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# ACTA TECHNICA CORVINIENSIS – BULLETIN of ENGINEERING

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## INDEXES & DATABASES

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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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## AIMS, MISSION & SCOPE

### General Aims

**ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** has been published since 2008, as an online supplement of the **ANNALS OF FACULTY ENGINEERING HUNEDOARA – International Journal Of Engineering**. Now, the **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** is a free-access, online, international and multidisciplinary publication of the Faculty of Engineering Hunedoara. **ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING** exchange similar publications with similar institutions of our country and from abroad.

**ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** is an international and interdisciplinary journal which reports on scientific and technical contributions. 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 areas of engineering. 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. Topical reviews in materials science and engineering, each including:

- ✓ surveys of work accomplished to date
- ✓ current trends in research and applications
- ✓ future prospects.

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- ✓ Scientific Papers – concise, high impact original theoretical articles,
- ✓ Perspectives – commissioned commentaries highlighting the impact and wider implications of research appearing in the journal.

**ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** encourages the submission of comments on papers published particularly in our journal. The journal publishes articles focused on topics of current interest within the scope of the journal and coordinated by invited guest editors. Interested authors are invited to contact one of the Editors for further details.

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We strongly believe that the open access model will spur research across the world especially as researchers gain unrestricted access to high quality research articles. Being an Open Access Publisher, Academic Journals does not receive payment for subscription as the journals are freely accessible over the internet.

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- ✓ Metallurgical Engineering
- ✓ Agricultural Engineering
- ✓ Control Engineering
- ✓ Electrical Engineering
- ✓ Civil Engineering
- ✓ Biomedical Engineering
- ✓ Transport Engineering
- ✓ Nanoengineering

#### CHEMISTRY

- ✓ General Chemistry
- ✓ Analytical Chemistry
- ✓ Inorganic Chemistry
- ✓ Materials Science & Metallography
- ✓ Polymer Chemistry
- ✓ Spectroscopy
- ✓ Thermo-chemistry

#### ECONOMICS

- ✓ Agricultural Economics
- ✓ Development Economics
- ✓ Environmental Economics
- ✓ Industrial Organization
- ✓ Mathematical Economics
- ✓ Monetary Economics
- ✓ Resource Economics
- ✓ Transport Economics
- ✓ General Management
- ✓ Managerial Economics
- ✓ Logistics

#### AGRICULTURE

- ✓ Agricultural & Biological Engineering
- ✓ Food Science & Engineering
- ✓ Horticulture

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- ✓ Computer Science
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#### EARTH SCIENCES

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- ✓ Geology
- ✓ Hydrology
- ✓ Seismology
- ✓ Soil science

#### ENVIRONMENTAL

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- ✓ Environmental Science & Ecology
- ✓ Environmental Soil Science
- ✓ Environmental Health

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- ✓ Biotechnology
- ✓ Biomaterials

#### MATHEMATICS

- ✓ Applied mathematics
- ✓ Modeling & Optimization
- ✓ Foundations & methods

### Invitation

We are looking forward to a fruitful collaboration and we welcome you to publish in our **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering**. You are invited to contribute review or research papers as well as opinion in the fields of science and technology including engineering. We accept contributions (full papers) in the fields of applied sciences and technology including all branches of engineering and management.

**ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering** publishes invited review papers covering the full spectrum of engineering and management. The reviews, both experimental and theoretical, provide general background information as well as a critical assessment on topics in a state of flux. We are primarily interested in those contributions which bring new insights, and papers will be selected on the basis of the importance of the new knowledge they provide.

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**Keywords:** gear, gearbox, micro pitting, pitting, scoring, scuffing

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**Keywords:** safety and health of work, protective measures

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**Keywords:** Multimedia learning, Multimedia presentation, Multimedia design, Multimedia example in mathematics, Engineering education

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**Keywords:** avalanches, chronology, avalanche patch, susceptibility, pioneer species, progression dynamics

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**Keywords:** stirling engines, clean energy industry, energy conversion

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**Keywords:** Reverse Logistics, Green Logistics, Supply Chain, Sustainability

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**Keywords:** Fibre orientation, Composites, Numeric simulation, Finite element analysis, Stereology

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**Keywords:** optically thin gray gas; Hartmann number; porous media; heat transport; unsteady boundary layer flow

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**Keywords:** Quenching, Polyethylene Glycol, Impact Energy

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**Keywords:** Energy consumption, Open source, Closed source, Building automation

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**Keywords:** Expansive Soil, Lime Stabilization, Red Mud, Egg Shell Ash, Early Strength

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**Keywords:** data privacy, regulation, European Union, the USA, trans-Atlantic relationship

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**Keywords:** e-governance, trends, service, administration, data, registers

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**Keywords:** panel heating; floor-ceiling heating; heat flux; experimental

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**Keywords:** cooling tower, climatic curves, wet-bulb temperature

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**Keywords:** perforated plate, pressure drop, heat transfer

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**Abstract:** Energy harvesting is rapidly expanding into new applications. The idea of micro-scale energy harvesting, and collecting miniscule amounts of ambient energy to power electronic systems, was still visionary and limited to research proposals and laboratory experiments. Ultra-low-power technology is enabling a wide range of new applications that harvest ambient energy in very small amounts and need little or no maintenance-self-sustaining devices that are capable of perpetual or nearly perpetual operation. An increasing number of systems are appearing that take advantage of light, vibrations and other forms of previously wasted environmental energy for applications where providing line power or maintaining batteries is inconvenient. The following article will discuss several technical challenges and show how ultra-low power technology is playing a key role in overcoming them.

**Keywords:** energy harvesting, ultra-low, power, ultra-low power, technology, ultra-low power technology

22. **Mila MIHAJLOVIĆ, Vanja ŠUŠTERŠIĆ, Gordana BOGDANOVIĆ – SERBIA**

**LEED TECHNOLOGY IN URBAN PLANNING**

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**Abstract:** Urban planning is a set of measures, guidelines and suggestions for improvement and unification of economic, social and sustainable development of certain areas. Planning in the modern era, accompanied by a number of bad consequences, has led to a steady rise in consumption of natural resources used to build traffic and utility infrastructure and expansion of settlements. Insufficient care of human race for environment and ecosystems caused the emergence of large-scale climate change and global warming. LEED (Leadership in Energy and Environmental Design) in urban planning represents a new approach to planning, which enables the use of renewable energy sources. The main goal of LEED technology is the protection and improvement of the environment, through the creation of modern and energy-independent urban space. In this paper, using the methods of description and comparison, as well as case studies of some examples, the possibilities offered by green building will be shown.

