. The undersize that passed through the 600µm sieve aperture were used in the samples making.

» **Phase and Mineralogical Composition of Raw Kaolin and Graphite**

The kaolin clay and graphite electrode samples were carefully prepared for these analyses by digesting in reagents as described by Nabil and Barbara, (2012) [12]. The mineralogical phases present in the samples were determined using X-ray diffractometry (XRD).

The samples were prepared for XRD analysis using a back loading preparation method. They were analyzed using a PANalytical X'Pert Pro powder diffractometer with X'Celerator detector and variable divergence- and receiving slits with Fe filtered Co-Kα radiation. The phases were identified using X'Pert Highscore plus software. The receiving slit was placed at 0.040°. The counting area was from 5 to 70° on a 2θ scale. The count time was 1.5s. The temperature-scanned XRD data were obtained using an Anton Paar HTK 16 heating chamber with Pt heating strip Graphical representations of the qualitative result follow below.

The relative phase amounts (weight %) was estimated using the Rietveld method (Autoquan Program) as reported by Young et al [13]. Amorphous phases, if present were not taken into consideration in the quantification. The phases are reported in Figures 1 and 2 and also in Table 1.

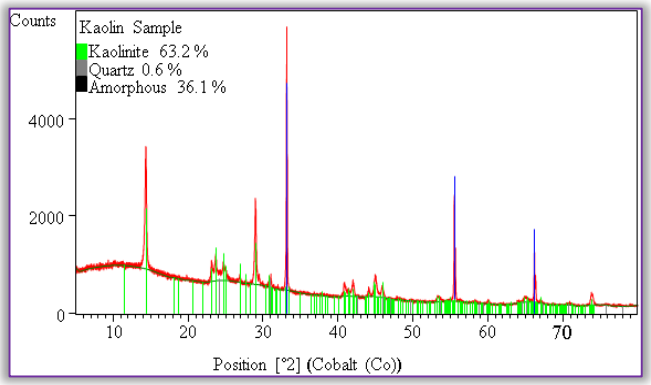


Figure 1. X-Ray Diffractometry Pattern (Phase Analysis) of kaolin sample [11]

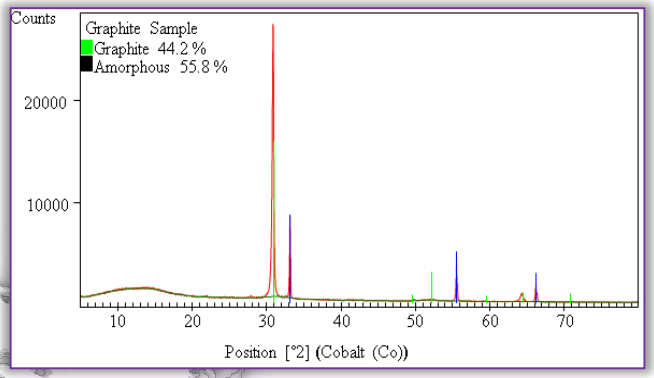


Figure 2. X-Ray Diffractometry Pattern (Phase Analysis) of graphite sample [11].

Table 1. XRD Results of kaolin and graphite sample showing the quantity of different phases present [11]

Materials	Kaolinite (wt. %)	Quartz (wt. %)	Amorphous wt. (%)	Graphite (wt. %)
Kaolin Sample	63.23	0.65	36.13	-
Graphite Sample	-	-	56.9	43.1

EXPERIMENTAL PROCEDURE

» **Composition calculation using the Rule of Mixtures Technique**

Rule of Mixtures is a method of approach to approximate estimation of composite material properties, based on an assumption that a composite property is the volume weighed average of the phases (matrix and dispersed phase). According to Rule of Mixtures [14] the density of composite materials are estimated as follows:

$$\rho_{mixture} = W_{tf\,kaolin} \times \rho_{kaolin} + W_{tf.graphite} \times \rho_{graphite} \quad (1)$$

$$M_{mixture} = \rho_{mixture} \times vol._{mould}. \quad (2)$$

where: $\rho_{mixture}$ represent density of the mixture, $M_{mixture}$ is the mass of the mixture, $W_{tf.\,kaolin}$ is the weight fraction of kaolin, ρ_{kaolin} is the density of kaolin, $W_{tf.graphite}$ is the weight fraction of graphite, $\rho_{graphite}$ is the density of graphite and $vol._{mould}$ is volume of mould.

» **Composites Production**

The raw materials in the samples making were 3:2vol. % of kaolin and graphite respectively with the addition of 2 and 4 (vol.) % titania respectively. The mixture were blended thoroughly for proper distribution of constituents materials in a ball mill for 3 hours at a speed of 72 rev/min after weighing via electronic weighing balance in accordance with the composition calculation initially prepared [11, 15]. The resulting blended compositions were mixed with 10% water of the amount of kaolin content in each composition, this was in order to enhance the plasticity of the mixture during compaction. The mixed samples were subjected to uniaxial compaction, which was carried out mechanically under pressure. The moulded materials were fired at varying temperatures (1300˚C, 1400˚C and 1500˚C). After which the samples were subjected to various test, to examine the phase analysis, evaluate their physical and mechanical properties.

» **Sintering Process**

The molded materials were fired at varying temperatures (1300°C, 1400°C and 1500°C) in an electric furnace. The rate of firing differs with increased temperature (room temperature to 500°C the sintering rate was 25°C/minute, 501°C to 1000°C the sintering rate was 10°C/minute while above 1000°C the sintering rate was 1°C/minute). On reaching the various sintering temperatures, the samples were held for one hour at the temperature before the furnace was switch off and the samples were allowed to cool in the furnace. The samples were subjected to various test to examine the phase analysis, evaluate their physical and mechanical properties.

Testing

» **Shrinkage Measurement**

The shrinkage properties of the pressed samples were determined by measuring both the green and fired dimensions, using a digital vernier caliper. The thickness and diameters were measured for evaluation and computation of the shrinkage [15].

$$\% \text{ linear shrinkage} = \frac{(Lg - Lf)}{(Lg)} \times 100 \quad (3)$$

where: Lg represent the green length and Lf represent the fired length.

$$\% \text{ volumetric shrinkage} = \frac{(Vg - Vf)}{(Vg)} \times 100 \quad (4)$$

where: Vg represent the green volume and Vf represent the fired Volume

» **Apparent porosity (AP)**

Test samples from each of the ceramic composite samples were dried out for 12 hours at 110˚C. The dry weight of each fired sample was taken and recorded as D. Each sample was immersed in water for 6 hours to soak and weighed while being suspended in air. The weight was recorded as W. Finally, the specimen was weighed when immersed in water [6, 15]. This was recorded as S. The apparent porosity was then calculated from the expression:

$$\% \text{ apparent porosity} = \frac{(W - D)}{(W - S)} \times 100 \quad (5)$$

» **Bulk Density**

The test specimens were dried out at 110˚C for 12 hours to ensure total water loss. Their dry weights were measured and recorded. They were allowed to cool and then immersed in a beaker of water. Bubbles were observed as the pores in the specimens were filled with water. Their soaked weights were measured and recorded. They were then suspended in a beaker one after the other using a sling and their respective suspended weights were measured and recorded [6, 15]. Bulk densities of the samples were calculated using the formula below:

$$\text{Bulk density} = \frac{D}{(W - S)} \quad (6)$$

where: D represent weight of dried specimen, S represent weight of dried specimen suspended in water, and W is weight of soaked specimen suspended in air.

» **Water Absorption**

The test sample was dried out in an oven till a constant weight of the sample was obtained. The sample was then placed in a vessel containing water in order to be completely submerged without touching the bottom of the vessel in which it is suspended. The vessel was then heated slowly so that the water boiled after heating. After boiling for about an hour with the evaporated water replaced, the sample was allowed to cool at room temperature for 24 hours. The sample was then renamed, blotted and then reweighed [15]. The percentage water absorption was calculated as showed below:

$$\% \text{ water absorption} = \frac{(\text{soaked wt} - \text{dried wt})}{(\text{dried wt})} \times 100 \quad (7)$$

» **Cold Compression Strength, Modulus of Elasticity and Absorbed Energy**

Cold compression strength test is to determine the compression strength to failure of each sample, an indication of its probable performance under load. The standard ceramic samples were dried in an oven at a temperature of 110˚C, allowed to cool. The cold compression strength tests were performed on INSTRON 1195 at a fixed crosshead speed of 10mm min^{-1}. Samples were prepared according to ASTM C133-97 (ASTM C133-97, 2003) [6, 15] cold crushing strength, modulus of elasticity and absorbed energy of standard and conditioned samples were calculated from the equation:

$$CCS = \frac{(\text{Load to fracture})}{(\text{Surface area of sample})} \quad (8)$$

RESULTS AND DISCUSSION

PHASE/MINERALOGICAL COMPOSITION OF THE RAW KAOLIN AND GRAPHITE SAMPLES

The phase/mineralogical composition of the kaolin and graphite samples were characterised (investigated)

with the aid of X-ray diffractometer. The results of the phase analysis of kaolin and graphite powder quantified by XRD were presented in Table 1, Figures 1 and 2. The phase/mineralogical composition of the raw materials used have been discussed extensively in [11] they are only reported for the purpose of showing that the compositions of the starting raw materials were known.

EFFECTS OF TITANIA (TiO_2) ADDITION

» Effects of Titania (TiO_2) Addition on the Phase Development in the Mullite-Carbon Ceramic Composite Samples Produced from Raw Kaolin and Graphite

The XRD results of the sintered samples are presented in Table 2 showing the various phases developed in the various sample at various sintering temperature.

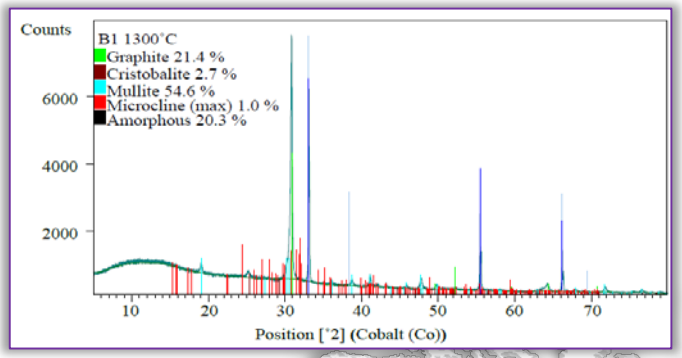


Figure 3. X-Ray Diffractometry Pattern of Sample B1 at 1300°C

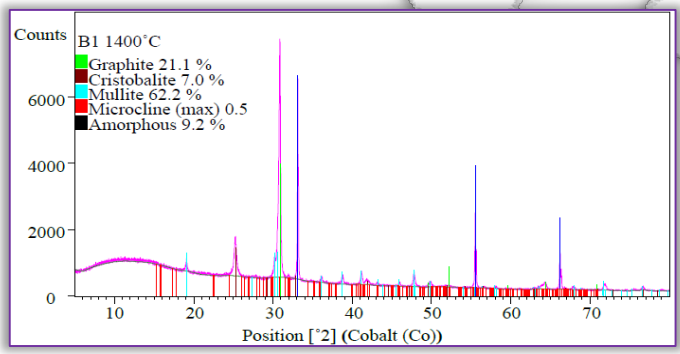


Figure 4. X-Ray Diffractometry Pattern of Sample B1 at 1400°C

Table 2. XRD Result of composition B1 and B2 sintered ceramic sample showing the quantity of different phases present.

Sample/ Sintering Temperature (°C)	Phase Developed (wt.%)				
	Graphite	Cristobalite	Mullite	Microcline	Amorphous
B1/1300	21.43	2.71	54.61	0.97	20.27
B1/1400	21.07	7.01	62.19	0.52	9.21
B1/1500	20.69	6.58	59.41	0.58	12.73
B2/1300	20.78	3.2	52.69	0.79	22.55
B2/1400	20.62	7.1	62.5	0.92	8.86
B2/1500	20.58	6.83	63.28	0.73	8.57

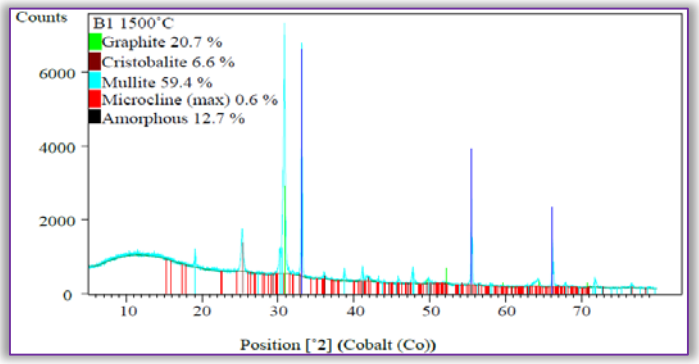


Figure 5. X-Ray Diffractometry Pattern of Sample B1 at 1500°C

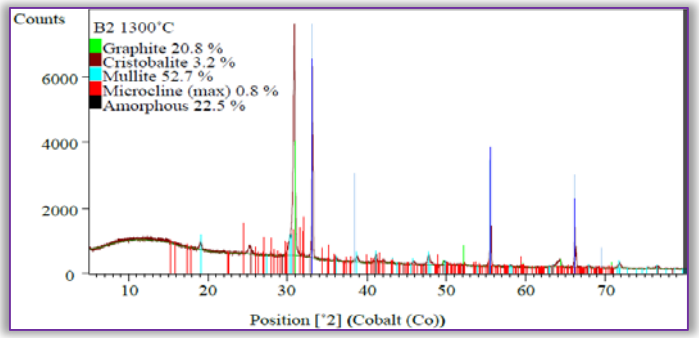


Figure 6. X-Ray Diffractometry Pattern of Sample B2 at 1300°C

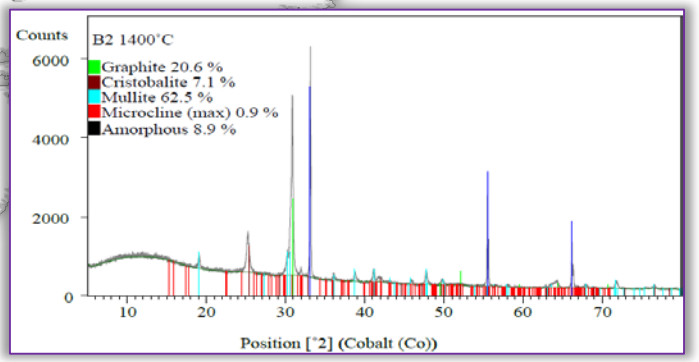


Figure 7. X-Ray Diffractometry Pattern of Sample B2 at 1400°C

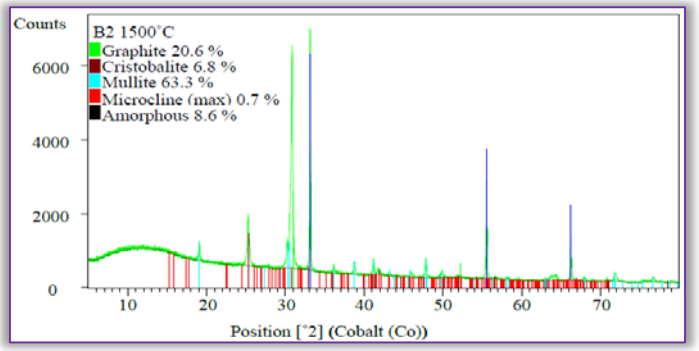
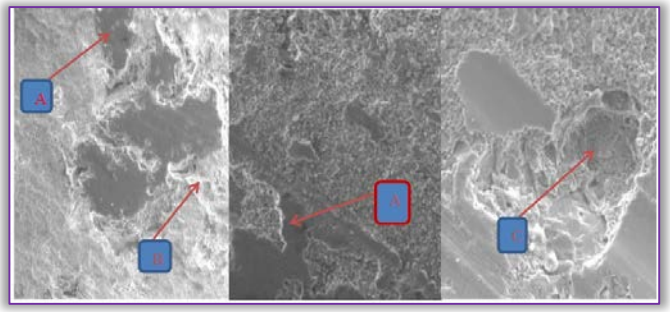


Figure 8. X-Ray Diffractometry Pattern of Sample B2 at 1500°C

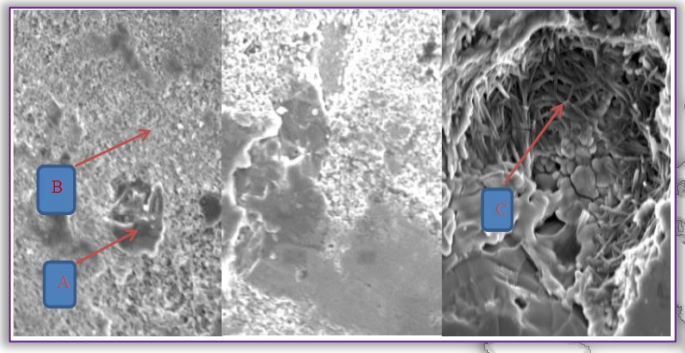
Figure 3 to 5 which show the x-ray diffraction patterns of the samples with addition of 2% TiO_2, labelled as sample B1. While Figure 6 to 8 show the x-ray diffraction

patterns of the samples with addition of 4% TiO_2 to the raw kaolin and graphite, labelled as sample B2.



(a) (b) (c)

Plate 1. Typical SEM micrographs (Back Scattered Image) of Sample B1 showing its morphology at varied temperature (a) sample B1 at 1300˚C showing the Secondary Electron Image A = graphite phase and B = mullite phase, (b) sample B1 at 1400˚C showing the Secondary Electron Image of graphite phase and mullite phase (c) sample B1 at 1500˚C showing the Secondary Electron Image of graphite phase and C = mullite fibre Phase.



(a) (b) (c)

Plate 2. Typical SEM micrographs (Back Scattered Image) of Sample B2 showing its morphology at varied temperature (a) sample B2 at 1300˚C showing the Secondary Electron Image A= graphite phase and B= mullite phase, (b) sample B2 at 1400˚C showing the Secondary Electron Image of graphite phase and mullite phase (c) sample B2 at 1500˚C showing the Secondary Electron Image of graphite phase and C = mullite fibre Phase.

The XRD analysis, show that the sintered samples contains mullite, graphite, amorphous, cristobalite and microcline phases while plate 1 and 2 show the SEM morphology of the phase present in sample B1 and B2 respectively. With an increase in sintering temperature, the mullite phase of sample B1 increased rapidly from 1300˚C to 1400˚C and reduced slightly when the sintering temperature was raised to 1500˚C. Furthermore, cristobalite phase increased from 1300˚C to 1400˚C and reduced slightly when the sintering temperature was raised to 1500˚C.

This is due to mullitization process of the kaolinite contents of the kaolin which yields mullite and excess silica as the sintering temperature is increased beyond 900°C [6, 15, 16]. This expains the reasons why the mullite and cristobalite (a polymorph of silica) contents of the samples generally increased with increased sintering temperature Also, graphite reduced from 1300˚C to 1500˚C. Microcline reduced from 1300˚C to 1400˚C and increased slightly when the sintering temperature was raised to 1500˚C. Amorphous phase reduced from 1300˚C to 1400˚C and increased slightly when the sintering temperature was raised to 1500˚C. In sample B2, the mullite phase increased rapidly when the sintering temperature was raised from 1300˚C to 1500˚C. Also, cristobalite phase increased from 1300˚C to 1400˚C and reduced slightly when the sintering temperature was raised to 1500˚C.