**Keywords:** Urban planning, LEED technology, environmental protection, renewable energy sources

23. **Cristian BÂRZ – ROMANIA**  
**Tihomir LATINOVIC – BOSNIA & HERZEGOVINA**  
**Sorin Ioan DEACONU, Adina POP-VĂDEAN, Adela BERDIE, Paul Petrică POP – ROMANIA**  
**REMOTE CONTROL OF A ROBOTIC ARM USING THE OPERATOR PANEL**

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**Abstract:** This paper presents the adopted solution for remote control via Ethernet of a robotic arm controlled by a Siemens PLC. PLC control interface is designed with a touch screen Weintek. This HMI control the local PLC, entering the coordinate on the axes X, Y and Z. The HMI command so the stepper motors which actions on the axis of the robotic arm. This presents the Ethernet interface to be controlled remotely. With authentication (user and password) you can interference on the displacement path of robotic arm. Subject allows the development in a virtual environment for e-learning and monitoring of actions (webcam).

**Keywords:** PLC, robotic control, HMI, remote control

24. **Miloš SIMONOVIĆ, Vlastimir NIKOLIĆ, Ivan ĆIRIĆ, Emina PETROVIĆ – SERBIA**  
**RECURRENT NEURAL NETWORK SHORT-TERM PREDICTION OF DISTRICT HEATING SYSTEM IN TRANSIENT REGIMES**

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**Abstract:** District heating companies have growing and significant need for improving economic and energy efficiency. Also, they have a challenge to keep the cost of produced and delivered heating energy as lower as possible. That is why it is very important to optimize production of heating energy using better prediction and control of customer needs. In this paper, the focus is on short-term prediction. Real historical data are used from city of Nis, south-eastern Serbia, heating plant Krivi vir, 128 MW installed power. This prediction is particularly important for heating in transient regimes which unlike the standard heating regime does not have continuous supply of heating energy throughout the specified heating time period. An application of neural networks is realized based on original historical data of heating source by using recurrent neural network to fulfill demands on variation in ambient temperature during a heating day and satisfied results are obtained.

**Keywords:** district heating system, recurrent neural network, short-term prediction, energy efficiency

25. **Sorina SERBAN, Teodor HEPUT, Imre KISS – ROMANIA**  
**THE Datafit ANALYSIS OF SMALL AND POWDERY FERROUS WASTES DESTINED FOR THE PRODUCTION OF BRIQUETTES IN SOME LABORATORY EXPERIMENTS**

137

**Abstract:** From steel industry activities derive a wide range of wastes, that can be categorized as recyclable wastes (ferrous and nonferrous wastes) and storable wastes, as well (slag, sludge, tar, oils). On the platform of a steel mill virtually all sectors contribute to the pollution of at least one environmental factor. Most frequent, ferrous scrap results from the steel industry while processing iron and steel. Reintroduction into the economic circulation of products of small and powdery ferrous wastes (fine and pulverous ferrous wastes) lead to reduction of water/air/soil pollution levels. Every tone of ferrous waste recovered and returned to steel production circuit leads to an economy of investments and operating costs. The paper approaches the problem of fine and pulverous wastes recovery from mining and steel industry. In fact, our research carried out shows that wastes can be used to produce briquettes.

**Keywords:** pollution, environment, steel industry, usage, wastes, briquetting, the Datafit analysis

26. **Dominika PALAŠČÁKOVÁ – SLOVAKIA**  
**ANALYSIS AND REQUIREMENTS FOR FLEXIBLE MANUFACTURING ENTERPRISE**

143

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**Keywords:** CIM-OSA, JIT, CIB, CIM, HIM

27. **Sunday ARIBO – NIGERIA**  
**PITTING TEMPERATURE OF DUPLEX STAINLESS STEELS IN OILFIELD ENVIRONMENTS**

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**Abstract:** The critical pitting temperatures of some selected duplex stainless steels have been determined. Potentiostatic polarisation was conducted for all the alloys in aerated and CO<sub>2</sub>-saturated oilfield brine. A constant potential of 250 mV versus Ag/AgCl was applied and the temperature of the solution was ramped at 1oC/second. The critical pitting temperature was determined as the temperature at which the current densities of the alloys exceeded 100 µA/cm<sup>2</sup>. Results showed that the critical pitting temperature was lower for the alloys in the CO<sub>2</sub>-saturated oilfield brine compared with the aerated environment. Also, the pitting resistance equivalent number did not seem to determine the resistance of the lean duplex stainless steels as UNS S32101 and UNS S32304 with equivalent PREN exhibited different pitting temperatures.

**Keywords:** Pitting, oilfield brine, stainless steels, PREN



- 28. M.K. NAYAK, G.C. DASH – INDIA**  
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- Keywords:** Hiemenz magnetic flow; Porous medium; DTM; Finite difference; Quasilinearization
- 29. Sorina SERBAN, Teodor HEPUT, Imre KISS – ROMANIA**  
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- Keywords:** pollution, environment, steel industry, usage, wastes, briquetting, Matlab analysis
- 30. C. A. FAPOHUNDA, K. A. SHITTU, S. O. ADEROJU, A. Y. AKINSANYA – NIGERIA**  
**STRENGTH CHARACTERISTICS OF CONCRETE HAVING CRUSHED BONE AS PARTIAL REPLACEMENT OF FINE AGGREGATES AT DIFFERENT WATER-CEMENT RATIOS** **163**
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- Keywords:** Concrete, Fine Aggregate, Crushed Cow Bone, Water-Cement Ratio, Compressive Strength
- \*\*\* MANUSCRIPT PREPARATION – GENERAL GUIDELINES** **171**

The ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Tome IX/2016, Fascicule 1 [January–March/2016] includes scientific papers presented in the sections of:

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4. Slobodan STOJADINOVIĆ, 5. Zoran KARASTOJKOVIĆ

## STUDY OF THE POSSIBILITY OF APPLYING ALLOYED FLUX-CORED WIRE FOR PRODUCTION OF CORES FOR COATED ELECTRODES

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**Abstract:** The main objective of the paper is to explore the technological possibilities of making improved quality coated electrodes with alloyed flux-cored wire cores. Using experimental equipment at the Research Center IHIS alloyed flux-cored wire was produced with optimal thickness of the metal sheath, internal label IHIS E 35 R-3  $\varnothing$  3.25mm in diameter from which the core of the new rutile coated electrode was made. The paper presents the test results of the chemical composition and microstructure of the weld metal made with the new electrode. The test results of the chemical composition and structure of weld metal made with the produced electrode indicate the justifiability of further research towards the development of new coated electrodes with a core of alloyed flux-cored wire.

**Keywords:** coated electrode, alloyed flux-cored wire, weld metal structure

### INTRODUCTION

Development and mastering of rutile electrodes with a core of alloyed flux-cored wire for manual metal arc welding and surfacing is a complex research process, which involves defining the chemical composition of the coating and the flux-cored wires [1-3]. The rutile electrode coating (internal marking IHIS E 35 R-3) is mainly composed of rutile  $TiO_2$  containing more than 50% and the rest of the components are: marble, granite, kaolin, FeMn, mica, feldspar, talc,  $CaF_2$ , magnesite and Lucel. Introduced into the composition of the coating are ingredients which protect the weld pool and weld metal from the influence of atmospheric gases, create slag, eliminate or restrict the content of oxygen and nitrogen, increase meltability and stabilize the arc [4-7]. When making a coated electrode the coating is applied continuously to the cores using a suitable technological process. The cores are made of alloyed flux-cored wire, 350 mm in length and  $\varnothing$ 3.25mm in diameter with a medium thick coating. Produced rutile electrodes are intended for manual metal arc welding (MMAW) and surfacing with a coated electrode for low alloyed steels, alloyed

structural steels, heat resistant steels and high alloyed steels with special properties. At the stage of development and mastering technology for production of coated rutile electrodes of improved quality with cores of alloyed flux-cored wire, and to economize, for experimental welding and testing of weld metal microstructure, steel plates of low carbon alloyed steel thickness of 10 mm were selected.

The microstructure of weld metal made with a rutile electrode depends on many factors such as: composition of the coating and core of the electrode, cooling rate, heat input during welding, etc. [8,9].

This paper presents the results of examination of chemical composition and microstructure of weld metal, which should contribute to defining a new quality of special rutile electrodes with a core of flux-cored wire in terms of operational and welding properties.

The results showed that a rutile electrode with a core of alloyed flux-cored wire, produced with domestic raw materials, improves the formation of a homogeneous structure of weld metal in welded joints.



**MATERIALS AND EXPERIMENTAL DETAILS**

Production of rutile electrodes with a core of alloyed flux-cored wire with local raw materials was carried out on experimental equipment in the Research Center IHIS. For the core of the rutile electrodes selected and produced were alloyed flux-cored wires of designed quality for welding and surfacing low alloyed steel, alloyed structural steel and high alloyed steels with special properties.

The experimental part includes welding a sample of low-carbon non-alloyed steel, 10 mm thick using a produced medium coated rutile electrode (in-house marking IHIS E 35 R-3). Determining the quality of the rutile electrode was done based on the results of testing the chemical composition of pure weld metal using spectrochemical analysis and the OES method on the ARL 2460 and the results of microstructure tests. Examination of the microstructure of the base metal and analysis of micro-constituents present in the weld metal was done on a scanning electron microscope (SEM).

**RESULTS AND DISCUSSION**

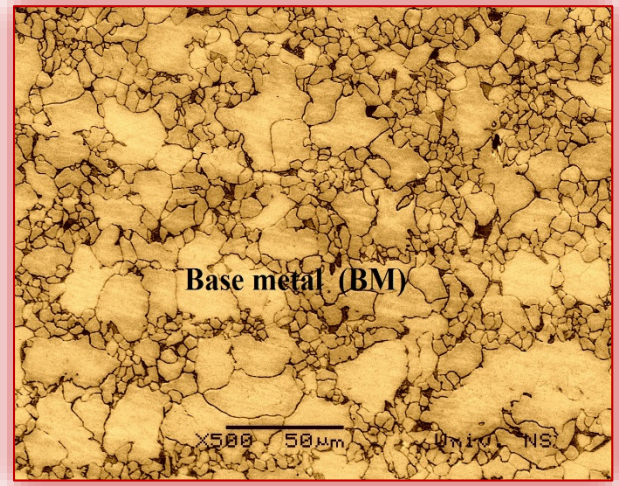
Table 1 shows the chemical composition of pure weld metal of a sample welded using a rutile electrode with a core of alloyed flux-cored wire. Examination of the composition of the weld metal was conducted to link the influence of Ni and Mo, from the core of the flux-cored wire with rutile coating, on the microstructure of the weld metal of the welded joint. Metallographic tests of the weld metal of welded joints showed that the chemical analysis of the weld metal (WM) is directly related to the microstructure.

**Table 1.** Chemical composition of the pure weld metal

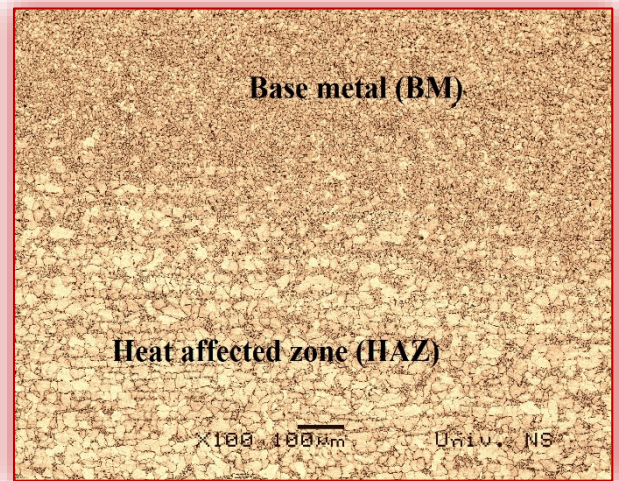
Chemical composition, wt.%				
C	Si	Mn	Cu	Al
0.023	0.539	0.97	0.092	< 0.003
Cr	Mo	Ni	Ti	Nb
0.025	0.32	3.284	0.012	<0.003

Nickel and molybdenum from the core of the electrode made of alloyed flux-cored wire favored forming of a large share of acicular ferrite (AF) in the weld metal, they lowered the share of proeutectoid ferrite (PF) and completely removed upper bainite [10] and this was confirmed by metallographic analysis of the weld metal.