The graphite reduced when the sintering temperature was raised from 1300˚C to 1500˚C. Microcline increased from 1300˚C to 1400˚C and reduced slightly below the amount attained at 1300˚C when the sintering temperature was raised to 1500˚C. Amorphous phase reduced from 1300˚C to 1500˚C. Moreover, many other researchers [17-21] have reported on the various transformations occur when kaolinite is fired from temperature just below 200°C to around 1000°C; this includes dehydration, dehydroxylation annd structural breakdown. As seen from Table 2, the raw Okpella kaolin's constituents are; 63.23% kaolinite, 0.65% quartz, 36.13% amorphous which undergo a series of high temperature phase transformation as the temperature was raised from 1300-1500˚C, the sintering reactions take place via;

$$Si_2Al_2O_5(OH)_4 \xrightarrow{\sim 420\text{-}660^\circ C} Al_2O_3{\cdot}2SiO_2 + 2H_2O$$

which involves the combination of two OH groups to form H_2O and oxygen which remains incorporated in metakaolin. At about 900˚C, metakaolinite decomposes to amorphous $SiO_2$and γ-Al_2O_3–type spinel via

$$Al_2O_3{\cdot}2SiO_2 \xrightarrow{900^\circ C} \gamma\text{-}Al_2O_3 + 2SiO_2$$

γAl_2O_3-type spinel and SiO_2 recrystallize into mullite at temperatures above 1100˚C via

$$3\gamma\text{-}Al_2O_3 + 2SiO_2 \xrightarrow{>1100^\circ C} 3Al_2O_3{\cdot}2SiO_2$$

Srikrishna, *et al*. (1990) [22], reported the formation of a single phase (with composition close to mullite) and excess SiO_2 at 900˚C. Thus the formation of mullite begins at temperatures >900˚C and the process continues till 1000˚C. Kausik *et al*. (2004) and Omani *et al*. (2000) [23, 24] reported that mullitization can be increased by catalytic ions such as Fe^{3+} and Ti^{4+}. These metallic ions help in mullite formation by replacing the Al^{3+} ions in the glass structure during firing. The presence of Ti^{4+} from the addition of TiO_2 modifies the chemical composition of the ceramic bodies and therefore the sintering behaviour is characterized by mullitization. The excess silica left during transformation of metakaolin to aluminium-silicon spinel at 925˚C-950˚C and also as a result of crystalline cristobalite formed along with platelet mullite during spinel transformation at 1050˚C.

» **The Effects of Titania (TiO_2) Addition on the Physical and Mechanical properties of Mullite-Carbon Ceramic Composite Samples Produced from Raw Kaolin and Graphite**

Evaluation of the effects of (2 and 4) vol. % titania addition on various physical and mechanical properties of ceramic composite samples sintered at varied sintering temperature. Below are the results of various physical and mechanical properties of samples (B1, B2).

≡ **Apparent Porosity**

The effect of sintering temperature on the apparent porosity (AP) of Samples (B1 and B2) with varied amount (2 and 4 vol. %) of TiO_2 addition is clearly shown in Figure 9 and Table 3. From the Figure, it is observed that the apparent porosity of sample B1 (2% titania) at various sintering temperature is higher than that of the sample B2 (4% titania). it is also observed that the apparent porosity of sample B1 at 1300˚C is 31.667%, as the sintering temperature increased to 1400˚C the AP slightly reduced to 30.743% further increase in the sintering temperature to 1500˚C leads to an increase in the apparent porosity of the sample to 31.49%. The apparent porosity of sample B2 when sintered at 1300˚C is 27.289%, as the sintering temperature increased to 1400˚C the AP slightly increased to 27.748% further increase in the sintering temperature to 1500˚C leads to an increase in the apparent porosity of the sample to 31.309%. It is observed that the AP level of sample B1 reduced from 1300˚C to 1400˚C further increase in the sintering temperature to 1500˚C leads to an increased in the AP. This implies that the densification of the sample continues from 1300˚C to 1500˚C but well pronounce at 1400˚C this indicate that the maximum densification is achieved at 1400˚C, an increase in the temperature from 1400˚C leads to reduction in densification of the sample. For sample B2, the AP keeps increasing when the sintering temperature was raised from 1300˚C to 1500˚C. This implies that the densification of the sample reduces from 1300˚C to 1500˚C.

Generally, the densification of B2 samples is better at all temperature than B1 samples. It is observed that the apparent porosity of sample B2 is better than sample A, while sample A is better than sample B1 at all temperatures. This implies that 4 vol. % titania aids densification of the sample, with less pores. According to Calister, (2007) [25] voids exist between particles of the newly formed green (unfired) ceramic, much of these inter-particles voids are eliminated during firing/sintering to produce sintered ceramic. Furthermore, according to some other researchers [16, 17, 26], the decrease in the value of AP from 1300˚C to 1400˚C is because of additional increase in the filling of spaces between bigger particles contained in the ceramic samples. The drastic increase in the apparent porosity from 1400˚C to 1500˚C is as a result of carbon reaction with oxygen, the carbon burnt off, leaving pores within the samples. According to Sadrnezhaad *et al*. (2006 and 2007) [27, 28] and Nemati *et al*. (2005) [29], high temperature oxidations of graphite lead to drastic deterioration due to graphite diminution, which result to pores in the samples.

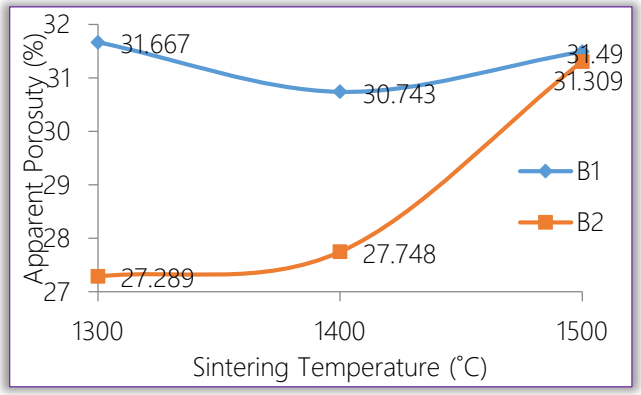


Figure 9. Effects of Sintering Temperature on Apparent Porosity of Sample with varied addition of TiO_2.

≡ **Bulk Density**

The effect of sintering temperature on the bulk density of the samples (B1 and B2) with varied amount (2 and 4 vol.%) of TiO_2 addition is clearly shown in Figure 10 and Table 3. From the Figure, it is observed that the bulk density of sample B1 at 1300˚C is 1.59gcm^{-3} as the sintering temperature increased to 1400˚C the bulk density slightly increased to 1.667gcm^{-3} further increase in sintering temperature to 1500˚C, the bulk density slightly reduced to 1.665gcm^{-3}. Also, the bulk density of sample B2 at 1300˚C is 1.891gcm^{-3} as the sintering temperature increased to 1400˚C the bulk density slightly reduced to 1.796gcm^{-3} further increase in sintering temperature to 1500˚C, the bulk density slightly reduced to 1.639gcm^{-3}. The bulk density of sample B1 and B2 are dictated by their apparent porosity, the sample with less pore is more dense. Generally, it can be deduce that the bulk density of B2 samples are higher than B1 samples due to their low porosity, this implies that the addition of 4 vol. % titania aids densification of the sample than 2 vol. % titania. According to Chandra *et al.* (2013) [7], substantial increase in bulk density was achieved with titania addition in the compacted sintered samples, which could be related to the influence of relatively higher density of TiO_2 itself. Furthermore, according to Aramide, (2012) and Brasileiro *et al.* (2006) [17, 26], the increase in bulk density is because of additional increase in the filling of spaces between bigger particles contained in the ceramic samples.

Summarily, samples with 4 vol. % titania (B2) attained maximum densification at 1300°C while the samples with 2 vol. % titania (B1) attained maximum densification at 1400°C.

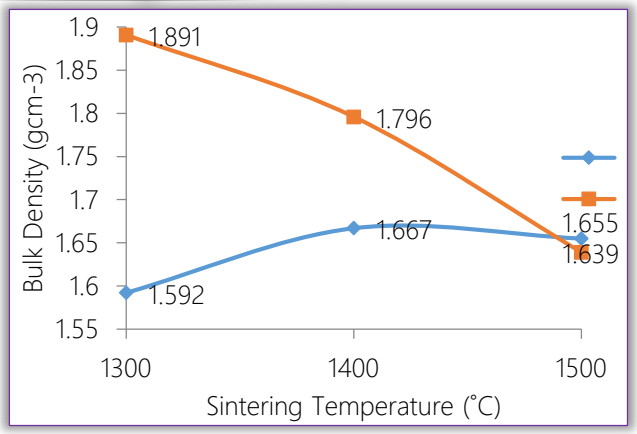


Figure 10. Effects of Sintering Temperature on the Bulk Density of Samples with varied TiO_2 addition.

≡ Water Absorption

The effect of sintering temperature on water absorption of the samples (B1 and B2) with varied amount (2 and 4 vol. %) of TiO_2 addition is clearly shown in Figure 11.

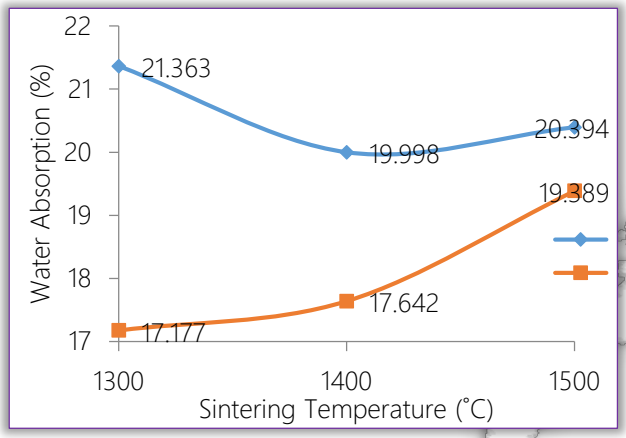


Figure 11. Effects of Sintering Temperature on the Water Absorption of Samples with varied TiO_2 addition.

From the Figure, it is observed that the water absorption of the sintered ceramic sample B1 is 21.363% at 1300˚C, with an increase in temperature to 1400˚C, the water absorption reduced to 19.998%. However, further increase in sintering temperature to 1500˚C, the water absorption of the sample increased to 20.394%. This followed the trend recorded for apparent porosity, which implies that the water absorption of the sample reduced when the sintering temperature was increased from 1300˚C to 1400˚C and later increased when the sintering temperature was raised to 1500˚C. For sintered ceramic sample B2, the water absorption is 17.177% at 1300˚C, with an increase in temperature to 1400˚C, the water absorption increased to 17.642%. However, further increase in sintering temperature to 1500˚C, the water absorption increased to 19.389%. This is because high temperature transformation of mullite and cristobalite in addition to some amount of carbon burn off leads to increased porosity as a result of reduced matter content of the samples. This is due to the sintering process; according to Calister, (2007) [25] voids exist between particles of the newly formed green (unfired) ceramic, much of these inter-particles voids are eliminated during firing/sintering to produce sintered ceramic. It is observed that the water absorption of sample B1 is higher at all temperature than B2.

≡ Cold Crushing Strength

The effect of sintering temperature on the cold crushing strength of samples (B1 and B2) with varied amount (2 and 4 vol.%) of TiO_2 addition is clearly shown in Figure 12 and Table 3. From the Figure, it is observed that the CCS of sample B1 at 1300˚C is 6.76Mpa, 7.99Mpa at 1400˚C and 7.65Mpa at 1500˚C. This implies that with an increase in the sintering temperature, the cold crushing strength significantly increased from 1300˚C to 1400˚C, further increase in the sintering temperature to 1500˚C leads to reduction in the CCS of the sample. Also, the CCS of sample B2 at 1300˚C is 8.68Mpa, 8.47Mpa at 1400˚C and 7.1Mpa at 1500˚C. This implies that with an increase in the sintering temperature, the cold crushing strength significantly reduced from 1300˚C to 1500˚C. This showed that the highest CCS of sample B1 is achieved at 1400˚C and B2 is achieved at 1300˚C. Generally, the cold crushing strength of sample B2 is better compared to sample B1 at 1300˚C and 1400˚C, with sample B1 only better at 1500˚C. The CCS results correspond to bulk density dictation which was affected by the porosity level of the sample. The reason for this is that an increase in bulk density of the sample, means that the sample contains more matter to bear the applied load [17, 18]. According to Brasileiro *et al.* (2006) [26], increase in CCS may be assigned to better filling of pores, higher bulk density and the increase amount of mullite that leads to improved mechanical properties.

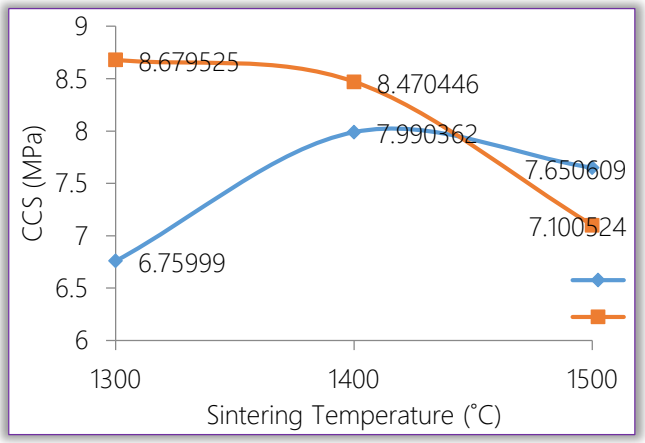


Figure 12. Effects of Sintering Temperature on the Cold Crushing Strength of Samples with varied addition of TiO_2.

≡ Modulus of Elasticity

The effect of sintering temperature on the modulus of elasticity (MOE) of samples (B1 and B2) with varied amount of TiO_2 addition is clearly shown in Figure 13 and Table 3. From the Figure, it is observed that the elastic modulus of sample B1 at 1300˚C is 60.431Mpa,

85.074Mpa at 1400˚C and 82.973Mpa at 1500˚C. This implies that with an increase in sintering temperature, the modulus of elasticity significantly increased from 1300˚C to1400˚C, further increase in the sintering temperature to 1500˚C, the MOE slightly reduced. Also, the modulus of elasticity of sample B2 at 1300˚C is 88.884Mpa, 88.584Mpa at 1400˚C and 68.033Mpa at 1500˚C. This implies that with an increase in sintering temperature, the modulus of elasticity slightly reduced from 1300˚C to 1400˚C, further increase in sintering temperature to 1500˚C, the MOE significantly reduced. Generally, the MOE of sample B2 is better compared to sample B1 at all temperatures. The MOE of the samples has the same trend with the CCS as dictated by the bulk density which was affected by the porosity level of the sample discussed earlier.

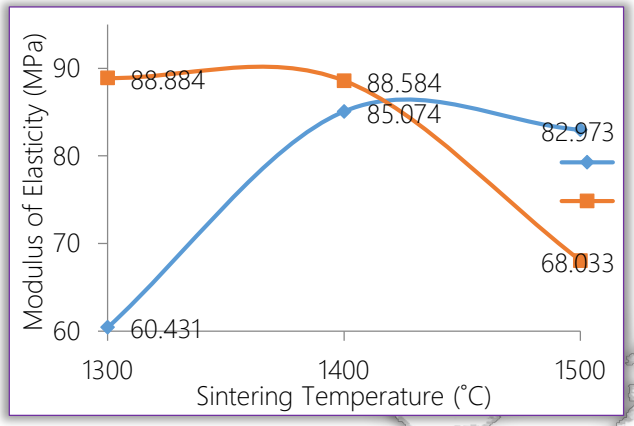


Figure 13. Effects of Sintering Temperature on the Modulus of Elasticity of Samples with varied addion of TiO_2.

≡ Absorbed Energy

The effect of sintering temperature on the absorbed energy (AE) of samples (B1 and B2) with varied amount of TiO_2 addition is clearly shown in Figure 13 and Table 3. From the Figure, it is observed that the absorbed energy of sample B1 at 1300˚C is 4.782J, 5.537J at 1400˚C and 5.488J at 1500˚C. This implies that with an increase in sintering temperature, the absorbed energy significantly increased from 1300˚C to 1400˚C, further increase in the sintering temperature to 1500˚C, the absorbed energy slightly reduced. Also, the absorbed energy of sample B2 at 1300˚C is 6.4926J, 6.063J at 1400˚C and 4.785J at 1500˚C. This implies that with an increase in sintering temperature, the absorbed energy slightly reduced from 1300˚C to 1400˚C, further increase in the sintering temperature to 1500˚C, the absorbed energy significantly reduced. The modulus of elasticity results shows that except from sample B1 at 1500˚C, sample B2 has higher MOE than B1 at 1300˚C and 1400˚C. The observed variation of absorbed energy with increased sintering temperature follows the same trend with that observed for the cold crushing strength as earlier discussed.

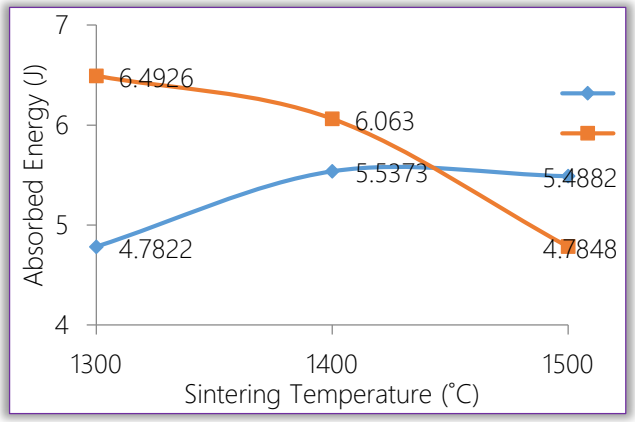


Figure 13. Effects of Sintering Temperature on the Absorbed Energy of Samples with varied addition of TiO_2.

≡ Linear Expansion

The effect of sintering temperature on the linear expansion of samples (B1 and B2) with varied amount of TiO2 addition is clearly shown in Figure 14 and Table 3. From the Figure, it is observed that the linear expansion of sample B1 is 1.018% at 1300˚C, 0.442% at 1400˚C and 2.216% at 1500˚C.

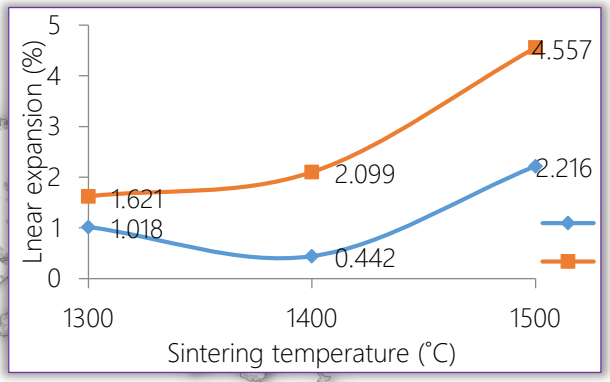


Figure 14. Effects of Sintering Temperature on the Linear Expansion of Samples with varied addition of TiO_2.