Figure 1a shows the microstructure of the base metal (BM) of 10 mm thick low carbon non-alloyed steel tested on the SEM. The microstructure of the non-alloyed steel is homogeneous and ferritic with a small portion of pearlite. Figure 1b shows the microstructure of the transition zone between the base metal (BM) and the heat affected zone (HAZ). On the SEM micrographs in the heat affected zone (HAZ) an increase in ferrite grains is visible.



a)



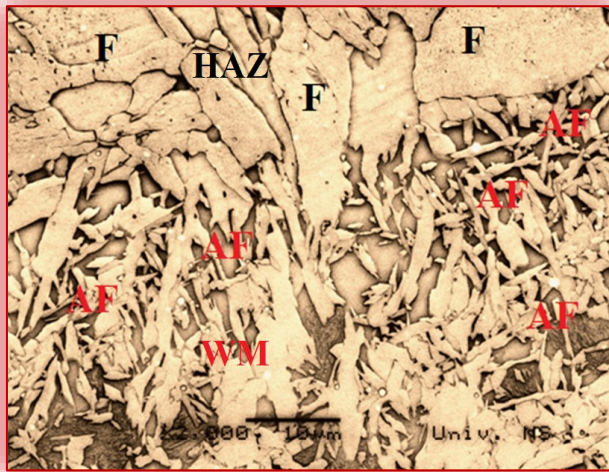
b)

**Figure 1.** SEM microstructure: a) base metal (BM), 500x; b) transition zone (BM) and (HAZ), 100x.

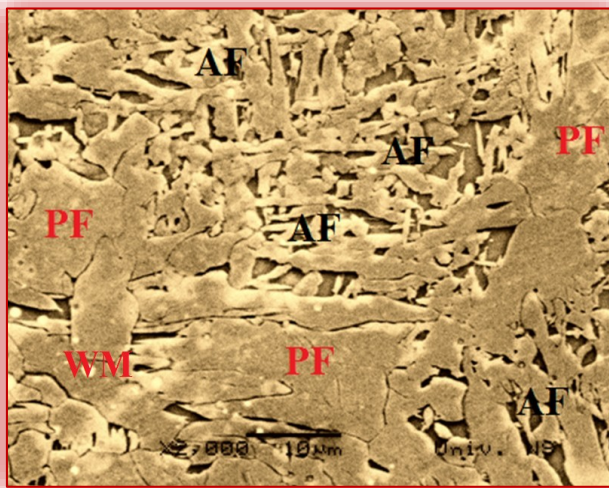
Figure 2a shows scanning electron micrographs (SEM) of the fusion line between the heat affected zone (HAZ) and weld metal (WM). The fusion line separates the coarse grain ferrite structure of the heat affected zone (HAZ) and the fine-grained structure of the weld metal (WM). The structure of the weld metal consists of austenite grains with formed acicular ferrite (AF) within the austenite grains.

Acicular ferrite is a type of ferrite characterized by a three-dimensional lenticular shape. At certain points along the boundaries of the acicular ferrite (AF) non-metallic spherical inclusions, from the rutile coating, can be seen. These inclusions serve as nucleation centers for acicular ferrite (AF) crystallization [11]. This microstructure has an advantage over other microstructures, because it increases the toughness of the weld metal of welded joints.





a)



b)

**Figure 2.** SEM microstructure: a) transition zone between (HAZ) and weld metal (WM), 2000x; b) weld metal (WM), 2000x

Figure 2b shows scanning electron micrographs (SEM) of the microstructure of pure weld metal. Austenite grains are present in the weld metal; along their boundaries proeutectoid and polygonal ferrite (PF) are present. These types of ferrite are formed as primary phases along grain boundaries during cooling of austenite. Ni and Mo from the core of the alloyed flux-cored wire during cooling of the weld metal reduced the share proeutectoid and polygonal ferrite (PF) and thus increased the share of acicular ferrite (AF). In the austenitic crystal grains there were no observed secondary phases such as routed secondary phase ferrite (FS) and Widmanstatten ferrite which reduce the toughness of the weld metal (WM) of the welded joint. The microstructure of the weld metal of the welded joint is in full compliance with the chemical analysis of the weld metal.

## CONCLUSIONS

Based on the chemical and microstructural analysis of the weld metal of welded joints made with a medium coated rutile electrode with a core of alloyed flux-cored wire marked IHIS E 35 R-3 Ø 3.25mm in diameter, the following conclusions can be made:

- » Welding properties of mastered rutile electrodes relating to arc stability, uniformity of slag coverage of metal, splatter of molten material and porosity of the surface of the weld metal showed satisfactory quality.
- » Micro-alloying elements Ni and Mo from the core of the alloyed flux-cored wire and non-metallic inclusions from the rutile coating influenced forming of a large share of acicular ferrite (AF) in the weld metal (WM) of welded joints, which indicates high weld metal toughness and uniform distribution of Ni and Mo in the rutile electrode.
- » The rutile type electrodes, produced using domestic raw materials with a core of flux-cored wire, created a homogeneous structure of the weld metal and the planned chemical composition.

The results of examination of the weld metal justified further development and application of alloyed flux-cored wire for production of the core of coated rutile electrodes based on local raw materials.

## Acknowledgements

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## Note

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## GEAR FAILURES EMBEDDED IN MANUAL GEARBOXES

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**Abstract:** During exploitation motor vehicle gearboxes are exposed to varying conditions. The changes are stochastic and dependent on many factors. These changes directly affect also to the gearboxes damage, and therefore the gears damage. Different types of damage can occur on gears, so that this paper will give focus on the damage on gears. According to DIN 3979 over 20 types of damage appearing on gear are given, while in this paper only damages on gears that are in gearboxes embedded will be presented. The paper contains the results of the damage percentage of manual gearboxes and the results of cumulative damage of manual six-speed gearboxes.