The linear expansion of sample B1 reduced significantly as sintering temperature increases from 1300˚C to 1400˚C, further increase in the sintering temperature to 1500˚C, the linear expansion of the sample significantly increased. Also, the linear expansion of sample B2 significantly increased when the sintering temperature was raised from 1300˚C to 1500˚C. Apart from sample B1 that reduced from 1300 to 1400, increase in sintering temperature leads to an increase in the linear expansion of the samples. Sample B1 has lower linear expansion than B2 samples at all temperature. The shrinkage due to cristobalite and mullite transformation was first compensated for by the graphite expansion before the sample later expand. Graphite has $0.6\text{-}4.3\times10^{-6}m/mk^{-1}$ as coefficient of linear expansion, the expansion was clearly recorded as an increment in the length of the samples after sintering. According to Grim, (1971) [30] during sintering process, the porosity of the ceramic body is reduced due to the vacancies and pores filling by molten (glassy phase). So, shrinkage size is equal to size

of pore removed or lost. Sintering temperature has an extreme effect on the value of linear shrinkage as increasing sintering temperature leads to increases linear shrinkage due to increasing amount of molten filling pores and product high shrinkage in the sample. The limited expansion recorded makes the composite (B1 and B2) suitable for high temperature applications.

≡ **Volumetric Shrinkage**

The effect of sintering temperature on the volumetric shrinkage of samples (B1 and B2) with varied amount of TiO_2 addition is clearly shown in Figure 15 and Table 3. From the Figure, it is observed that the volumetric shrinkage of sample B1 is 4.325% at 1300˚C,5.295% at 1400˚C and 5.673% at 1500˚C.

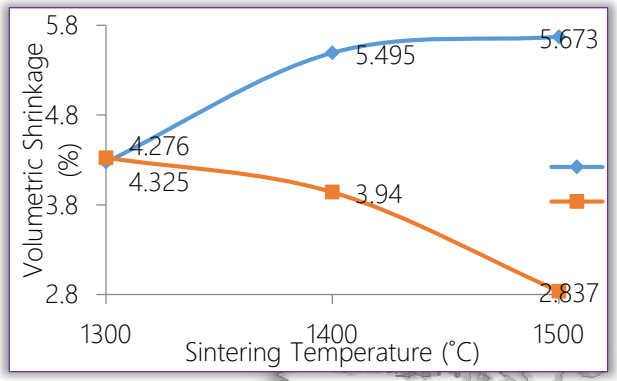


Figure 15. Effects of Sintering Temperature on Volumetric Shrinkage of Samples with varied addition of TiO_2.

Table 3. Mechanical Properties of the Sintered Ceramic Samples

Temp. (˚C)	Cold crushing strength (Mpa)	Modulus of elasticity (Mpa)	Absorbed energy (%)	Apparent porosity (%)	Bulk density (g/cm3)	Linear expansion (%)	Volumetric shrinkage (%)
B1/ 1300	6.75999	60.431	4.7822	31.667	1.592	1.018	4.276
B1/ 1400	7.99036	85.074	5.5373	30.743	1.667	0.442	5.495
B1/ 1500	7.65061	82.973	5.4882	31.490	1.655	2.216	5.673
B2/ 1300	8.67953	88.884	6.4926	27.289	1.891	1.621	4.325
B2/ 1400	8.47045	88.584	6.0630	27.748	1.796	2.099	3.940
B2/ 1500	7.10052	68.033	4.7848	31.309	1.639	4.557	2.837

With an increase in sintering temperature, the volumetric shrinkage of sample B1 significantly increased from 1300˚C to 1500˚C. Also, the volumetric shrinkage of sample B2 is 4.276% at 1300˚C, 3.94% at 1400˚C and 2.837% at 1500˚C. With an increase in sintering temperature, the volumetric shrinkage of sample significantly reduced from 1300˚C to 1500˚C. This implies that an increase in sintering temperature aids the volumetric shrinkage of sample B1 while volumetric shrinkage of sample B2 reduced when the temperature was raised from 1300˚C to 1500˚C. It is observed that the volumetric shrinkage of sample B2 is lower than B1 at all temperatures. This is because the carbon content of sample B1 is higher than sample B2.The limited shrinkage recorded makes the composite suitable for high temperature applications. According to Gupta, (2010) [31], a refractory material should be able to maintain sufficient dimensional stability at high temperatures and after/during repeated thermal cycling.

CONCLUSIONS

From the discusses data it is concluded that;

- mullite and cristobalite (a polymorph of silica) contents of the samples generally increased with increased sintering temperature;
- addition of titania improves on the densification of the samples at various sintering temperatures;
- the addition of 4 vol. % titania to the sample aids densification at relatively lower sintering temperature than when 2 vol. % titania is added;
- the addition of 4 vol. % titania to the sample improves on the cold crushing strength of the samples sintered at relatively lower sintering temperature than when 2 vol. % titania is added;
- 2 vol. % titania in the sample leads to progressive increased volumetric shrinkage as the sintering temperature increased while, 4 vol. % titania leads to reduction in the volumetric shrinkage with increased sintering temperature;
- the optimum mechanical property of the ceramic samples produced was achieved with sample that contain 4 (vol.) % titania and sintered at 1300˚C.

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QUALIFICATION SYSTEM OF THE PRIVATE SECURITY SECTOR

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Abstract: Elaborating a system of qualifying enterprises operating in the private security sector is a topical problem nowadays. It is necessary to introduce an unbiased qualification system with which every Hungarian enterprise operating in the field of property protection within the private security sector can be properly categorised and classified.On the one hand, the introduction of the system would rule out enterprises that are operating illegally, and on the other hand it would provide assistance to the Principals in selecting the companies being appropriate to carry out the task in question, in wording tender requirements, and in the long run it would result in the improvement of the entire sector.Later on the rating activity could be extended. During complete safety audits, the plans of security systems, for example, could be inspected, alongside with the already functioning systems.
Keywords: qualification, private security, planning, security technology

ANTECEDENTS

The need for the rating of enterprises was engaged in the private security sector and their activities arose nearly six to eight years ago. At that time, during the board meetings of the Hungarian Chamber of Bodyguards, Security Guards and Private Detectives,[1] proposals on the creation of a professional rating system were often on the agenda. Different rating criteria were established, however, none of these has ever been adopted.

Certain players in the sector vehemently opposed to the introduction of a professional rating system. Most often those criticising the introduction of such a system cited as an excuse that only individuals actually engaged in this trade are able to appropriately audit these professional activities; however, it is unacceptable for market participants that an expert of a competing firm audits their activities and gains an insight into their processes and documents.

Development of an evaluation system which is based on objective criteria, as well as voluntary participation in the rating are the key to the implementation and adoption of a professional rating system. At first, enterprises should be categorised[2], and later on, in certain professional fields, this could be extended to individuals (e.g. for security guards).

The next task following the implementation is to disseminate information on the system to those using private security services, i.e. to Customers. The scope of companies with a rating will only be expanded for real when the Customers start browsing the list of businesses having a rating, and when they prescribe in their invitations to tender the existence of one of the professional rating categories as a minimum eligibility criteria.

This process can be accelerated if the Insurance Companies include in their insurance terms and conditions the minimum rating category of companies that are allowed to install security systems in facilities and to provide manned guarding services.

The cooperation of MABISZ VKB[3] and the rating body is very important for a successful implementation of the system. Currently, MABISZ VKB conducts the rating of various security product lines[4] and defines its own technical standards for the application of rated devices[5] on the basis of protection categories and risk limits [1];

[1] hereinafter as the 'Chamber'
[2]classification into rating categories
[3]Property Safety and Lost Prevention Commission of the Association of Hungarian Insurance Companies
[4]it deals with the rating of safe deposit boxes, mechanical and physical protection devices, safety glasses and foils, components of electronic signaling systems, video security/surveillance systems and access control equipment
[5]these criteria are not compliant with the applicable standards of the European Union concerning this field

however, it does not deal with the entities performing the design and installation tasks and the various security service providers.

WHO SHOULD PERFORM RATINGS?

Rightfully arises the question: Who should devise the rating system and perform the ratings?

The answer to this question is quite simple; it can be found in Section 38 (1) (d) of Act CXXXIII of 2005 on Security Services and the Activities of Private Investigators: 'Pursuant to the agreement concluded with the Minister in charge of law enforcement, as regards the vocational training qualifications required to carry out the activities falling within the scope of this Act, as defined in a separate legal instrument, the Chamber will develop and maintain a framework for professional and examination requirements and a professional rating system; furthermore, it will participate in vocational education, training and examination, present proposals concerning vocational training qualifications to be recognised by the State, the Vocational Examination Regulations, as well as the persons who may authorise the organisation of vocational examinations and may be seconded as an expert during the auditing of examination organisation activities.' [2]

Thus, in the case of enterprises engaged in the private security sector, the Chamber is responsible for determination of the vocational qualification and examination requirements, as well as development of a professional rating system.

Based on the above, it seems logical that, being an independent professional organisation, the Chamber should also develop and operate a system for the rating of enterprises, as well as keep records and publish the list of rated companies.

The Chamber has already devised a system for rating businesses dealing with training courses included in the National Qualifications Register (here after referred to as OKJ) [3]. [4] However, this rating system only applies to companies providing such vocational education and training courses that fall within the competence of the Minister of the Interior and ensure a place for students where they can do the practical training required to obtain a given vocational training qualification (which must be included in the OKJ).

Therefore, this system was created only for the purpose of 'authorisation, rating, registration and control of legal entities engaged in private security services and entitled to provide on-the-job training in relation to vocational education and training aimed at obtaining vocational qualifications' [4].

WHO SHOULD BE RATED?

Introduction of a rating system is possible in several ways. Steps of a realisable implementation are as follows described.

As the first step, firms engaged in different areas of the private security sector must be rated based on the information provided by them. The requested information must be accompanied by supporting documentation and declarations, as is customary in procurement procedures. The rating/categorisation of companies can be completed based on the information provided (even in an automated manner). At this stage, businesses voluntarily submitting a declaration may be included in a certain rating category by simultaneously marking that the rating has not been verified. This would only be an indicative rating.

Business included in a certain rating category could request the rating body (i.e. the Chamber) to verify the information submitted, which would be carried out by a team of independent experts in the framework of an on-site audit (the number of experts in the team is to be increased in proportion to the company's headcount). On these occasions, similarly to supplier audits, the team of experts would check the information provided by the company, as well as the company's processes, operation of its quality management system, etc. The costs of on-site audits would be borne by the company requesting the audit. As a result of an audit, a certificate may be issued as proof of the rating category obtained.

In the future, this rating system may even be refined by classifying businesses into various categories based on their different activities. For example, not all companies engaged in the installation of security systems undertake design tasks or install automatic fire alarm systems. Similarly, a business engaged in manned guarding sometimes may install minor intrusion detection systems since it has two or three qualified employees who have a vocational qualification (included in the OKJ in security system installation, as well as an official licence from the police authority to install security systems, but this is not commensurate with a company that carries out the same activities with a headcount of 40-50 people in, say, huge industrial facilities. The various activities of these companies having several activities could be categorised separately.

The next important step could be auditing the design documentations and installation processes of contractors engaged in the design and installation of security systems. This is crucial because with improper installation one may set up a very poor security system despite the fact that the designs and the equipment are of high quality, and vice versa, not even an excellent contractor using high-quality equipment can build a robust system without vulnerabilities based on a bad

design documentation. For high-security-risk facilities, having project documentations and installations audited by independent experts would be vital.

The same is a current daily problem in the field of manned guarding services. The security staff, i.e. the human factor, is a key security element in the protection of facilities. It is quite hard to find a security guard who has the right capabilities needed to perform a given task, also finds this task fulfilling and thus is motivated to perform their job duties well. Currently, there is no such rating system in place under which security guards could be classified into categories based on their capabilities, even though such a system would be of great help to employers in the recruitment and hiring process, as well as to clients (i.e. entities using security services) in the formulation of requirements applicable to security guards to be hired. [5]

RATING CRITERIA

In compiling the rating criteria, the most important thing is to request such information based on which the various businesses can be categorised objectively.

Enterprises engaged in the various fields of the private security sector cannot be categorised on the basis of the same rating criteria. A company engaged in manned guarding services must be rated based on entirely different criteria than a business designing security systems. Similarly, we cannot require a company providing manned guarding services to have an employee who is a qualified safety engineer and has the necessary license to design safety systems, just as we cannot require an enterprise providing safety system design and installation services to have, say, 10-20 full-time security guards. Of course, in the above example, we could have mentioned companies engaged in private investigation as well, for which again completely different requirements must be established.

The criteria must be different for each professional field, yet universally applicable within a given field. Determining individual criteria for each field ensures general applicability within the field concerned.

Ideally, determination of the relevant criteria should be done so that working groups are set up the member of which are familiar with the technical and technological conditions as well as economic characteristics of the sector's various players. Working groups should be set up individually for each professional field (e.g. a working group establishing the criteria for private investigation companies, a working group establishing the criteria for companies engaged in security systems, etc.). Working group members would individually compile a list of evaluation criteria. After aggregation of the criteria compiled by the individuals independently, there will be certain criteria listed by several members of the working group and ones that have only been mentioned by a single person. The end result will definitely be an unmanageably large set of criteria. This set of criteria must be reduced to a manageable size in such a manner that the comprehensiveness of the criteria is maintained, i.e. the remaining criteria must enable a comprehensive evaluation of players of the sector. This set can be significantly reduced using the Pareto principle.[6] The criteria relating to the same feature or function have to be eliminated because these may because distort the results of the evaluation. Furthermore, controversial evaluation criteria that may be mutually exclusive must be eliminated as well. It is very important that the criteria established should be easy to understand, contain accurate yet simple definitions and possibly not include more than 15 elements[7]. [6] However, a properly simplified list of criteria that fully describes the players in the sector is not yet suitable for categorisation and rating of enterprises meeting these criteria. This is evident, because the various evaluation criteria have different importance from the companies' point of view. In order to ensure that factors having a minor impact on the quality of services are considered in the evaluation to a smaller extent, evaluation criteria should be weighted in proportion to their importance.

Weighting is as important task as the formulation of appropriate criteria. When weights are being determined, all subjective influence should be excluded, i.e. the weighting system should be created independently of any companies or individuals. Similarly to the establishment of the criteria, determination of weights should be carried out by working groups made up of experts who are familiar with the specific fields. Economists and mathematicians have devised a great deal of methods for the determination of weights. We present three of these to demonstrate the key differences between them. The direct estimation method is the simplest of the three: in the case of this method, the expert in charge of determination of weights prioritises the criteria using estimates. In case of n number of criteria, $1/n$ weight is assigned to each criterion so that the total number of weights should add up to 1. This method can be applied in the case of a small number of evaluation criteria, but it requires a very large level of concentration and consistency already for a set of 10-15 criteria. It is obvious that the expert's subjectivity cannot be excluded in the case of this method. Having a direct

[6]Pareto claimed that in the distribution of wealth, 80% of the goods produced will go to 20% of the society; this principle has proven to be true in many other areas of life as well, e.g. 80% of the problems can be traced back to 20% of the causes, or in our case, 20% of the list of criteria determined, which consists of many elements, covers 80% of the factors influencing the rating of firms.

[7]I will return to the importance of this when I discuss determination of the weighting of the criteria.

estimate performed by several experts, the consistency and accordance of experts can be examined (rank correlation coefficient). In this case, ideally, the prioritisation of criteria set up by the experts will be the same, but the estimated weights will be different and will not be accurate. [7]

In 1957, Churchman and Ackoff developed two procedures for increasing accuracy, [8] which are jointly called 'Churchman/Ackoff Technique' in the specialised literature. This technique is based on the pairwise comparison of prioritised criteria. Upon determining the weights, the first criterion (i.e. the criterion considered the most important) will be assigned a weight of 1, and then all the other criteria will be compared to this and assigned a relative weight compared to the importance of the first criterion.

Then, the criteria are classified into groups and we examine the proportion that the sum of the weights assigned to the criteria in the given group bears to a specific criterion which is regarded as important, and we adjust the weights in the group or the weight of the more important criterion accordingly. This is carried out with the involvement of all criteria; eventually, by normalising the thus determined weights, we obtain the final weighting. Then the sum of normalised weights will be 1. A drawback of this method is that it requires a large amount of work, thus it is no longer recommended if there are more than 7 criteria. [9]

Churchman and Ackoff suggest a second method for comparing a larger number of criteria, in which groups of maximum 5 criteria are created, assigning a specific criterion to each, the weight of which will be 1; after this, an evaluation is performed in each group according to the first method, and then we examine whether the resulting order corresponds to the order of priority established earlier. If it does not, then the procedure has to be repeated selecting a different criterion. If it does, the final weighting can be determined by normalising the established weights.

Guilford's method [10] is easier than those presented so far, which I recommend to use to determine the weight of each criterion included in the set of criteria developed for the rating of businesses engaged in the private security sector. This method is based on the pairwise comparison principle. Rating criteria are arranged in a $n \times n$ matrix, where each criterion is compared to all the others. If criteria are marked with C, then the (i, j)th$(i \neq j)$ element of the matrix is 1 if C_i is more important than C_j, and 0 if C_j is more important than C_i. None of the criteria is examined compared to itself, thus the main diagonal of the matrix is left empty. The sums of each row of the matrix show how many other criteria were less important than a particular criterion. After normalisation of the sums of each row, we get the weights, the total amount of which will add up to 1. [6] Weights can be further refined by transforming the thus established weighting on the basis of the normal distribution; i.e. by normalising the weighted averages. [11] The use of this method is simple in case of sets of ca. 12 to 15 criteria, however, requires care and consistency.

A big advantage is that consistency of the expert filling in the matrix can be examined, thus errors (e.g. formation of cycles) committed by this person can be eliminated. In the case of involvement of more experts, a joint expert opinion can be created using purely mathematical methods. [7] The thus prepared weighting of the rating criteria can be considered objective.

IMPACT OF THE RATING SYSTEM ON THE PRIVATE SECURITY SERVICES SECTOR

The rating system will achieve its goal when we reach the milestone mentioned in the introduction, namely that customers prescribe the existence of a specific rating category as the minimum requirement in their requests for proposal and invitations to tender. This will trigger a self-generating and self-sustaining development process in the private security sector. Businesses that are currently still operating without a license will apply for an official licence from the police authority in order to be included in the rating system, and after this, the police will be able to control their activities. In order to obtain a rating, they will register with the Hungarian Trade Chamber. Should a complaint be received by the Chamber in relation to their activities, the Chamber's Ethics Committee will launch proceedings against the firm concerned [12], which may even result in a suspension of their registration with the Chamber and/or getting excluded from the rating system, and thus they will not be able to participate in tender procedures.

Companies seeking to achieve higher rating levels in the hope of larger, i.e. better paying, customer orders, will develop their businesses and train their employees to this end. What is more, employees will be more willing to work for companies with a better rating knowing that they can expect higher salaries there. In this way, businesses achieving higher ratings will be able to recruit from a larger labour pool, and select the best-trained employees who are the best-suited for a given task. This will induce job seekers to pursue self-improvement activities.

In the long term, the implementation and consistent operation of a professional rating system could entail clarification and transparency of the private security sector, improvement of the enterprises engaged in the sector as well as an increased prestige of this trade. As a consequence of the foregoing, the value of services provided by this sector is expected to rise, too.

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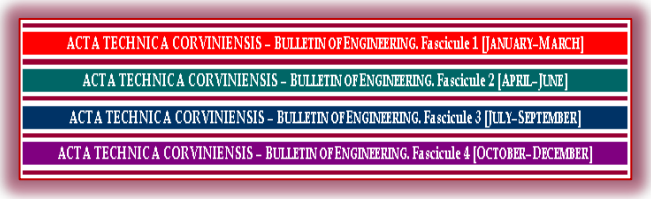
We are very pleased to inform that our international and interdisciplinary journal **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** completed its nine years of publication successfully [**issues of years 2008 –2016, Tome I–IX**].

In a very short period it has acquired global presence and scholars from all over the world have taken it with great enthusiasm.

Every year, in four online issues (**fascicules 1 – 4**), **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering** [**e-ISSN: 2067-3809**] publishes a series of reviews covering the most exciting and developing fields of science and technology. Each issue contains papers reviewed by international researchers who are experts in their fields. The result is a journal that gives the scientists and engineers the opportunity to keep informed of all the current developments in their own, and related, areas of research, ensuring the new ideas across an increasingly the interdisciplinary field.

Now, when will celebrate the tenth years anniversary of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!

On behalf of the Editorial Board and Scientific Committees of **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**, we would like to thank the many people who helped make this journal successful. We thank all authors who submitted their work to **ACTA TECHNICA CORVINIENSIS ■ Bulletin of Engineering**.



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INFLUENCE OF AGING HEAT TREATEMENT ON SOME MECHANICAL PROPERTIES OF THE AlZn5.7MgCu ALLOY THROUGH EXPERIMENTAL RESEARCHES

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Abstract: The paper presents the results of experimental research at laboratory scale on the influence of AlZn5.7MgCu alloy thermal processing mode. Two types of aging heat treatment were studied, namely: a natural aging and an artificial aging treatment. For each of the two types of technological heat treatment, the change of the mechanical properties was monitored according to the parameters of the aging procedure. The experimental research of this paper highlights the advantage of artificial aging as compared to natural aging, but this advantage must also be seen in terms of the costs implied by the two types of treatment.
Keywords: aluminium alloy, heat treatment, mechanical characteristics

INTRODUCTION

There is a close relationship between the development of the aviation industry and the evolution of the materials it uses. It is well known that this top area of the technique requires advanced materials with special physical and mechanical properties.

AlZn5.7MgCu alloy is part of special aluminium alloys from Al-Zn-Mg-Cu system, of zicral type. These alloys have high mechanical characteristics and low density, which is why they are interesting for the aviation industry and automotive industry [1-6].

In the raw molded state in general, these alloys have a low mechanical strength and deformability which modifies very much by applying heat treatments [6].

Al-Zn-Mg-Cu alloys have a tensile strength which becomes greater as the precipitates formed after the aging process, natural or artificial, are more numerous, finer and more dispersed in the mass of the base solution (solid solution).

The phase transformations in the solid state occurring during thermal processing, if they are allowed in the alloy equilibrium diagram, represent an essential condition for making a heat treatment, by quenching, putting it in solution and artificial or natural aging, of an aluminium alloy. An alloy of this type can support an order-disorder reaction.

In the case of aluminium alloys with structural hardening, the increase of mechanical characteristics occurs on account of the complex interactions between the dislocations of the basic matrix and the precipitate particles arising in the alloys structure following aging.

The high strength of Al-Zn-Mg-Cu alloys is directly proportional to the increase of the amount of Zn or Zn + Mg content, thus generating metastable fine precipitates zones, rich in Zn and Mg, which represent the so-called GP zones [1].

The stages of the structure hardening mechanism after applying aging heat treatments are: forming the supersaturated solid solution through quenching by putting it in solution, forming Guinier - Preston areas during the aging process; first precipitates form a metastable zone (η'), then, as the temperature gradient is higher, these areas become stable (η), i.e. the formation of $MgZn_2$ precipitates [2].

MATERIAL AND METHOD

The materials for the experimental research are samples of the Al-Zn-Mg-Cu system alloy, whose chemical composition is shown in Table 1. The chemical composition of the alloy studied falls within the EN 573-3-2013 requirements [10].

Table 1. Chemical composition of the researched alloy [10]

Alloy / Element	Zn	Mg	Cu	Si	Fe
AlZn5,7MgCu	5.76	2.61	1.55	0.15	0.19
Alloy / Element	Pb	Cr	Mn	Al	
AlZn5,7MgCu	0.021	0.19	0.10	rest	

In order to be used in the aviation industry or in the automotive industry, this alloy must acquire, after applying thermal processing regimes (natural or artificial aging), the mechanical properties stipulated in EN 485-2-2013 [11], which are shown in table 2.

Table 2. Alloys properties [11]

Alloy \ Element	Rm / MPa	$Rp_{0,2}$ / MPa	A_5 / %	HB
AlZn5,7MgCu	540	470	7	161

In this paper, the influence of some heat treatment regimens on the mechanical properties of the AlZn5.7MgCu alloy was experimentally researched.

Experiments have been conducted in two thermal processing technological variants: variant I, which is represented by the natural aging, and variant II, which is the artificial aging regime.

Ingots casting was performed on the casting system of SC Wagstaff from Alro Slatina S.A., Romania. Also at SC Alro S.A. was performed the ingots homogenization treatment at a temperature of 480/°C in an Olivotto semi-continuous furnace operating within the 460-610/°C temperature range.

Samples heating for hot-rolling at a temperature of 435/°C, hot plastic deformation with a reduction rate of 25/%, heating the samples at 500/°C for quenching through putting in solution as well as warming the samples to artificial aging temperatures were conducted in the Laboratory of Plastic Deformation and Heat Treatment of the Faculty of Engineering with "Lower Danube" University of Galati. These technological operations are common for both variant I and II.

The temperatures of artificial aging are: T_1 = 120C, T_2 = 140/°C, T_3 = 160/°C, T_4 = 180/°C, T_5 = 200/°C with the resistance time of: τ_1 = 4/hours, τ_2 = 8/hours τ_3 = 12/hours, τ_4 = 16/hours, τ_5 = 20/hours for each temperature.

Research variant I studied, for a degree of hot plastic deformation ε = 25%, the influence of the resistance duration in the case of natural aging for τ_1 = 24/hours, τ_2 = 72/hours τ_3 = 168 / hours τ_4 = 360/hours, τ_5 = 720/hours τ_6 = 1080/hours, τ_7 = 1440/hours, on the mechanical properties studied.

Research variant II studied, for a degree of hot plastic deformation ε = 25%, the influence of temperature and resistance time in the case of artificial aging, on the mechanical properties studied.

The manufacturing from the homogenized ingots of the samples (test pieces) for carrying out the experiments, according to variants I and II, was made after metal cutting to the dimensions: length = 105/mm, height = 7/mm, width = 55/mm. After the hot plastic deformation, the sample dimensions had the following values: length = 150/mm; height = 5/mm; width = 60/mm.

RESULTS

After thermo-mechanical treatment, the samples were subjected to thermo mechanical testing and the mechanical characteristics were determined: Rm, $R_{p0.2}$, A_5 and HB. On the basis of these results, there have been made the graphs of mechanical properties variation depending on the temperature and aging time.

The graphical representation of mechanical properties variation with natural aging time, according to variant I, is shown in Figures 1 and 2.

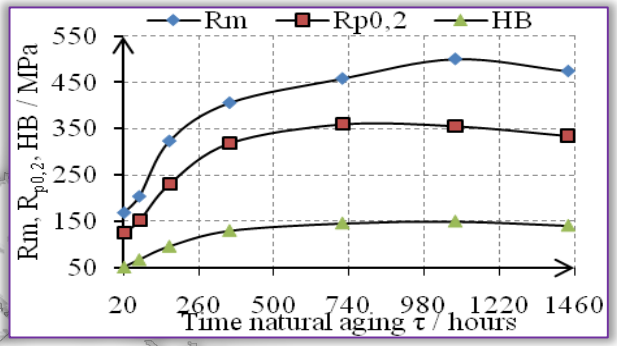

Figure 1 - Variation of Rm, Rp0.2 and HB during natural aging

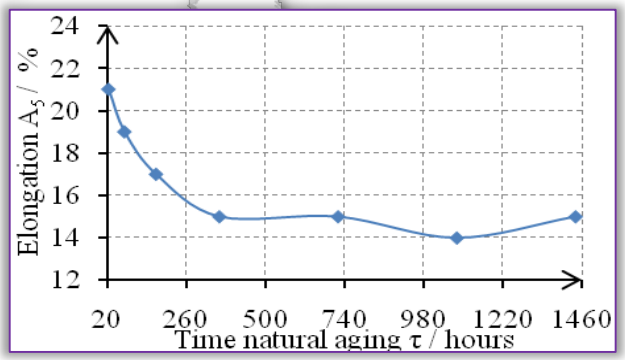

Figure 2 - Variation of elongation at break with natural aging time

Figure 1 shows resistance properties variation according to natural aging time and it can be noticed that these mechanical characteristics increase as the natural aging time increases, up to a maximum value corresponding to a time of 1080 hours.

The graph in Figure 2 shows that the elongation at break decreases as the natural aging time increases and records a minimum at the time of 1,080 hours, followed by a slight increase.

For the tensile properties, as well as for elongation, this variation can be explained by the fact that the

precipitates formed during the natural aging process reached a critical value of their size, after which their growth by coalescence followed.
More specifically, the growth of the large ones occurs at the expense of the small ones, and structurally is recorded a decrease of grain limits, which lowers the mechanical strength at the expense of plasticity. In Figures 3-6 are shown the properties variations of the studied alloy, according to experimental research variant II.

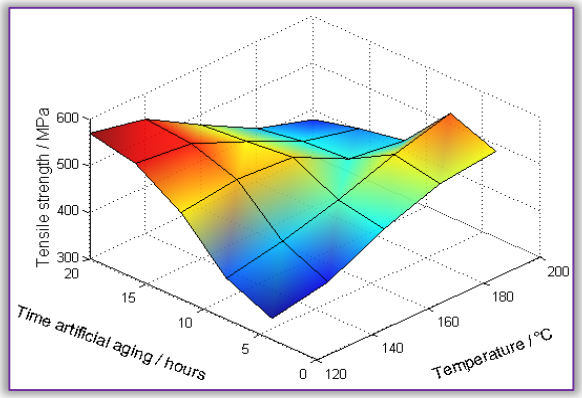

Figure 3 - Mechanical resistance variation with artificial aging time and temperature

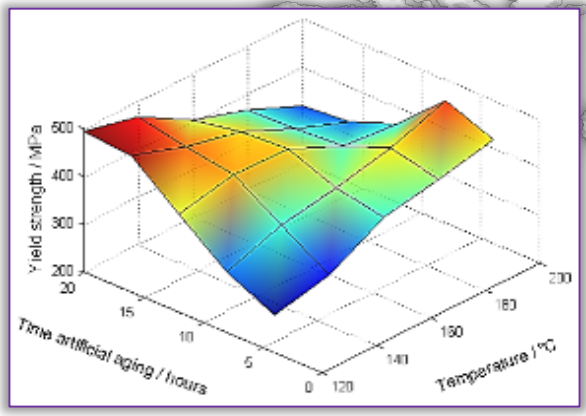

Figure 4 - The variation in yield strength with artificial aging time and temperature

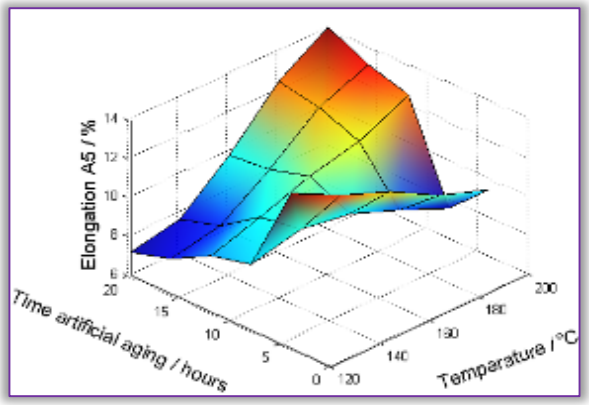

Figure 5 -Variation of elongation at break with artificial aging time and temperature

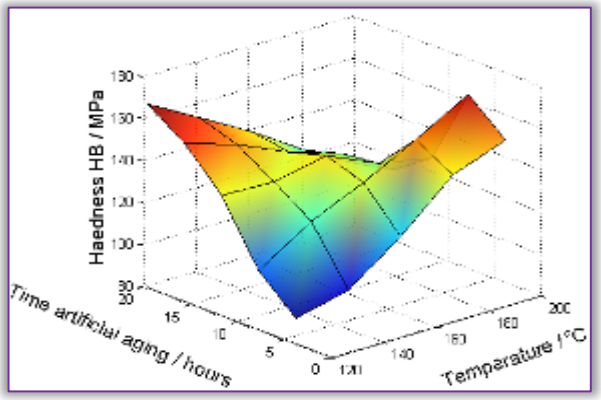

Figure 6- HB hardness variation with artificial aging time and temperature

For properties Rm, $R_{p0.2}$, HB was found a growth of their values with the increasing of the duration of treatment at temperatures of 120 and 140/°C.
The thermal regime with temperatures of 180 to 200/°C and duration of 8 hours, led to maximum values of the mechanical characteristics.
As the aging time increases above this value, the mechanical properties decrease.
The temperature of 160/°C leads to mechanical resistance values that increase with the increasing of the treatment time, up to a period of 12 hours, after which a decrease in mechanical properties can be seen.
The variation of the elongation at break is inversely proportional to that of the strength properties. The highest value for A5 is obtained at 200/°C and a treatment time of 20/hours.
Figure 7 shows the microstructure of the alloy that was submitted to natural aging for 729 hours, and where the formed precipitates on the basis of Al, Zn and Mg, leading to material hardening, are noticed.

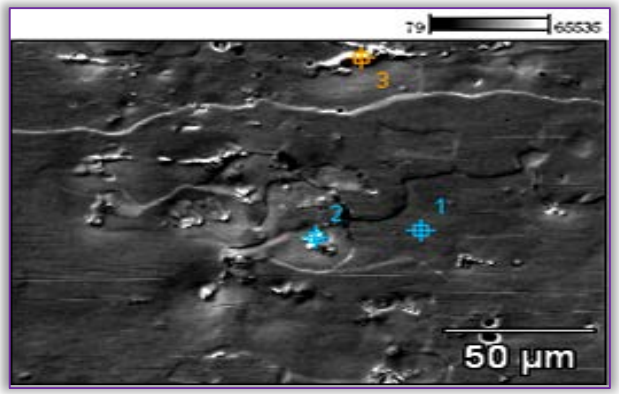

Figure 7 - Natural aging microstructure (τ =720 / hours), 1509: 1 zoom

Figure 8 shows the microstructure of the alloy after having been artificially aged at 140/°C for 8/h. By comparing the two images, it can be seen that after artificial aging, the number of precipitates is bigger and they are more finely dispersed in the base matrix of solid solution α, as compared to those formed by natural aging.

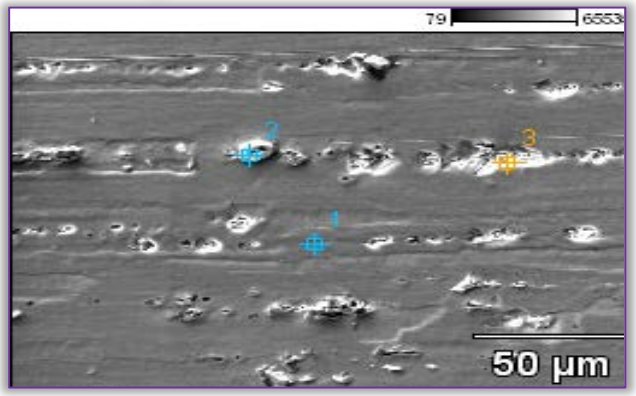

Figure 8 - SEM electron microscopy of the studied material subjected to treatment variant II at 140/°C and a time of 8/h, 1448: 1 zoom

This also explains the high values of the mechanical characteristics that were obtained from thermal processing according to variant II.

CONCLUSIONS

After conducting experimental research the following conclusions can be drawn:

- the aging of quenched alloys leads to supersaturated solid solution decomposition with the emergence of secondary phases in a controlled dispersion and the solid solution getting closer to equilibrium;
- the type, size, distribution and amount of the precipitated particles in an alloy depend on the temperature, duration of aging and initial state of the microstructure;
- the mechanical properties of the alloy continuously vary with the temperature and duration of aging;
- increasing the temperature of aging or extending durations over a certain value decreases the resistance properties, but gives good dimensional and properties stability (over aging with precipitates coagulation);
- the allure of the properties variation curves at aging shows that the maximum values of one of the followed properties decreases as the temperature or duration rise above the optimum value; approximately the same values of a feature can be obtained either at higher temperatures and shorter durations, or at lower temperatures and longer durations);
- mechanical resistance varies inversely with elongation at break, so that to achieve high strength while maintaining a sufficient plasticity, moderate temperatures and extended durations are selected;
- of the two types of heat treatment researched, the best mechanical resistance properties were obtained after the artificial aging regime;
- the properties required by EN 485-2-2013 for the studied alloy are met for only some thermal processing parameter values in the variant II.

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ERGONOMIC ASPECTS OF THE SPORTS ACTIVITIES MICROENVIRONMENT AT THE TECHNICAL UNIVERSITY OF VARNA

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Abstract: Ergonomic norms are part of the norms limiting harmful effects on human health. Using them, the limit of people's satisfaction by the effects of environment is determined. Failure to observe these norms, especially in the conditions of active motor activity, causes various physiological reactions in athletes' organisms and increases the risk of respiratory diseases. The article reflects on the parameters of the microclimate in the sports hall of the Technical University of Varna. The experimental part includes measuring of the temperature, relative humidity, air dust and light in the hall. An analysis of the data obtained is carried out and the conformity of the data to the ergonomic standards and requirements is established.
Keywords: microclimate, air parameters, ergonomics

INTRODUCTION

As a complex interdisciplinary science based on knowledge of methods and science of humans and human labour which are aimed at altering working environment, ergonomics provides for maximal preservation of working capacity and human health [1]. Working environment is a multi-component system including the conditions at which certain activities are carried out. It is affected by the following factors: illumination, noise, vibrations, microclimate (air motion and humidity, temperature, dustiness, etc.) [2].

The multi-functional sports hall at the Technical University of Varna was renovated in 2009. The capacity of the hall is 80 sportspeople. The building is of a panel type and insulation is provided for its bases. The measurements of the hall are 20/42 and the built-up area is 840 m^2. Natural illumination filters through double windows which are set in the walls on both opposite sides alongside the building. The illuminated height of the area is 2.20 m. The hall has TARKET flooring and a Euro-certificate for 8 kinds of sport and this allows for its continuous use. The characteristics of the hall are in compliance with the norms for such types of buildings with regard to fire-extinguishing systems, lighting, emergency lighting, radiant and gas heating [3].