**Keywords:** gear, gearbox, micro pitting, pitting, scoring, scuffing

### INTRODUCTION

During operation of the gearbox, gears occupy a very important place. Defects and damages during the work of gearbox occur on the gears, so diagnosing of failures shows that the received signal is efficient and suitable for early detection of local failures of gearboxes [1]. In [1] monitoring and diagnostics of industrial gearbox was carried out. According to the lowest spectrum that is based on the current frequency spectrum, new parameter was developed. The parameter for estimation of the gearbox damage, on the basis of real measured signals, has been proved as insensitive to variations due to changes caused by various speeds and loads.

During operation of gearboxes, gear tooth flanks are exposed to the contact pressures, and therefore the combination of rolling and sliding [2]. This kind of load can cause a specific type of fatigue that is called rolling-sliding contact fatigue [2]. In order to successfully construction and dimensioning of gear pairs, in [2, 3], the possible damaged of gear pairs due to fatigue are given, as well as the mechanisms that lead to their occurrence.

During the work of gearbox comes to damage of gears, bearings, couplings, seals, etc... The damage speed of these components are influenced by the working conditions of gear. Based on years of research the authors of [4] presents the results which indicate that all gear failures occur due to the frequency of the system startup. Summarizing the results, it was concluded that the bearings are subject of damage more than 49%, while the gear failure occurs 41%. The remaining 10% damages are related to the other components [4].

Based on the Neale Consulting Engineers Ltd (NCEL) report, mistake making gear, outdoor dirt, the input torque of the gearbox, oil and metal particles in it, bearings damages and unexpected loads of bearings have been established as primary effects which may cause the damage on the gear teeth and bearings [4]. In that report the defects when making gears were represented by 6%, which are the result of different influences which depend on machines, measuring equipment, process control and various other influences. If we specify stricter criteria in control of gear making, and thereby strictly control of subsequent processing, these errors could be minimized. However, without stringent control the percentage of errors could increase. Since the destruction of gears depend on several factors and how there are stochastic, in [5] author gives a destruction probability diagram of gears for annealed gears, where we can see that with the increasing number of changes the stress that gears can withstand is decreased. With stress decreases, which gears can with stand during operation, possibility of damage is increased. Author of [6] gives the results of gear damage due to pitting, poor lubrication and explains destruction of surface-annealed gears, while the authors of the paper [7] carry out an analysis of the impact of gear pairs with different damages and their effect on the generation of noise and vibration. In the paper [7] tests were performed on eight different gear pairs, of which on one pair was no damage, three pairs of gear were damaged by pitting, three pairs were damaged by spalling, while one pair was with a broken tooth.

During the tests it was concluded that there is no a direct proportion between the vibration generated by gears and their wear, as well as other damages caused during their operation (rotation). Contrary, wear may affect the reduction of vibration level since the gears mutually adjusted.

Investigation in [8] and [9] were performed on test benches with closed power flow and with application of standardized respectively FZG methodologies (TU Munich).

#### POTENTIAL DAMAGES THAT MAY APPEAR IN GEARBOXES

During operation of gearbox, i.e. during power transmission through the gear different types of damage may incur. During the years of testing gear power transmitters, damages at 931 gears were appeared, of which the most prominent is fracture of gears [10]. On the other side, on high-power gear drives most common damage are incurred due to overload (21.7% [11]). These are some of the indicators that the gears are exposed to stochastic changes and that should be paid great attention to the potential damage that can occur on them. Depending on the load, as well as working conditions which they are exposed, it is possible occurrence of over 20 types of defects of gears, which are given in DIN 3979<sup>th</sup>. Basically, fracture of gears in gearboxes happens very rarely, or if arise they are consequence of accidents, while damage or complete destruction of the working surfaces of gear teeth more frequently appear. Any of these defects can be formed by combining various influences, such as defects in material, residual stresses, poor production quality of the gears, poor lubrication, etc. The process of gear destruction is permanent and initially poorly expressed and it is very slow, while at the end of life circle becomes progressive. Operating conditions of gearboxes are variable, so that this process consists of different entities such as: micro pitting, pitting, spalling, abrasion, scratch and plastic injection of particles, scuffing, etc. An overview of some possible damages in gearboxes will be given below.

**Micro pitting** is a type of damage to the tooth flanks, which occurs due to high pressure and increased speed of skating. As such kind of damage occurs in the beginning of life circle of gear due to even out irregularities on the gear flanks. Micro pitting is similar to abrasive wear in the initial stages of formation and development, which creates confusion among many young engineers. Besides that, micro pitting can occur after a relatively small number of coupling (if the gears are made of a material of poor quality) or after a larger number of coupling (surface reinforced gears). Usage of inadequate sophisticated additive to enable the operation of gear in extreme conditions may indirectly contribute to the emergence of micro

pitting. The process can be identified with the naked eye as a gray color or spots on the flanks, which represents the formation of micro cracks or dimple depth up to several microns. Figure 1 shows a schematic representation of damage due to micro-pitting and Figure 2 presents the resulting micro pitting on the side of the gear. Identical damage is possible on the gear that is built into the gearbox.