Ergonomic norms are part of the norms limiting harmful effects on human health. Using them, the limit of people's satisfaction by the effects of environment is determined. Failure to observe these norms, especially in the conditions of active motor activity, causes various physiological reactions in athletes' organisms and increases the risk of respiratory diseases [4,5,6].

Table1. Ergonomical norms for measuring the level of comfort at the working place

Parameter	Values	
Temperature	Optimal	21^{o}C
	Perturbation Influence	27-30^{o}C
	Harmful Effect	34^{o}C
Humidity	Optimal	30-70%
	Perurbation Influence	20-80%
	Sanitary Norm	15-90%
Illumination	Optimal	200-500 lx
	Ergonomic	150-200 lx
	Harmful Effect	100-50 lx
Noise	Optimal	40 dB
	Ergonomic	65dB
	Sanitary	90-100 dB

- **Aim:** Obtaining accurate and reliable data about the physical parameters of the microenvironment at the multi-functional sports hall of TU-Varna.
- **The object of the research** is the working environment at which specialized sports training classes are held at TU-Varna.
- **The subject of the research** is the condition and alteration of the physical parameters: temperature, relative humidity of air, level of illumination and dustiness at the sports facility.

Tasks:

» Development of methodics for carrying out the research.
» Elaboration of instruments for measuring the indicators of the working environment condition.
» Processing and analyzing the obtained results.

METHODICS

The research was carried out during the winter semester of the Academic year 2015/2016 and is in compliance with the respective regulatory requirements [2,8,9,10].

It is a known fact that the accuracy of the results of scientific research is a function of a number of factors, among them being the working environment parameters. The latter consists of the following components:

- ✓ Air temperature
- ✓ Temperature of spraying
- ✓ Relative humidity
- ✓ Air purity
- ✓ Lighting

As a combination of activities ensuring precision, reproducibility, repetitiveness and accuracy of the results, metrological supervision includes determining and choosing:

» Indicators whose condition and changes are measured
» time and place for the study
» devices (means of) measuring and their metrological characteristics
» methods of registering, preserving and systemizing the results
» software for processing the obtained information

For the purposes of this study, an experimental setting which is in compliance with the requirements for distance from the source of natural illumination was mounted at the sports hall.

Figure1. Experimental setting

A twenty-four-hour measuring was carried out, as the processed data is derived between 8.00 a.m. and 17.00 pm.

Air temperature is a main factor determining the heat load on an individual who is in a closed room. Measuring is carried out with a thermosensitive resistor, elaborated from semiconductive material.

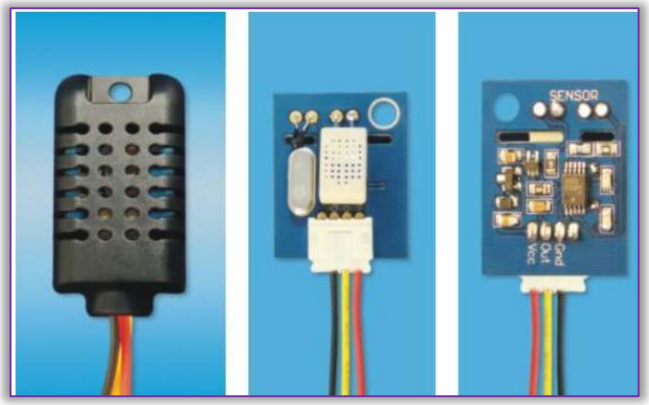

Figure 2. A combined AM2301 sensor for temperature and relative air humidity measuring [7]

The device measures two temperatures simultaneously- the air temperature according to the so-called dry thermometer and spraying temperature.

The latter indicates the temperature at which condensation of the moisture contained in air begins.

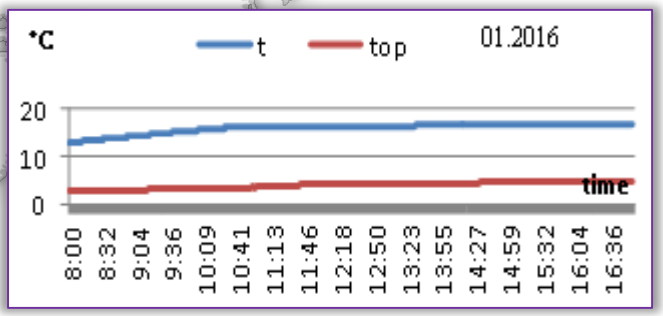

Figure 3 a. Hourly alteration of air temperature and spraying temperature in January 2016

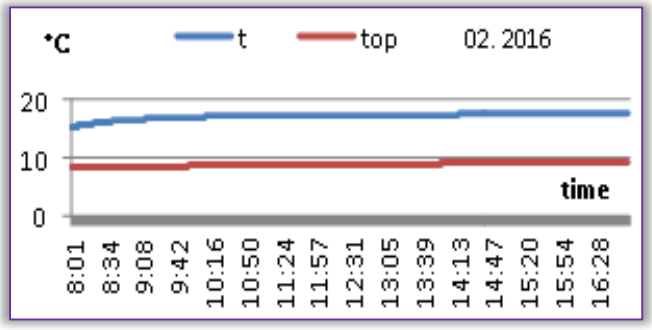

Figure 3b. Hourly alteration of air temperature and spraying temperature in February 2016

Figure 3a, Figure 3b, Figure 4a and Figure 4 b illustrate the hourly and daily values of air temperature and spraying temperature in a sports hall. The hourly values of air temperature for January vary between 12.9°C (8:00h) and17°C (16:00h).

The daily values are: min 12.0°C (18.01.) and max 18.5°C (31.01.). The values of spraying temperature are respectively hourly: 2.9°C (8:03 h) and 4.8°C (17:00h) and daily min -1.97°C (18.01) and max 8.54°C (12.01)

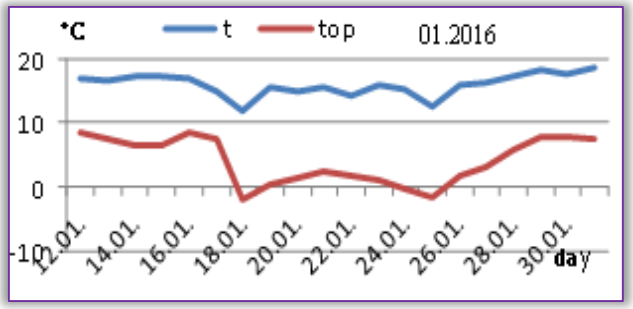

Figure 4a. Alteration of air temperature and spraying temperature in January 2016

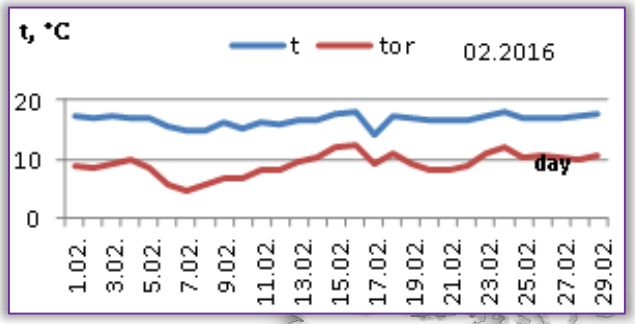

Figure 4 b. Alteration of air temperature and spraying temperature in February 2016

According to the same indicators the data for February are, as follows: hourly min 15.45°C (8:01h), max 17.8°C (16:53h). The daily minimal values are 14.08°C (17:02.) and the maximal are 18.09°C (16.02.).

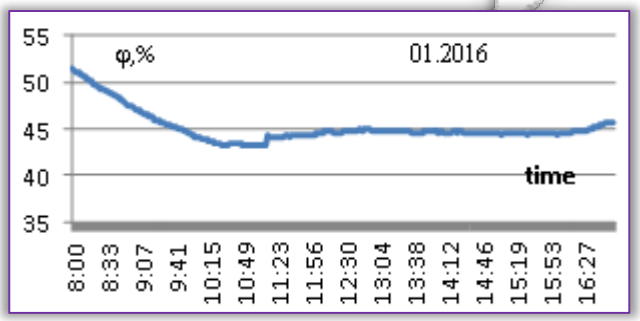

Figure.5a. Hourly alteration of air relative humidity in January 2016

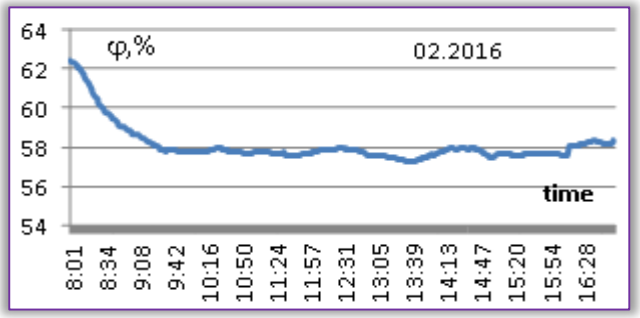

Figure 5b.Hourly alteration of air relative humidity in February 2016

The hourly values for air irrigation temperature are respectively: min 8.28°C (8:01 h) and max 9.04°C (16:50h).The daily values show 4.58°C (7.02) and 12.14°C (16.02).

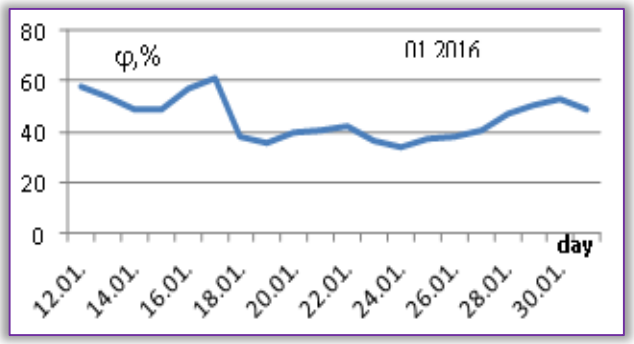

Figure.6a. Alteration of air relative humidity in January 2016

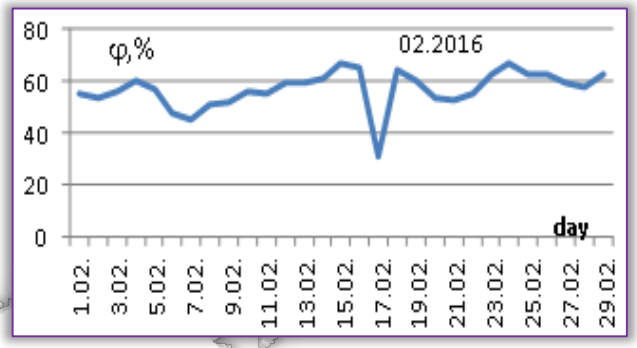

Figure 6b. Alteration of air relative humidity in February 2016

Figure 5a, Figure 5b, Figure 6a and Figure 66 illustrate the hourly and daily values of relative humidity of air in the sports hall. The hourly values for January are in the range between 43.23% (10:55 h) and 51.38% (8:00h). The daily values are respectively: from 34.12% (24.01.) to 61.43% (17.01.).

The hourly data in the studied indicator for February are: 57.2% (13:40h) and 62.4% (8:01h). The daily values are: min 31.09% (17.02.) and max 66.85% (24.02.).

- Another physical factor of the working environment is **room illumination**.

[11] regulates illumination of sports halls with the aim of providing good visual conditions for the users of the sports facility (athletes, judges, spectators) and in compliance with the requirements for colour television broadcasts). The standard specifies values to the lighting in terms of illumination, uniform distribution of light, dazzle-limiting and colour properties of the sources of light. It also sets down the methods of measuring these values.

The illumination of the sports hall is measured with a GL55 sensor – Figure7.

The results obtained by the measurements are shown in Figure 12 and Figure13.

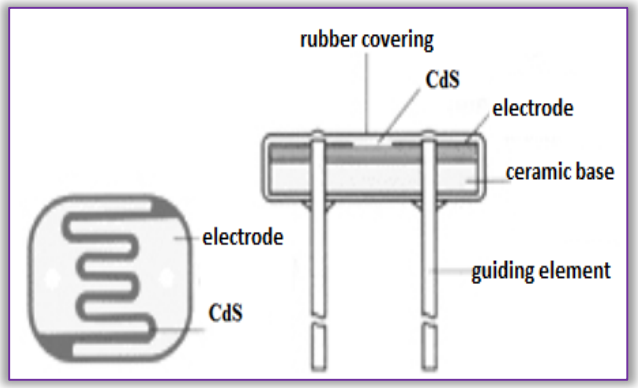

Figure 7. GL55 Illumination measuring sensor [12]

Figure 8a, Figure 8b, Figure 9a and Figure 9b illustrate the hourly and daily values of illumination of the sports hall. The hourly values for January range between 58.9Lux (8:00 h) and 490 Lux (13:50h). The minimal daily value is 105 Lux (16.01.) and the maximal one is 390 Lux (13.01.).

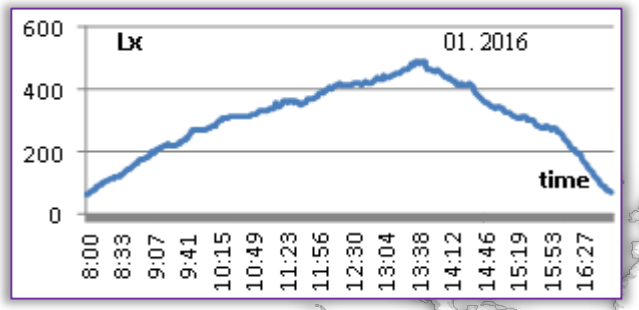

Figure 8a.Hourly alteration of the illumination of the sports hall in January 2016

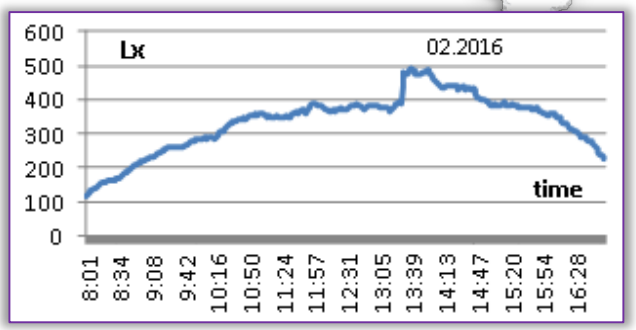

Figure 8b. Hourly alteration of the illumination of the sports hall in February 2016

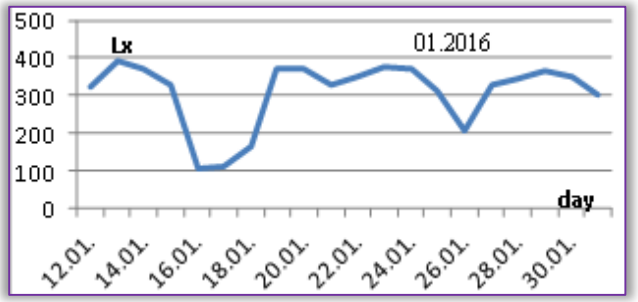

Figure 9a. Daily alteration of the illumination of the sports hall in January 2016

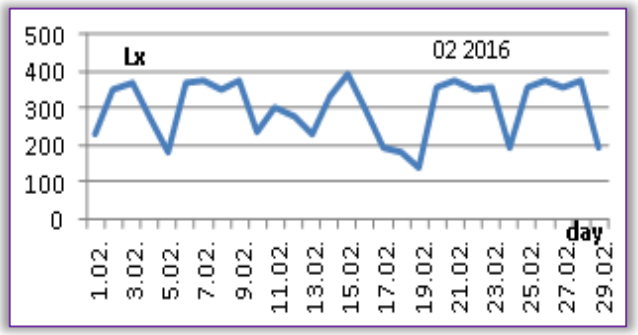

Figure.9b. Daily alteration of the illumination of the sports hall in February 2016

The hourly illumination distribution for February is 115 Lux (8:01h) and 490 Lux (13:40h). The daily values are in the range between 134 Lux (19.02.) and 393 Lux (15.02.).

Dustiness

The sanitary and hygienic requirements to air purity in the rooms are determined not only by the condition of comfort for the occupation by people, but also the conditions of the whole volume, ensuring safety of living to organisms.

Dust concentration should not exceed 10 mg/m^{3}in closed rooms and depends on the activity and the number of the athletes.

Polluted air is particularly harmful to the students due to a number of reasons: doing sports increases inhaling tenfold; deeper inhaling leads to larger saturation with polluted air of the most sensitive parts of lungs; most often polluted air is inhaled through the mouth as result of which penetrates into lungs freely.

Figure 10. GP2Y1010AU0F sensor

GP2Y1010AU0F is a sensor for registering the presence of dust particles in the air on the basis of optical measuring instruments. Reflected light of the fine dust particles in the air is registered, measured in V for their transformation into mg/m^3 is illustrated in Figure 9.