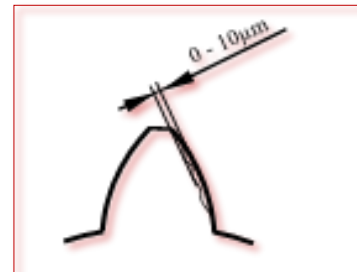


Figure 1. Micropitting

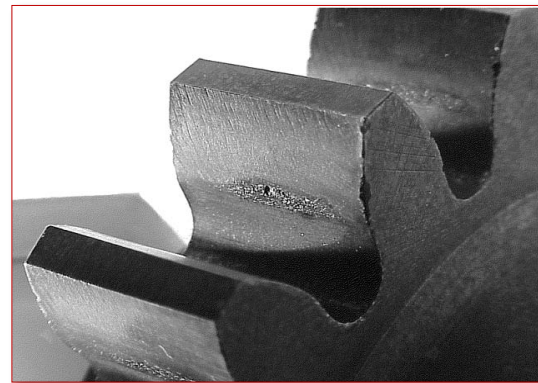


Figure 2. Micropitting[2]

**Pitting** is the type of gear failure that occurs between the sliding surfaces under high pressure. In the case of pairing gears made of various materials pitting occurs on the gear made of poorer material, whereas in the case when the gears are made of the same material pitting occurs on the gear with a smaller number of teeth. In the case of gears built into the gearbox, pitting occurs on gears with the smaller number of teeth, which are usually driven gears, that is not the case at the higher speeds where the driver gears have a higher number of teeth of the driven gears. The cracks are small at the beginning, while during the lifetime lubricant enters the cracks, causing further damage. Depending on the lubricant, according to Hertz's pressure, the maximum stress can occur below the surface layer (by poorer lubrication) or between the bumps on contact surfaces (by better lubrication) [6]. Unlike micro pitting, pitting occurs after larger number of changes ( $10^5$ ), and its appearance is not possible at the number of changes of less than  $10^4$ . A better machined surface reduces the possibility of pitting, which causes an increasing of machined surfaces quality. Increasing of the quality of lubrication and oil film thickness decreases the frictional force and the possibility of pitting.



According to ISO 10825 there are two types of pitting: initial and destructive pitting. The cause of the initial pitting can be attributed to the accuracy of making gear pair or poorer quality of the machined surfaces of gear. The destructive pitting can occur due to the development of micro cracks under certain overloads, while it can also appear as a growth of damages of initial pitting. Figure 3 shows a schematic representation of damage due to pitting.

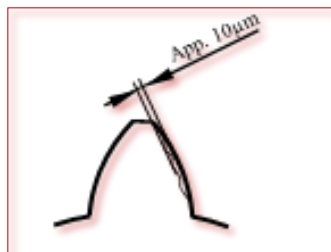


Figure 3. Gear pitting failures

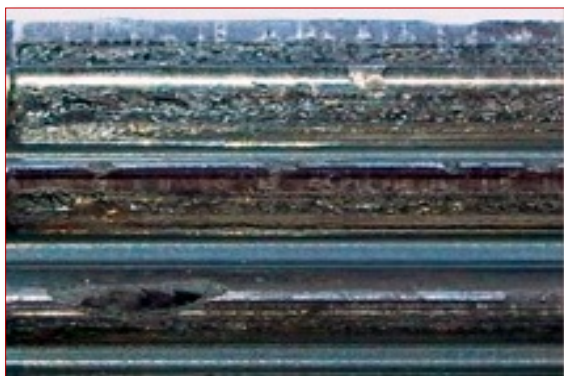


Figure 4. Gear pitting failures [12]

**Spalling** is another form of failure of hardened gear tooth flanks. It is characterized by appearing as a brittle fracture. Spalling is characterized by the appearance of cavities of several tens of microns to 0.2 mm (Figure 5) i.e. from 0.25-0.35 to the half of length of the contact line on gears flank [13].

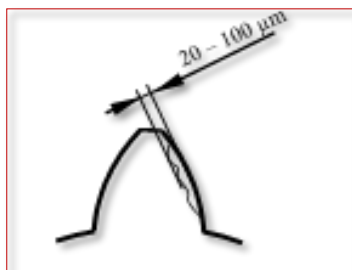


Figure 5. Spalling

Basically, spalling is similar to destructive pitting, with the difference that the damages are higher. In this type of gear failure cracks are initially wider under the surface of the gear (parallel to the surface), so that at one time, due to the increased surface pressure, changes their direction to the surface layer, bursting material particles in the form of flakes leaving the form of brittle fracture. Usually from the gear surface strengthening depend the size

of torn particles. In the case of surface hardened gear flanks, separation of larger pieces of the gear surface layer is occurred, whereby the bottom of the fracture is usually between hardened and unhardened layer. On gear damages caused by spalling, the characteristic sharp edges along the surface can be noticed. Initial cracks are small, and when the number of such particles accumulating in one place creates larger cracks. Figure 6 presents the damage due spalling on the gear flank.

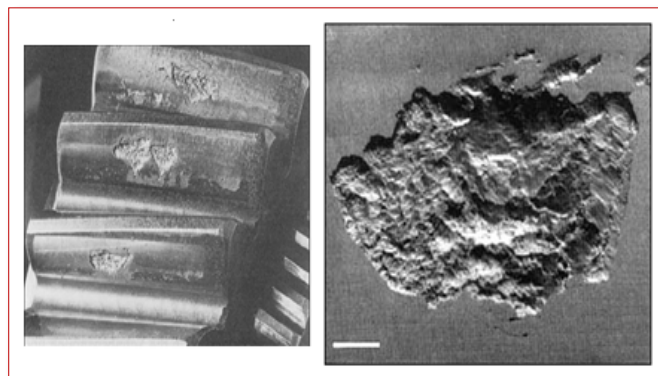


Figure 6. Spalling [14]

**Scuffing** is a type of gear failure, which is manifesting by large number of longitudinal damages in the form of furrows in the direction of sliding (figure 7). The position of furrows depends on the contact surfaces (Figure 8).



Figure 7. Gear scuffing failures [12]

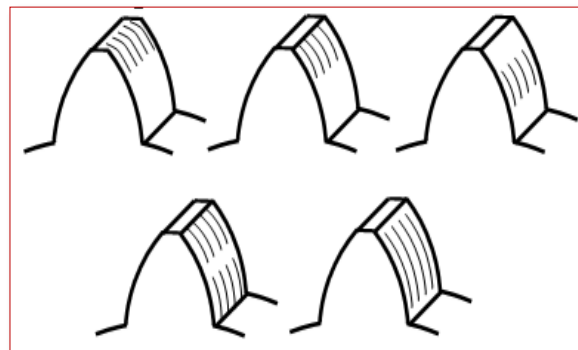


Figure 8. The position of furrows due to scuffing damage

The cause of this type of damage is interruption of oil film between the contact surfaces of the gear flanks caused by overload or high sliding speeds.