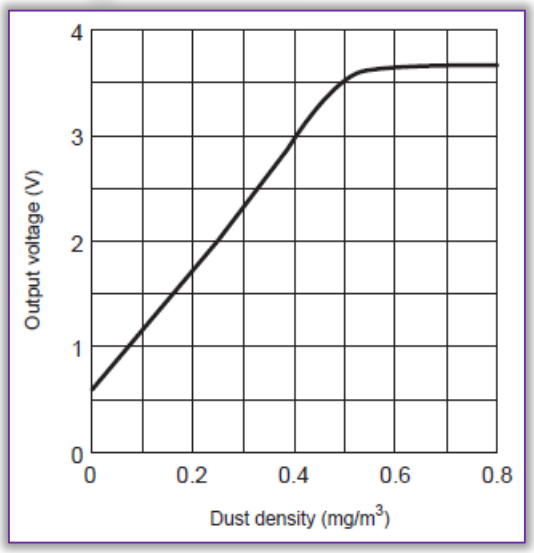

Figure.11.Transformation of V into mg/m³

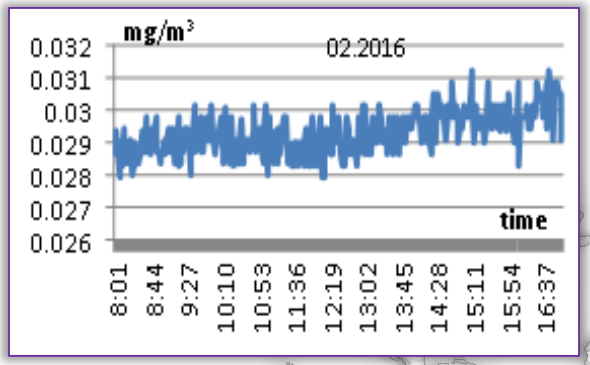

Figure.12a. Hourly alteration of air dustiness in January 2016

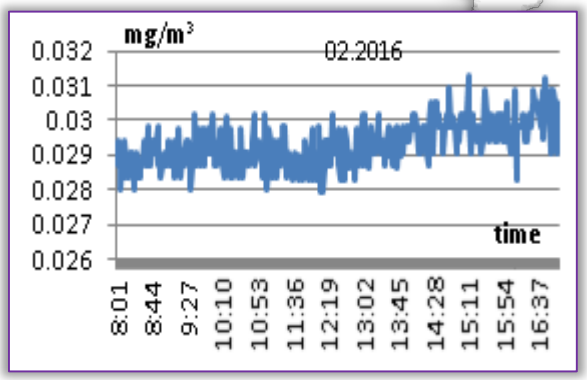

Figure.12b. Hourly alteration of air dustiness in February 2016

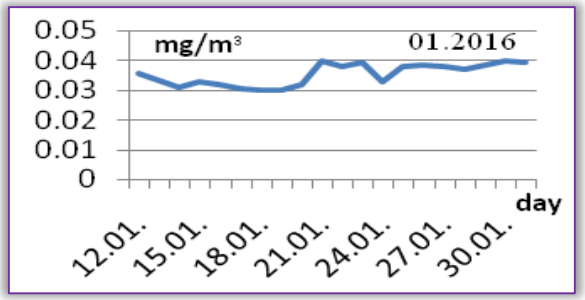

Figure 13a.Daily alteration of air dustiness in January 2016

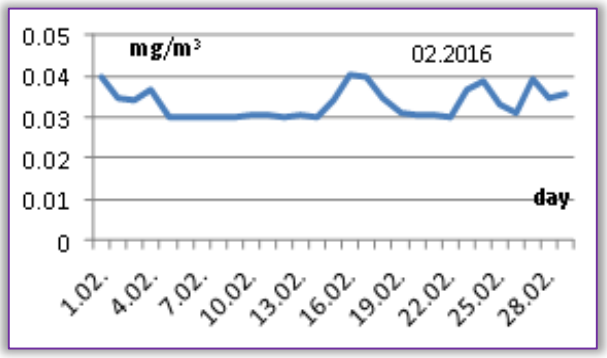

Figure.13b. Daily alteration of air dustiness in February 2016

Figure 12a, Figure 12b, Figure 13 a and Figure 13b reflect the hourly and daily values of air dustiness of the sports hall. The hourly values for January range from 0.033mg/m³ (8:01 h) to 0.038 mg/m³ (15:50h). The daily values indicate: 0.03 mg/m³ (18.01.) and 0.04 mg/m³ (21.01.).

The hourly data for dustiness for February are 0.028 mg/m³ (8:05h) and 0.031 mg/m³ (16:45h) and the respective daily values are: 0.032 mg/m³ (19.02.) and 0.040 mg/m³ (16.02.).

ANALYSIS OF THE OBTAINED RESULTS

- The data (hourly and daily) for the air temperature in the object of the study are in compliance with the sanitary and hygienic requirements for the winter period (18-22°C).
- The measured data for air relative humidity are in the ergonomical norms for comfort for the studied indicator. The measured temperatures of air spraying are in the allowable limits and do not create the preconditions for condensation.
- The illumination at the sports hall is in compliance with the requirements and this is corroborated by the obtained results.
- The registered low values of the indicator of dustiness are explained with the availability of special flooring and the option for natural ventilation.

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ROBOTIC ARM FOR AUTOMATED COLORED OBJECT SORTING

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Abstract: This paper presents aspects related to the design, construction and operation of the mechanical structure and the action of an anthropomorphic robot with 4 degrees of freedom and prehensive mechanism. The robotic arm is equipped with a color sensor and several servomotors, is completely autonomous and has the ability to sort different color objects. Depending on the color of each object, it moves to a predetermined position and catches the object which is a randomly chosen color by the operator, rotates and positions over the color sensor, depending on the value returned by the sensor, inserts it into one from the red, green or blue boxes on the stand. Robot programming is done using the Arduio software.
Keywords: robotic arm, color sensor, Arduino, servomotors, programming

INTRODUCTION

One of the first definitions given to the robot takes into account that it is a device that mimics man to a certain extent, either as a form or as a means of action. Thus, the robot is defined as an automatic mechanism that can substitute man for some operations, being able to modify its execution cycle by photoelectric detection, electronic brain, servomotor, etc. [1],[2],[3]

There are, of course, other definitions for industrial robots, of which:

- The Japan Industrial Robots Association's definition - Japan Industrial Robot Association (JIRA) shows that the robot is a versatile and flexible device that offers movement functions similar to those of human limbs or whose movement functions are commanded by sensors and its own means recognition;
- Definition of the UK Robot Association - The BRA (British Robot Association) shows that the robot is a reprogrammable device designed for the manipulation and transport of parts, tools, or other means of production by variable movements programmed to perform the specific manufacturing tasks;
- The Robot Institute of America (RIA) - Robot Institute of America, says that the robot is a reprogrammable multifunctional manipulator designed to move materials, parts, tools, or other specialized devices through programmed variable motions to perform different tasks.

The robot is a reprogrammable device designed for handling and transporting parts, tools, or other means of production by variable programmed movements to perform the specific manufacturing tasks [4-6].

From the above definitions, the following features of the industrial robots come to light [7,10]:

- they are designed to perform mainly handling, displacement and transport
- operations requiring speed and accuracy but for limited forces;
- they are equipped with several degrees of freedom (between 2÷6) so that they can perform complex operations, each movement being controlled by the driving unit;
- are autonomous, functioning without systematic human intervention;
- they are equipped with a reprogrammable memory capable of conducting equipment necessary to perform operations that can be changed by changing the initial program;
- they are endowed with a very low logic capacity, with which they can perform tests and choose between two alternatives, as well as change approval signals with other devices [6,7,10].

The technical characteristics of industrial robots include: dimensions, achievable travel values, precision, repeatability, freedom of movement, type of drive, robot

weight, workspace volume, command and control system capability, speed, transportable load, working conditions, to have several working arms [5,8].

MECHANICAL STRUCTURE AND ROBOT FUNCTION

This robot arm is completely autonomous and is designed to sort different objects according to color. The robot has 4 degrees of mobility and a prehension mechanism that helps him make complex moves.

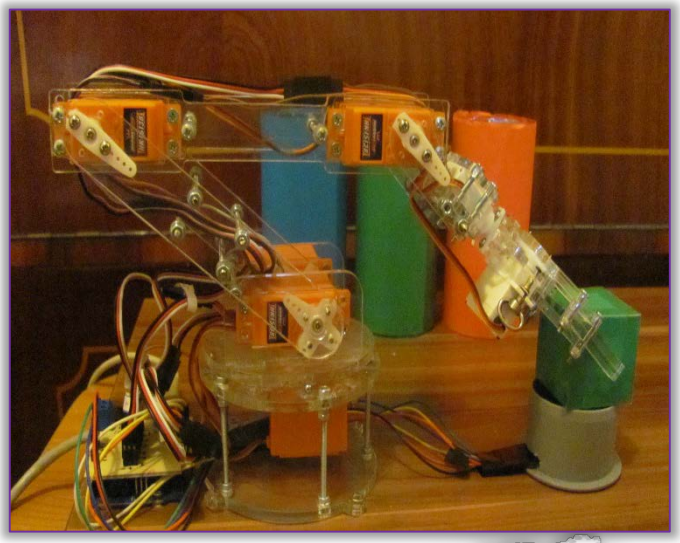

Figure 1. Mechanical structure of robot

It is made of 4 mm plexiglass, cut on a CNC laser machine, and is commanded by an Arduino Uno development board.

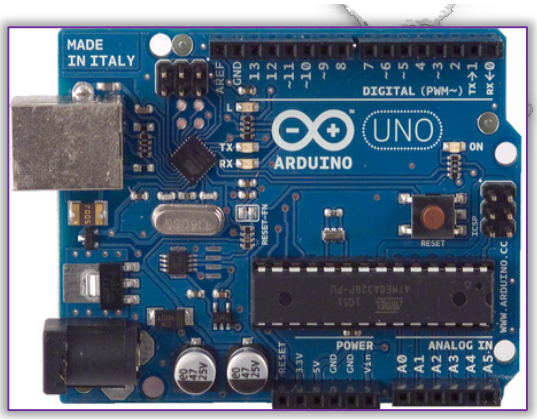

Figure 2. Arduino UNO

Figure 3. Colour sensor

Arduino UNO is an open-source processing platform based on flexible and simple software and hardware. It consists of a small platform (6.8 cm / 5.3 cm - in the most common version) built around a signal processor and is able to retrieve data from the environment through a series of sensors and perform actions On the environment through lights, motors, servomotors, and other types of mechanical devices. The processor is able to run written code in a programming language that is very similar to C ++ [2,9].

They used:

- 5 servo motors: Servo Analog HK15138 Standard to control the base, shoulder, elbow and forearm,
- 2 Servo HK Servo HK 2.5 kg / 0.14 s Analog Micro to control the wrist and gripper
- for color sensor [2] 3 LEDs of 5mm red, green and blue were used, and for reading 5mm light-dependent light resistors (LDR) (Figure 5) [10], [11].

The color scheme of the color sensor is shown in Figure 4, and the Shield electrical diagram in Figure 5.

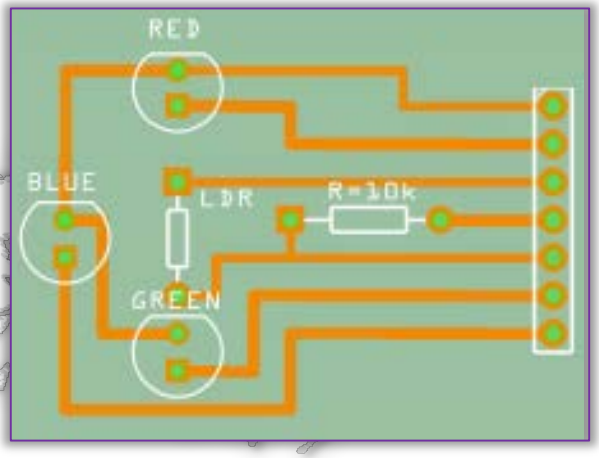

Figure 4. Electric scheme of colour sensor

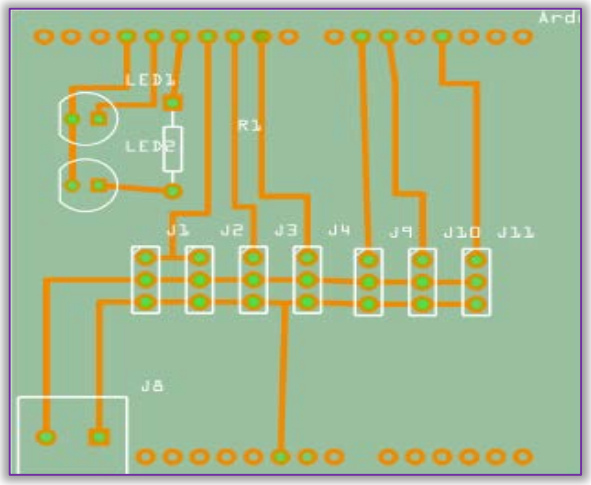

Figure 5. Shield

The LEDs are linked to the digital pins 4.7 and 8, and the photoresist at Artoino UNO's A0 pin (signal input pin). The shield linking the Arduino and the motors is shown in Figure 5 and is powered by a 6V voltage source.

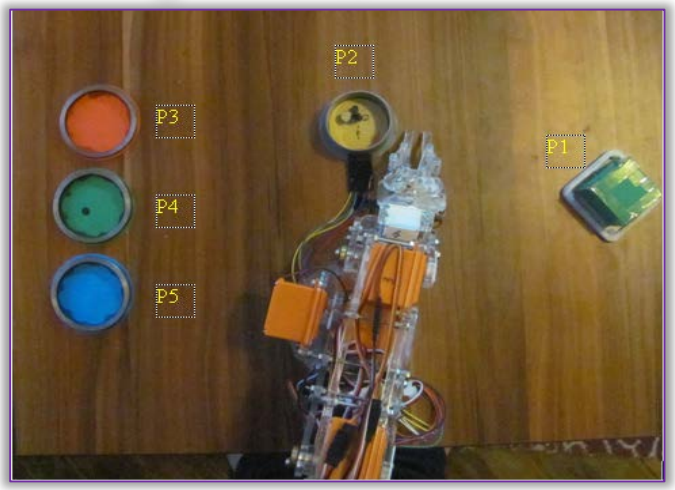

Figure 6. Robot functioning

The robot moves to the right in a predetermined P1 position and catches the cube that has a random color chosen by the operator, rotates and positions above P2 sensor. Depending on the value returned by the sensor [11], it puts it in one of the left, red, green or blue (P3, P4 or P5) left boxes.

SOFTWARE IMPLEMENTING

The language used for correct operation is similar to C ++ and is called Arduino. The following window is a programming editor used only for Arduino development boards. For this, you must enter the tools menu and choose the plaque you are working with, and the selected computer port [8, 9].

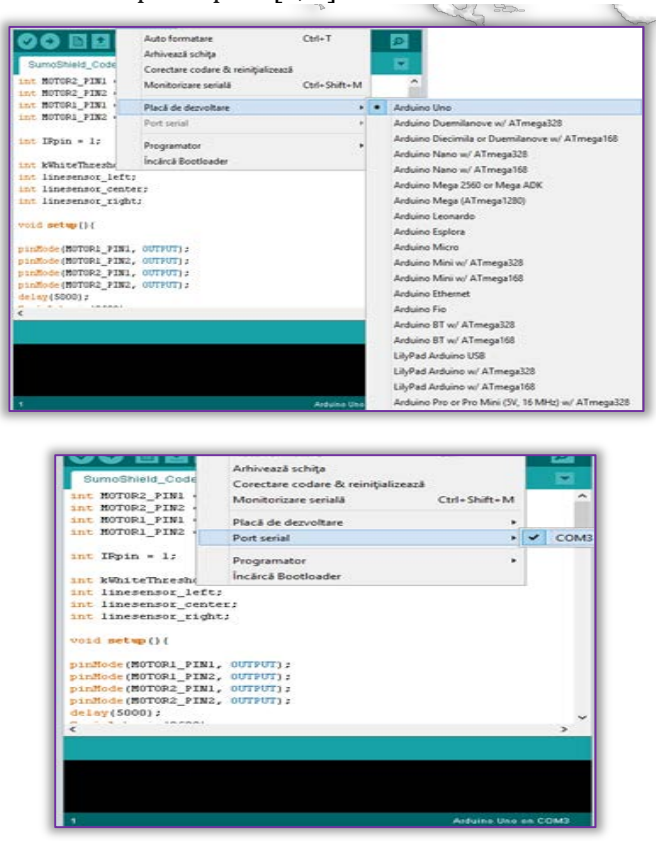

Figure 7. Arduino development board and selection of computer port

Any written program should be checked with the button which checks for errors in the program structure, and by displaying the "Done compiling" message, the program can be run by pressing the upload button which sends instructions via the COM3 port to the microcontroller, which processes and sends them to the output pins [9]. Here are some screens with the program code lines.

```
RoboCol
 digitalWrite(led,HIGH);
 delay(3000);
}

int senzor(void)
{
 int redv,albv,grev;
int minc;
int marcel;
     //ValCamera=analogRead(0);
     //Serial.println("Camera:");
     //Serial.println(ValCamera, DEC);
     //delay(6000);
     digitalWrite(red,HIGH);
     delay(200);
     redv=analogRead(0);
     digitalWrite(red,LOW);
     digitalWrite(alb,HIGH);
     delay(200);
     grev=analogRead(0);
     digitalWrite(alb,LOW);
     digitalWrite(gre,HIGH);
     delay(200);
     albv=analogRead(0);
     digitalWrite(gre,LOW);
     Serial.println("ROSU:");Serial.println(redv,DEC);
     Serial.println("VERDE:");Serial.println(grev,DEC);
     Serial.println("ALBASTRU");Serial.println(albv,DEC);
     minc=1025;
```

Figure 8. Program code lines

CONCLUSIONS

This paper presents an application to sort colored objects with a robotic arm. We have a robotic arm which picks different colored cubes and sorts them placing in different locations. The color recognition is made using a color sensor.

The robotic arms are widely used in the industry, but most of them are used in a PTP (Point To Point) trajectory, the moves are learned previously by the robotic arm. Very few robots in the industry are programmed to be smart, or to make decisions. In the future to completely replace the humans with robots, we need robotic arms which can make decisions. One example for a robotic arm can be a robotic arm which can sort objects by color. This can be used in many factories, by example can be used in a pencil factory.

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THERMO-PHYSICAL EFFECTS OF THERMAL RADIATION AND HEAT GENERATION ON FREE CONVECTIVE HEAT AND MASS TRANSFER OVER A VERTICAL PLATE

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Abstract: The thermo-physical effects of thermal radiation, heat generation and species concentration on Magneto-hydrodynamic free convective heat and mass transfer flow over a vertical plate with variable thermal conductivity is considered. The governing partial differential equations are transformed into coupled nonlinear ordinary differential equations with similarity transformations. The resulting coupled nonlinear differential equation is solved numerically by Runge-Kutta forth order with shooting technique. The effects of the thermo-physical properties on velocity, temperature and concentration profiles are illustrated graphically and numerical values of skin friction, Nusselt number and Sherwood number are presented in tables.
Keywords: MHD free convection; heat generation; thermal radiation; variable thermal conductivity; vertical plate

Introduction

The problem of fluid flow in an electromagnetic field has been studied for its importance in geophysics, metallurgy aerodynamic extrusion of plastic sheets and other engineering processes such as in petroleum engineering, chemical engineering, composite or ceramic engineering and heat exchanger (Sandeep and Sugunamma, 2013). Radiative convective flows are involved in countless industrial and environmental processes. For example, heating and cooling chambers, fossil fuel combustion energy process evaporation from large open water reservoirs, astrophysical flows, solar power technology and space vehicle re-entry. In the context of space technology and in processes involving high temperatures, the effects of radiation are of vital importance which has opened up to various investigators. Many researchers have investigated the interaction of thermal radiation, heat generation and free convection for different geometries, by considering various flow patterns. Muthucumaraswamy et al. (2006) investigated the effect of thermal radiation on the unsteady free convective flow over a moving vertical plate with mass transfer in the presence of a homogenous first order chemical reaction. Their result showed that velocity increases with decreasing radiation parameter or chemical reaction parameter. The interaction of free convection with thermal radiation of a viscous incompressible unsteady MHD flow past a moving vertical cylinder with heat and mass transfer was analysed by Reddy and Reddy (2009) and it was observed that when radiation parameter increases, the velocity and temperature decreases in the boundary layer. Khaleque and Samad (2010) studied radiation and viscous dissipation effects on a steady two-dimensional MHD free convection flow along a stretching sheet with heat generation. They observed that momentum boundary layer and the thermal boundary layer thickness reduce as a result of increasing radiation. Jana and Ghosh (2011) studied the effects of thermal radiation of a viscous incompressible fluid occupying a semi-infinite region of space bounded by an infinite horizontal moving hot flat plate in the presence of indirect natural convection by way of an induced pressure gradient. From their study, velocity slightly increases with increased radiation parameter as temperature increases with increasing values of

radiation parameter. Uddin and Kumar (2011) investigated the heat and mass transfer characteristics and the flow behaviour on MHD flow near the lower stagnation point of a porous isothermal horizontal circular cylinder. It was observed that with the increase in Schmidt number, skin friction and Nusselt number decreases while, Sherwood number increases.

Shit and Haldar (2012) studied the effect of thermal radiation and temperature dependent viscosity on free convective flow and mass transfer of an electrically conducting fluid over an isothermal sheet. The result of their study showed that effects of thermal radiation and variable viscosity can lead to the decrease of heat transfer, whereas, the presence of viscoelasticity of the fluid and magnetic field causes increase of heat transfer. Sandeep and Sugunamma (2013) analysed the effects of inclined magnetic field and radiation on free convective flow of dissipative fluid past a vertical plate through porous medium in the presence of heat source. Their results showed that decrease in inclination angle reduces the magnetic field effect but increase in radiation term does not show much effect on increase in skin friction, while, increase in heat source parameter causes the increase in velocity of fluid flow. Omowaye and Ajayi (2014) studied the effects of some thermo-physical properties on force convective stagnation point on a stretching sheet with convective boundary conditions in the presence of thermal radiation and magnetic field. They observed that increasing the value of magnetic field parameter resulted in the increase in skin friction coefficient, whereas, the Nusselt number decreases with increasing values of the magnetic parameter and radiation number.

A number of interesting applications of the principles of heat transfer are concerned with systems in which heat may be generated internally. Nuclear reactors, electrical conductors, exothermic and endothermic chemically reacting systems are some examples (Holman, 2002). Mixed convection MHD flow of nano-fluid over a non-linear stretching sheet with thermal radiation and suction and variable magnetic field is investigated by Keshtekar et al. (2014). Their results showed that thermal radiation, heat generation and the permeability parameter decreases with an increase in Prandtl number, suction and magnetic parameter. Animasaun and Oyem (2014) investigated the effect of variable viscosity, Dufour, Soret and thermal conductivity on free convective heat and mass transfer of non-Darcian flow past flat surface. Their result showed that with increase in Dufour and Soret Parameter, fluid velocity increases and temperature increases with increase in variation of Dufour but decreases with increase in Soret. Olajuwon and Baoku (2014) investigated the combined influence of internal heat generation, suction, thermal radiation and chemical reaction of nth order on an unsteady free convective heat and mass transfer flow of a chemically reactive third grade fluid over an infinite vertical porous plate with oscillating temperature applied to the plate. They noted that suction parameter has the influence of reducing velocity, temperature and species concentration fields, as the fluid velocity increases as the value of the second grade viscoelastic parameter increases.

GOVERNING EQUATION

A steady two-dimensional free convective heat and mass transfer fluid flow over a vertical plate with variable thermal conductivity, heat generation, thermal radiation and species concentration are considered. The flow in the x-axis is taken along the vertical plate in the upward direction and the y-axis is normal to the plate. Here, T_w and C_w are temperature and concentration of the fluid at the plate and T_∞ and C_∞ are the temperature and concentration outside the boundary layer as shown in figure 1.

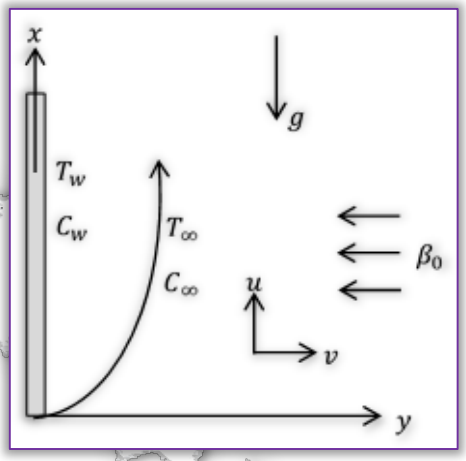

Figure 1. Problem schematics

Under the Boussinesq's approximation, the boundary layer is governed by the mass, momentum, energy and concentration equations as;

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \quad (1)$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\upsilon\frac{\partial^2 u}{\partial y^2}+g\beta(T-T_\infty)+g\beta^*(C-C_\infty)-\frac{\sigma\beta_0^2 u}{\rho} \quad (2)$$

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\frac{1}{\rho c_p}\frac{\partial}{\partial y}\left(\kappa(T)\frac{\partial T}{\partial y}\right)-\frac{1}{\rho c_p}\frac{\partial q_r}{\partial y}+\frac{Q_0}{\rho c_p}(T-T_\infty) \quad (3)$$

$$u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}=D\frac{\partial^2 C}{\partial y^2} \quad (4)$$

The radiative heat flux q_r is describes by the Rosseland approximation given by

$$q_r=-\frac{4\sigma^*}{3k^*}\frac{\partial T^4}{\partial y} \quad (5)$$

where σ^* is the Stefan-Boltzmann constant and k^* is the Rosseland mean absorption coefficient. Following

Chamkha (1997), the temperature difference within the flow is assumed to be sufficiently small so that T^4 may be expressed as a linear function of temperature T. This is accomplished by expanding T^4 in a Taylor's series about the free stream temperature T_∞ such that

$$T^4 \approx 4T_\infty{}^3T - 3T_\infty{}^4 \quad (6)$$

In this research, the author shall assume that the fluid thermal conductivity κ vary as a linear function of temperature (Prasad et al. 2010) as

$$\kappa(T) = \kappa^*[1 + \delta^*(T - T_\infty)] \quad (7)$$

where κ(T) is the thermal conductivity of the fluid depending on the fluid temperature T and δ^* being a constant which may either be positive or negative. In this research, $\delta > 0$ is thermal conductivity generation and κ^* is the thermal conductivity of the ambient fluid.

The corresponding boundary conditions are

$$u = 0 \;\; v = 0 \;\; T = T_w \;\; C = C_w \;\; \text{at } y = 0$$
$$u \to 0 \;\; T \to T_\infty \;\; C \to C_\infty \;\; \text{as } y \to \infty \quad (8)$$

The velocity components along the axes can be expressed as:

$$u = \frac{\partial \psi}{\partial y} \quad \text{and} \quad v = -\frac{\partial \psi}{\partial x} \quad (9)$$

substituting equation (9) into equation (1), equation (1) is satisfied. Defining similarity variable and the dimensionless variables as

$$\eta = y\sqrt{\frac{U_0}{2\upsilon x}}, \theta(\eta) = \frac{T - T_\infty}{T_w - T_\infty},$$
$$\phi(\eta) = \frac{C - C_\infty}{C_w - C_\infty}, \psi = \sqrt{2x\upsilon U_0}\, f(\eta) \quad (10)$$

where ψ is the stream function, f is dimensionless velocity, θ is the dimensionless fluid temperature and ϕ is the dimensionless concentration. Introducing equation (10) into equations (1)-(9), the coupled nonlinear ordinary differential equation is obtained

$$f''' + ff'' + Gr\theta + Gm\phi - Mf' = 0 \quad (11)$$
$$\left(1 + \gamma\theta + \frac{4}{3N}\right)\theta'' + Prf\,\theta' + \gamma\theta'^2 + PrQ\theta = 0 \quad (12)$$
$$\phi'' + Scf\phi' = 0 \quad (13)$$

subject to the boundary conditions

$$\eta = 0 ; \;\; f = 0 \;\; f' = 0 \;\; \theta = 1 \;\; \phi = 1$$
$$\eta \to \infty ; \;\; f' \to 0 \;\; \theta \to 0 \;\; \phi \to 0 \quad (14)$$

Equations (11) – (13) with boundary conditions (14) describe the heat and mass transfer over a vertical plate in the presence of magnetic field under variable thermal conductivity, thermal radiation, heat generation and species concentration. It is noteworthy that the local parameters Gr, Gm, M and Q in equations (11) – (13) are functions of x. Here, prime denotes the differentiation with respect to η and:

$Gr = \frac{2xg\beta(T_w - T_\infty)}{U_0^2}$ (local thermal Grashof number),

$Gm = \frac{2xg\beta^*(C_w - C_\infty)}{U_0^2}$ (local modified thermal Grashof number),

$M = \frac{2x\sigma\beta_0^2}{\rho U_0}$ (local magnetic field parameter),

$Pr = \frac{\upsilon}{\alpha}$ (Prandtl number),

$Q = \frac{2xQ_0}{\rho c_p U_0}$ (heat generation parameter),

$Sc = \frac{\upsilon}{D}$ (Schmidt number),

$\gamma = \delta(T_w - T_\infty)$ (variable thermal conductivity parameter),

$N = \frac{\kappa\kappa^*}{4\sigma^* T_\infty^3}$ (thermal radiation parameter of the flow).

NUMERICAL COMPUTATION

The set of equations (11) - (13) under the boundary conditions (14) are solved numerically by Runge-Kutta forth order technique with shooting method. The basic idea is to reduce the higher order nonlinear differential equations (11) - (13) to system of first order linear differential equations and they are further transformed into initial value problem and then apply shooting technique with Gr, Gm, M, Pr, Q, Sc, γ and N as prescribed parameters. The results are presented in figures 2 - 25.

Let $f = x_1, f' = x_2, f'' = x_3, \theta = x_4, \theta' = x_5, \phi = x_6, \phi' = x_7$. Then equations (11) – (14) are transformed into a system of first order differential equations as:

$$x_1' = x_2$$
$$x_2' = x_3$$
$$x_3' = Mx_2 - Grx_4 - Gmx_6 - x_1x_3$$
$$x_4' = x_5$$
$$x_5' = \left(\frac{3N}{3N(1 + \gamma x_4) + 4}\right)(-Prx_1x_5 - \gamma x_5^2 - PrQx_4) \quad (15)$$
$$x_6' = x_7$$
$$x_7' = -Scx_1x_7$$

subject to the following initial conditions:

$$x_1(0) = 0, x_2(0) = 0, x_3(0) = s_1, x_4(0) = 1,$$
$$x_5(0) = s_2, x_6(0) = 1, x_7(0) = s_3 \quad (16)$$

The computations are carried out by a program which uses a symbolic and computational computer language MATLAB with a step-size of $\Delta\eta = 0.001$, chosen to satisfy the convergence criterion of 10^{-6}. From the process of computation, the skin friction coefficient $f''(0)$, Nusselt number $-\theta'(0)$ and mass transfer coefficient in terms of Sherwood number $-\phi'(0)$ respectively are also worked out and their numerical values are presented in a tables 1 – 3.

RESULTS AND DISCUSSION

In order to get a physical insight into the problem, velocity, temperature and concentration profiles have been computed and displayed graphically. Skin-friction coefficient, Nusselt and Sherwood numbers are also computed for various values of the governing parameters: thermal radiation parameter(N), local thermal Grashof number (Gr), local modified thermal Grashof number (Gm), Prandtl number (Pr), local

magnetic field parameter (M), Schmidt number (Sc), heat generation parameter (Q) and variable thermal conductivity parameter (γ).

The velocity, temperature and concentration profiles are displayed in figures 2 – 4 respectively. It was observed from figure 2 that as γ increases in value, velocity increases steeply to a peak along the plate and decreases gradually away from the plate towards the free stream. In figure 4, concentration profiles decreases with an increase in variable thermal conductivity, while, in figure 3, temperature profiles increases with increasing values of thermal conductivity variation parameter γ.

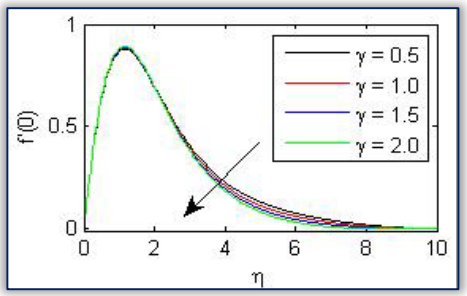

Figure 2: Velocity profiles over a vertical plate for various values of variable thermal conductivity γ

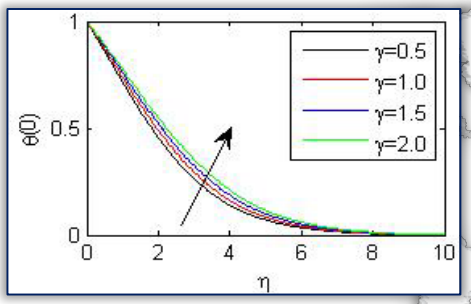

Figure 3: Temperature profiles over a vertical plate for various values of thermal conductivity variation parameter γ

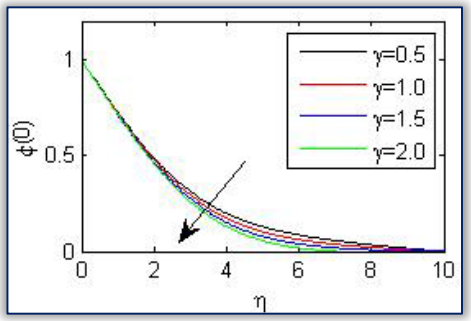

Figure 4: Concentration profiles for various values of γ

Prandtl number Pr is found to be the parameter that relates the relative thickness of the hydrodynamic and thermal boundary layer. Thereby making it the link between the velocity and the temperature fields (Holman, 2004). The effects of Prandtl number Pr on velocity, temperature and concentration distributions are displayed in figures 5, 6 and 7 respectively. Figures 5 and 6 shows that velocity and concentration profiles increases with the increase in Prandtl number Pr. It was also observed in figure 5 that there was an initial rise at $Pr = 0.71, 1.0$ and later, a sharp rise in velocity and concentration boundary layers away from the plate towards the free stream was observed at$Pr = 3.0$. Figure 6 shows that temperature profiles decreases as Prandtl number Pr increases. It is also interesting to note that increase in Pr means a decrease in variable thermal conductivity.

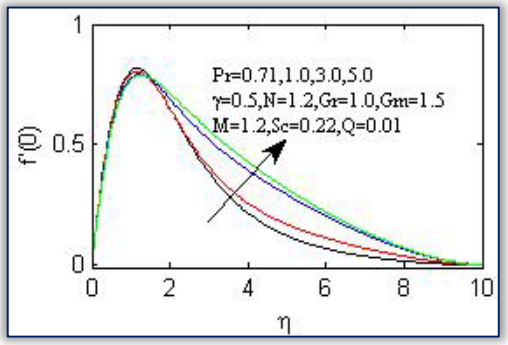

Figure 5: Prandtl number (Pr) effects on velocity profiles

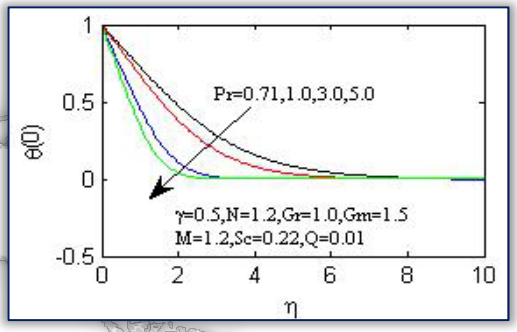

Figure 6: Prandtl number (Pr) effects on temperature profiles

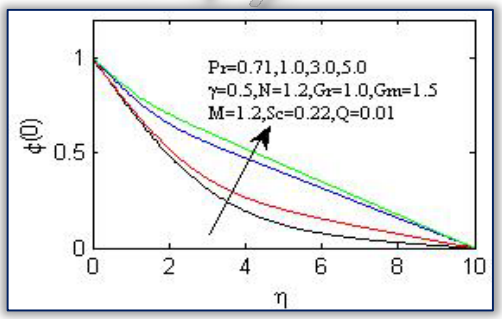

Figure 7: Prandtl number (Pr) effect on concentration profiles

It was observed from figure 6 that for $Pr = 0.71, 1.0$, there is a slight rise in the thermal boundary layers near the plate but decreases sharply for $Pr = 3.0$ towards the plate (Khaleque and Samad, 2010). In figure 7, increase in Prandtl number results in the increase in concentration profiles. It was observed that it increases sharply away from the plate towards the free stream.

Figures 8 - 10 shows the variation of velocity, temperature and concentration profiles respectively with local thermal Grashof number (Gr). From figure 8,

it was observed that velocity profiles increases spontaneously at an initial state near the vertical plate as local thermal Grashof number increased but moving away from the plate, a cross flow in the velocity is induced as velocity gently decreases away from the plate at a slower rate with increasing values of Gr. Since Gr > 0 corresponds to externally cooled plate, substantial increase in velocity distribution profiles is observed near the plate, thereby indicating greater cooling results in velocity increase and thermal boundary layer thickness. This situation reveals that the buoyancy force accelerates the velocity field and no flow reversal occurs to prevent separation (Khaleque and Samad, 2010, Jana and Ghosh, 2011).

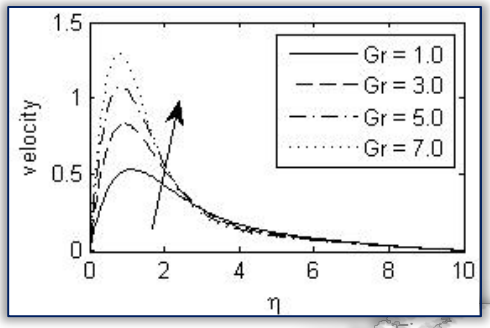

Figure 8: Grashof number (Gr) effect on velocity profiles

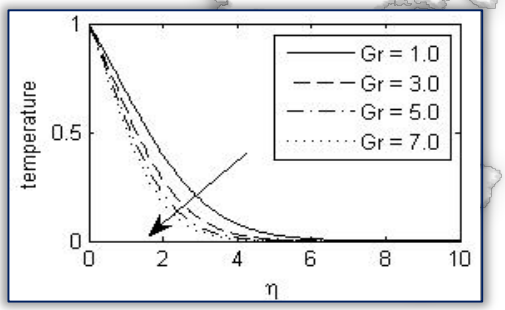

Figure 9: Grashof number (Gr) effect on temperature profiles

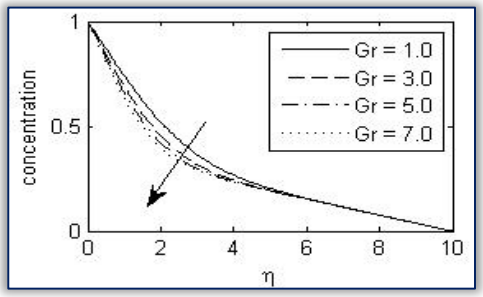

Figure 10: Grashof number (Gr) effect on concentration profiles

From figures 9 and 10, the thermal boundary layer on temperature profiles and concentration boundary layers reduces with increasing values of Gr, causing the fluid temperature to reduce at every point other than the plate. When a heated surface is in contact with the fluid, the result of temperature difference causes buoyancy force, which induces the natural convection (Abah et al. 2012).

Velocity, temperature and concentration distribution profiles for different values of thermal radiation parameter with Gr = 1.0, γ = 0.5, Sc = 0.2, Q = 0.01, Gm = 1.5, Pr = 0.71, M = 1.2 are displayed in figures 11, 12 and 13. It was observed from figure 11 that velocity profiles increases initially to a peak near the plate as η increases but decreases away towards the free stream as the thermal radiation parameter N increases. It also reveals that increasing values of N causes less interaction of radiation with the momentum boundary layer.