Due to the interruption of the oil film, comes to direct contact between gear flanks, whereby the contact surfaces are heated because of the increasing of friction. This heating causes connection (welding) contact surfaces of gear flanks. Further operating of gear causes the violent separation and tearing of the surface layers. Surfaces remain welded to the gear flanks and damage each subsequent surface of gear flanks that it is paired.

There are basically two types of scuffing: cold and hot scuffing. Cold scuffing occurs at low speed of sliding between the materials of lower quality, while hot scuffing occurs at a much higher speeds of sliding and surface pressures by heat-treated surfaces.

**Breakage of gear.** During operation of the gear, occurrence of fatal damage is possible, such as breakage of gears. This damage occurs very rarely in gearboxes. The cause of such damage is the occurrence of initial cracks that occurs in the weakest areas, where there is a high concentration of stress and bending stress. The damage extends over the entire surface of the tooth root, causing breakage that can be violent or fatigue.

Fatigue fractures are due to impact loads, causing a stress at the base of the gear teeth, which is larger than the static strength and are characterized by the fact that the refractive surfaces are coarse-grained structure. A fatigue fractures occurs as a result of action of dynamic loads in the tooth root and they are higher than permanent dynamic strength. Such damages are characterized by two zones of fractures, zone of fine-grained structure that arises due to the fatigue and the zone of coarse grain structure due to complete destruction. By the shape and structure of the breakage, it can be concluded which case of breakage was come. Gear teeth breakage is rare in gearboxes, but when it occur its cause of fatigue loads. This kind of breakage occurs mostly on gears which are build gearboxes of vehicles that drive over rough terrain, as a result of stochastic changes. According to available literature, there is no evidence that was coming to the violent breakages at the gearboxes.

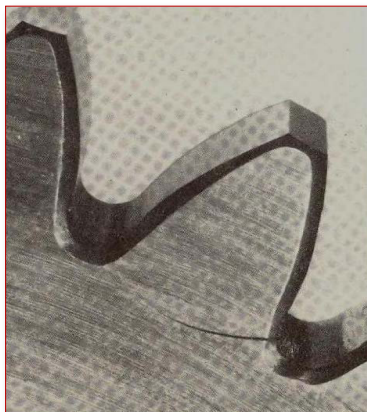


Figure 9. Crack of tooth root [14]



Figure 10. Breakage of more gearteeth [15]

One example of a crack in the root of the tooth is shown in figure 9, while figure 10 shown breakage of more gear teeth caused by a high-cyclic fatigue. During the work of gearbox comes to rapid changes of loads that directly act on the gears. Load changes influence directly the expansion of initial cracks, and thereby to gear breakage.

#### ANALYSIS OF GEARBOX DAMAGES

During operation of the gearboxes in the exploitation in different conditions, most of the components are exposed to changeable loads. Changes in working conditions, and thus changes of stress and the parameters of operating conditions can be constant or stochastic. Besides, conditions of use of same type gearboxes can be different. All of that directly affects to the damage of components, which may be different. According to statistics, 80% of cases of mechanical damage occurring due to fatigue.

Based on years of monitoring of the occurrence of damage at the gearboxes, obtained results are: 60% of damage occurs on the gears, while 20% damage occurs in bearings and 20% to other components .

Interview method with long-term users and maintainers of gearboxes was used for the data acquisition. The average age of the maintainers of freight motor vehicles was 32 years and 4 months. Most of the respondents had a full years of service in the maintenance freight vehicles. On the basis of this experience, it can be considered that their answers are very reliable.

According to the results, it did not coming to significant damages at the gearboxes before freight motor vehicle has done 300.000 km, and failures that have occurred was mainly on the synchro coupling. Some of the failures that have emerged are falling out one ball from synchro coupling, which causing the jamming of the system of speed change. Only after 500.000 km significant failures on the gearboxes were emerged and become more and more common, as confirmed by 28% of respondents. The damages has been appeared in the inner bearing and synchro coupling, but also occasionally traces damage by wear have emerged at gear pair.

Significant damages of the gears which are embedded in manual gearboxes emerged after 900.000 km. Respondents maintained manual and automatic gearboxes. In this paper only the analysis of manual gearboxes are included. Figure 11 shows the percentage of failures for different types of manual gearbox. The largest number of defects was emerging at the five-speed gearboxes. In addition to damage to the gears, failures on the sealing seams and synchro coupling were occurring.

Damage to gear pairs is generally created after driving 300.000 km and more. These damages are more balanced by freight motor vehicles which are driven across different terrains, while by freight motor vehicles, which are driven across mountainous terrains, damages appeared to lower gearbox speeds. In the case of vehicle driving only across lowland terrains, damages were created to higher gearbox speeds. Figure 12 shows the diagram of gear pairs damages for each respective speed of six-speed gearbox, for freight motor vehicles which were driven across different terrains.

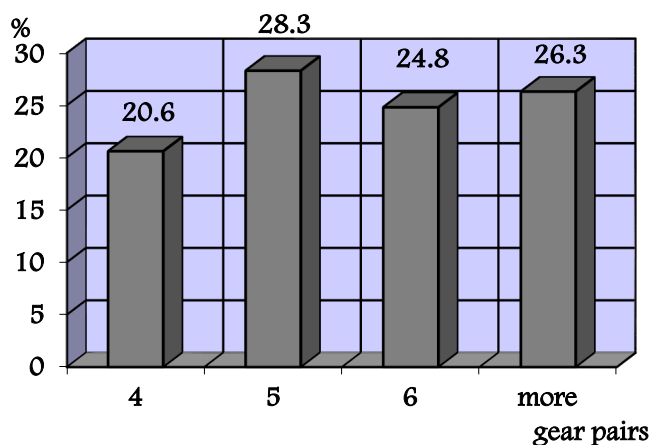


Figure 11. The percentage of failures for different types of manual gearbox

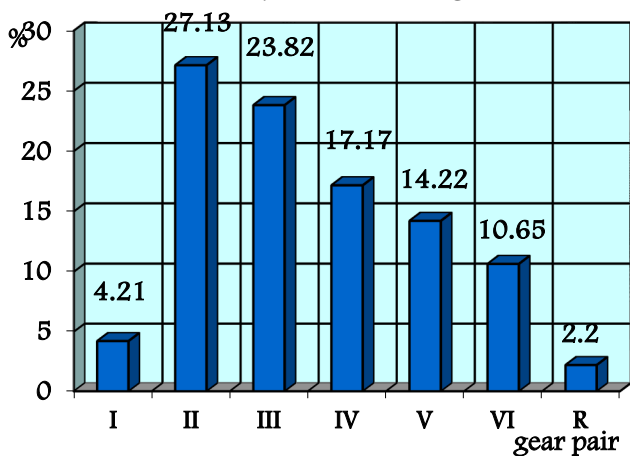


Figure 12. Diagram of gear pairs damages for each respective speed of six-speed gearbox  
During the disassembly of each gearbox, verification of all elements was carried out and the possible damages were determined. Types of damages have

depended on many factors on which generally affect the operating conditions.