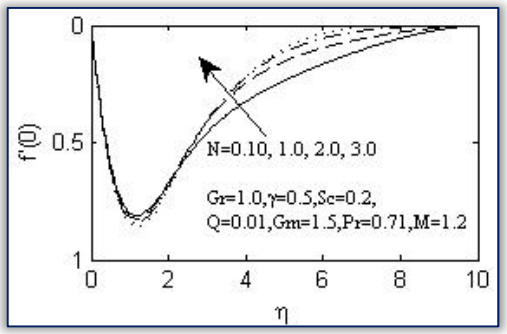

Figure 11: Velocity profiles against η for varying values of N

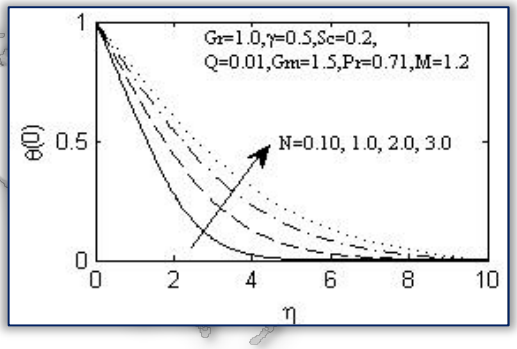

Figure 12: Temperature profiles against η for various values of thermal radiation parameter N

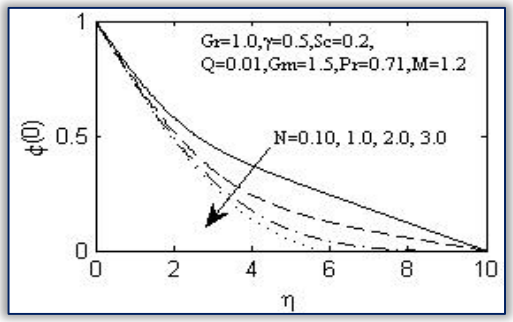

Figure 13: Concentration profiles for various values of thermal radiation parameter N

Figure 12 reveals that temperature profiles increase as radiation parameter N increases. This is because thermal radiation in the fluid increases the temperature within the boundary layer which accelerates the convection as well as increases the flow within the boundary layer. It was observed from figure 13 that the concentration profiles decreases in boundary layers away from the plate as thermal radiation parameter

increases. However, this result shows that concentration boundary layer thickness can be reduced as a result of increase in thermal radiation parameter N.

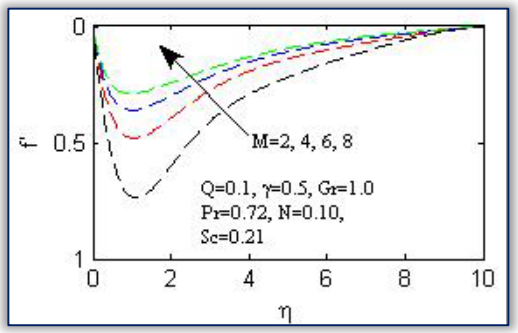

Figure 14: Variation of f′(η) with η for different values of M

For different values of the local magnetic parameter M, velocity profiles are plotted in figure 14. It was observed that velocity attains maximum point near the plate at low local magnetic parameter and decreases freely as M increases across the boundary layer because of the application of transfer magnetic field which tends to resist the fluid flow. Consequently, the boundary layer thickness decreases with an increase in the local magnetic field while, the separation of the boundary layer occurs earlier and the momentum boundary layer becomes thicker. But the reverse is observed within the boundary layer for temperature and concentration profiles as shown in figures 15 and 16.

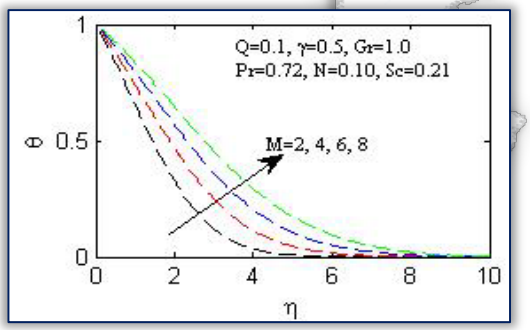

Figure 15: Temperature profile θ(η) with η for different values of M

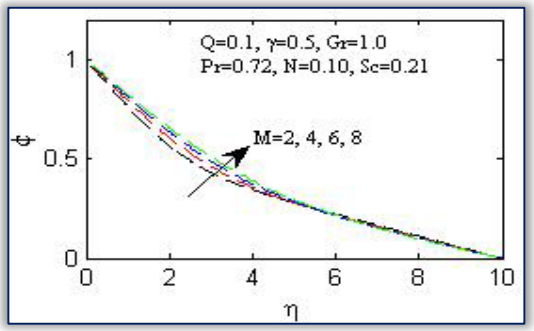

Figure 16: Variation of ϕ(η) with η for different values of M

It was observed that increasing local magnetic field, the temperature of the fluid increases while and concentration species has an enhanced effect on the flow from the plate to the free stream (Shit and Haldar, 2012).

Figure 17 presents the velocity profiles for various values of local modified thermal Grashof number (Gm). It was observed that increase in the values of Gm, have the tendency to induce more flow in the boundary layer due to the effect of thermal buoyancy, thereby producing an increase in velocity flow (Abah et al. 2012).

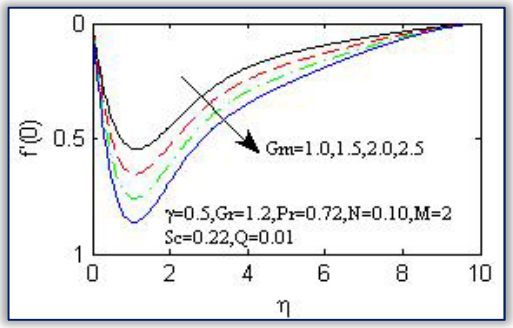

Figure 17: Velocity profiles f′(η) against η for different values of modified thermal Grashof number

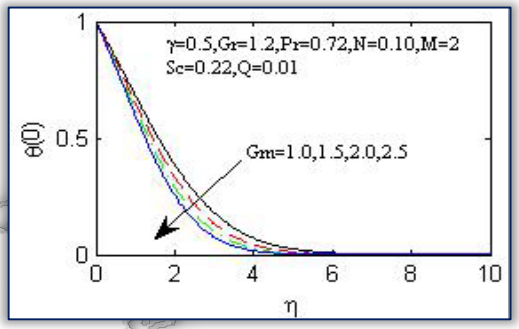

Figure 18: Temperature profiles θ(η) against η for various Values of modified thermal Grashof number Gm

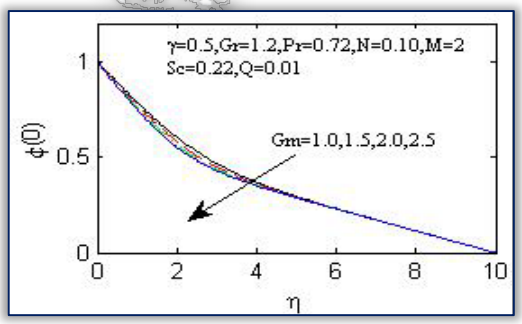

Figure 19: Concentration profiles θ(η) against η for various Values of modified thermal Grashof number Gm

Temperature and concentration profiles for Gm are presented in figures 18 and 19. It was observed that increasing the values of modified thermal Grashof number, both temperature and concentration profiles decreases gradually towards the free stream. Figures 20 – 22 shows the effects of Schmidt number Sc on velocity, temperature and concentration profiles. From figures 20 and 22, we observed that velocity and concentration profiles decreases respectively as Schmidt number Sc increases. We also observed from figure 20 that after an initial rise from zero to a peak in the velocity profile, Sc decreases greatly away from the plate. Meanwhile, temperature profiles increases gradually away from the

plate as the Schmidt number Sc increases in values as shown in figure 21.

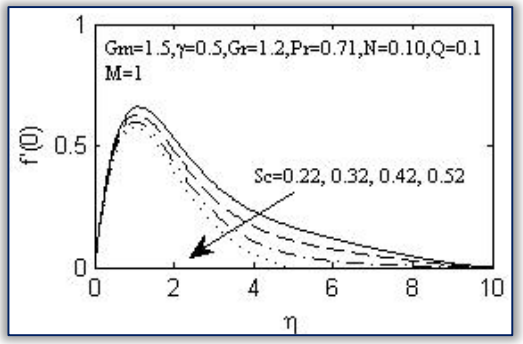

Figure 20: Velocity profiles for various values of Schmidt number Sc

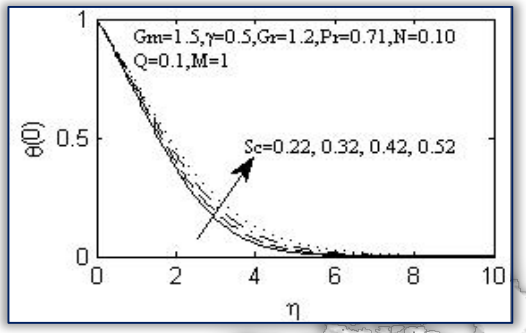

Figure 21: Temperature profiles for various values of Schmidt number Sc

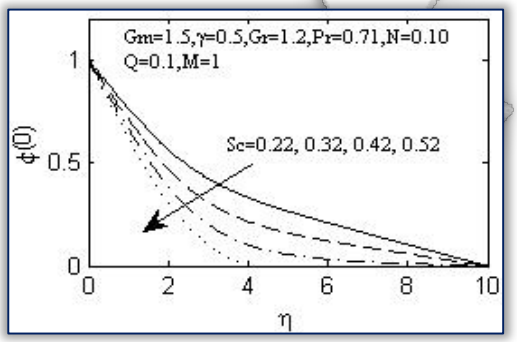

Figure 22: Concentration profiles for various values of Schmidt number Sc

The effects of heat source parameter Q on velocity, temperature and concentration boundary layers are displayed respectively in figures 23 – 25. From figures 23 and 24, it was observed that velocity and temperature profiles increases as heat source parameter Q increases. While, from figure 25, concentration profiles decreases with increase in heat generation parameter Q. Also, it was observed from figures 23 – 25, that for various values of $Q = 0.01, 0.04, 0.08, 0.1$, there was little but significant variations in the corresponding velocity, temperature and concentration profiles. However, the concentration boundary layer thickness reduces as a result of the increase in the heat source parameter Q and also shows that large values of heat source parameter Q have significant effect on velocity and temperature distributions.

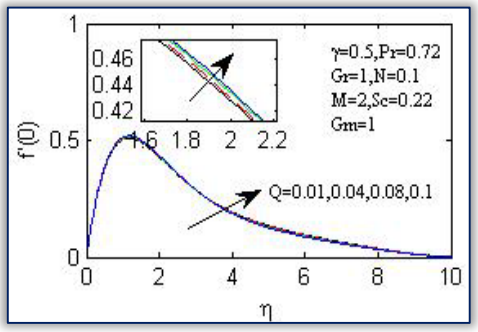

Figure 23: Velocity profiles for various values of Q

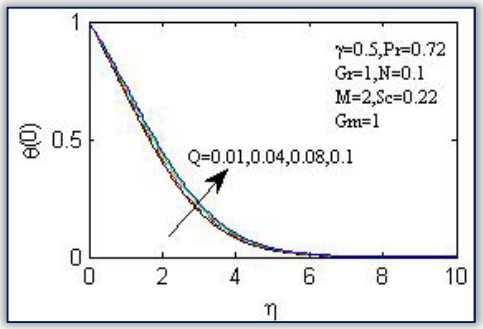

Figure 24: Temperature profiles for various values of Q

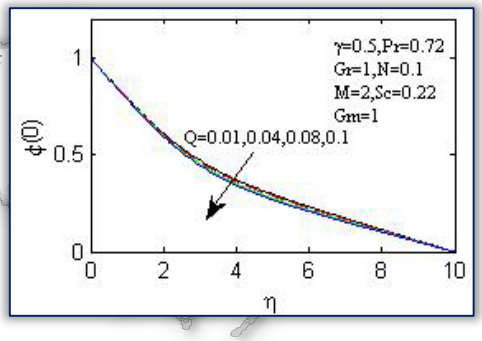

Figure 25: Concentration profiles for various values of Q

Numerical values of skin friction coefficient, rate of heat transfer and mass transfer are presented in tables 1 – 3. The effects of Pr, γ, N, Gr, Gm, M, Sc, and Q on the Skin friction (C_f) are numerically shown in Table 1. We observed that shear stress in terms of skin friction coefficient increases slightly as variable thermal conductivity (γ) increases but decreases with increase in Schmidt number, Prandtl number and local magnetic field parameter. It is observed that as buoyancy parameter and thermal radiation parameter increases, the skin friction coefficient increases. Similarly, we observed that a decrease in the modified thermal Grashof number Gm heat source parameter Q leads to a decrease in skin friction. The effects of Pr, γ, N, Gr, Gm, M, Sc, and Q on the rate of heat transfer in terms of Nusselt number are shown in Table 2. It is seen that as γ, N, Gr, Gm, and Q increases, the rate of heat transfer decreases. Also, as Prandtl number increase, the Nusselt number increases, whereas, it decreases with decreasing values in local magnetic field and Schmidt number respectively.

Table 1: Numerical values of shear stress in terms of skin friction (C_f)

γ	Pr	Gr	N	M	Gm	Sc	Q	C_f
0.5	0.71	1.0	1.2	1.0	1.5	0.22	0.01	1.8197
1.0								1.8258
1.5								1.8316
2.0								1.8371
0.5	0.71	1.0	1.2	1.2	1.5	0.22	0.01	1.7351
	1.0							1.7198
	3.0							1.6836
	5.0							1.6618
0.5	0.72	1	0.10	2	1.2	0.32	0.01	1.2612
		3						2.2405
		5						3.1447
		7						3.9984
0.5	0.71	1.0	0.1	1.2	1.5	0.2	0.01	1.7227
			1.0					1.7437
			2.0					1.7647
			3.0					1.7804
0.5	0.72	1.0	0.10	2	2.0	0.21	0.1	1.7418
				4				1.3417
				6				1.1332
				8				0.9998
0.5	0.72	1.2	0.10	2	1.0	0.22	0.01	1.2757
					1.5			1.5542
					2.0			1.8311
					2.5			2.1065
0.5	0.71	1.2	0.10	1	1.5	0.22	0.1	1.5649
						0.32		1.5323
						0.42		1.5045
						0.52		1.4816
0.5	0.72	1	0.10	2	1.0	0.22	0.01	1.1715
							0.04	1.1754
							0.08	1.1809
							0.10	1.1838

Table 2: The rate of heat transfer in terms of Nusselt number (Nu)

γ	Pr	Gr	N	M	Gm	Sc	Q	Nu
0.5	0.71	1.0	1.2	1.0	1.5	0.22	0.01	0.2781
1.0								0.2510
1.5								0.2296
2.0								0.2122
0.5	0.71	1.0	1.2	1.2	1.5	0.22	0.01	0.2695
	1.0							0.3241
	3.0							0.5427
	5.0							0.6686
0.5	0.72	1	0.10	2	1.2	0.32	0.01	0.3002
		3						0.3747
		5						0.4256
		7						0.4652
0.5	0.71	1.0	0.1	1.2	1.5	0.2	0.01	0.3699
			1.0					0.2861
			2.0					0.2345
			3.0					0.2040
0.5	0.72	1.0	0.10	2	2.0	0.21	0.1	0.3142
				4				0.2331
				6				0.1795
				8				0.1393
0.5	0.72	1.2	0.10	2	1.0	0.22	0.01	0.3056
					1.5			0.3365
					2.0			0.3637
					2.5			0.3881
0.5	0.71	1.2	0.10	1	1.5	0.22	0.1	0.2882
						0.32		0.2738
						0.42		0.2586
						0.52		0.2424
0.5	0.72	1	0.10	2	1.0	0.22	0.01	0.2958
							0.04	0.2789
							0.08	0.2551
							0.10	0.2427

Table 3: Numerical values of mass transfer in terms of Sherwood number (Sh)

γ	Pr	Gr	N	M	Gm	Sc	Q	Sh
0.5	0.71	1.0	1.2	1.0	1.5	0.22	0.01	0.2828
1.0								0.2881
1.5								0.2923
2.0								0.2956
0.5	0.71	1.0	1.2	1.2	1.5	0.22	0.01	0.2747
	1.0							0.2618
	3.0							0.2046
	5.0							0.1804
0.5	0.72	1	0.10	2	1.2	0.32	0.01	0.2616
		3						0.3148
		5						0.3513
		7						0.3798
0.5	0.71	1.0	0.1	1.2	1.5	0.2	0.01	0.2338
			1.0					0.2591
			2.0					0.2691
			3.0					0.2729
0.5	0.72	1.0	0.10	2	2.0	0.21	0.1	0.2394
				4				0.2083
				6				0.1893
				8				0.1762
0.5	0.72	1.2	0.10	2	1.0	0.22	0.01	0.2137
					1.5			0.2289
					2.0			0.2422
					2.5			0.2542
0.5	0.71	1.2	0.10	1	1.5	0.22	0.1	0.2368
						0.32		0.2907
						0.42		0.3392
						0.52		0.3821
0.5	0.72	1	0.10	2	1.0	0.22	0.01	0.2089
							0.04	0.2115
							0.08	0.2151
							0.10	0.2170

Similarly, numerical values on the effects of the prescribed parameters on Sherwood number Sh are shown in table 3. It was observed that rate of mass transfer coefficient increases with increasing values of γ, M and Pr but decreases as Gr, Gm, N, Sc and Q increases in values.

SUMMARY AND CONCLUSION

The problem on thermo-physical effects of thermal radiation and heat generation on free convective heat and mass transfer over a vertical plate is considered. The governing partial differential equations of the problem, using similarity transformations, were reduced to coupled nonlinear ordinary differential equations and solved numerically using Runge-Kutta fourth order method with shooting technique. The effects of local magnetic parameter, Prandtl number, local thermal Grashof number, modified local thermal Grashof number, heat generation parameter, variable thermal conductivity, Schmidt number and radiation parameter on velocity, temperature and concentration profiles are presented. From the results, the following conclusions are drawn:

i). The skin friction and Nusselt number increase with increasing values of γ, N, and Q, but decreases in Sherwood number. An increase in Pr, M and Sc cause an increase in Nusselt number and Sherwood number and decreases in the skin

friction. Similarly, Sherwood and Nusselt number decreases with increasing values of Gm and Gr but increases in the skin friction.

ii). The velocity boundary layer thickness decreases with γ, N, M, Sc

iii). The thermal boundary layer thickness increases with γ, N, M, Sc, Q and decreases with Pr, Gr, Gm

iv). The species concentration decreases with γ, Gr, N, Gm, Sc, Q but decreases with increasing values in Pr, M.

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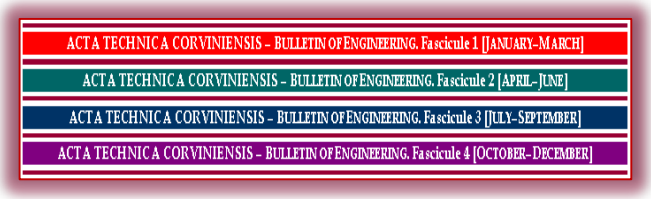

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