### CONCLUSION

During operation of the motor vehicle gearbox transmissions are subjected to stochastic changes that depend on a number of factors, which directly affect the damages of gearbox, and thereby the gears. There are several types of gear failure, and in this paper are described only damages caused at gearboxes. This paper reviews the results of the percentage damages of gears built in six-speed gearbox. The results are based on empirical data, as well as on information obtained by the maintainers of motor vehicle in which these types of gearboxes were incorporated.

### Note

This paper is based on the paper presented at The Vth International Conference Industrial Engineering and Environmental Protection 2015 – IIZS 2015, University of Novi Sad, Technical Faculty „Mihajlo Pupin”, Zrenjanin, SERBIA, October 15-16th, 2015, referred here as[16].

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3. Tale GERAMITCIOSKI, 3. Vladimir MIJAKOVSKI

## SOME EXPERIENCES OF SAFETY AND HEALTH OF WORK DURING THE MODERNIZATION OF TPP REK BITOLA

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**Abstract:** In this paper the critical activities for health and safety at work during working operations for assembly/disassembly of parts under pressure were detected. After that protective measures during loading, unloading and transportation of elements at height and protective measures during working at height were discussed. Thermal power plant (TPP) Bitola is the largest electricity producer in the Republic of Macedonia with installed capacity of 3x225 MW, which provides 80 % of the total energy production in the Republic of Macedonia, with average annual production 4.200 GWh. Rehabilitation and performance improvement for TPP Bitola are provided to modernization and revitalization of turbines, generators and automation, revitalization and modernization of the boilers with NOx emissions reduction and revitalization of cooling towers, and revitalization for SOx, dust and particle emission reduction. Taking this into account in this paper some safety measures at work during the execution of assembly and disassembly works of parts under pressure, boiler casing and assembly of pipeline components with air under pressure were discussed.

**Keywords:** safety and health of work, protective measures

### INTRODUCTION

Thermal power plant (TPP) 'Bitola' is the largest electricity producer in the Republic of Macedonia with installed capacity of 3x225 MW. TPP 'Bitola' provides 80 % of the total energy production in the Republic of Macedonia, with average annual production 4.200 GWh [1]. It is a lignite fired power plant, in operation since 1982, 1984 and 1988 respectively. With the project Revitalization and Modernization of TPP Bitola which is developed in accordance to the results of the analysis performed in the study „Rehabilitation and performance improvement for TPP Bitola”, prepared by MWH-Italy and financed by EBRD [2], is provided to:

- » modernization and revitalization of turbines, generators and automation. After that operational life time of TPP Bitola shall be extended for 120.000 hours, increased of coefficient of utilization, increased of power capacity for additional 8.32 MW per unit or 24.96 MW for TPP,
  - » revitalization and modernization of the boilers with NOx emissions reduction and revitalization of cooling towers, and
  - » revitalization of TPP Bitola for SOx, dust and particle emission reduction.
- The activities of modernization of the boiler and reducing of NOx of unit 3 have been finished in 2013. From the revitalization of boilers is expected to:
- » increase the coefficient of utilization of boilers, i.e. providing production of 700 t/h super-heated steam (545°C, 140 bar), with decreased and variable coal quality;
  - » examination, determining of existing condition of heating areas, replacing the same in accordance with examination results, and at the same time, extending their life time for 120.000 hours;
  - » examination and modification of the system for preparation of coal dust, aero mixture, as well as combustion system in order to provide reduction of NOx during work with coal with variable and lower quality. After this has been accomplished NOx emissions should not be higher than 200mg/Nm<sup>3</sup> (in accordance with Directive 2001/80/EC).

The main causes for accidents of work in thermal power plant are analyzed Kumar et al., [3]. The highest number of injuries are caused by:

- » chain pulling (8.474%),
- » weight lifting (8.474%),
- » slip and trip on the operational area (8.474%),
- » struck by object (6.779%),
- » fall from height (6.779%),
- » conveyor (6.779%),
- » plate cutting (5.085%),
- » crusher house (5.085%),
- » coal mill (5.085%),
- » bucket (5.085%),
- » burn (5.085%),
- » electrical burn (5.085%),
- » stroked by object (5.085%).

Something minor injuries caused by:

- » welding (3.390%),
- » accidents by transport vehicle (3.390%),
- » electrical shock (3.390%), and
- » others.

Taking this into account in this paper some safety measures at work during the execution of assembly and disassembly works of parts under pressure, boiler casing and assembly of pipeline components with air under pressure were discussed.

#### **DETECTING THE CRITICAL ACTIVITIES FOR HEALTH & SAFETY AT WORK**

The work operations for assembly/disassembly of parts under pressure include the following activities:

- » replacement of 175 pipe bends of the economizer-1, WE 1;
- » replacement of 175 pipe bends of the economizer-2, WE 2;
- » replacement of 38 pipe bends of the shielded super heater, SSm/SSf;
- » replacement of 2 super heater packs 1, SCP
- » replacement of 2 super heater collectors 1, SCP
- » replacement of 35 pipe bends 1, SCP.

The works for disassembling parts under pressure include the following activities:

- » installation of electrical screws for vertical transportation and their attestation (validation);
- » cutting elements using grinder and torch (autogenously cutting);
- » horizontal transportation using carts or manual transportation to the location for lowering loads, vertical transportation of disassembled elements using crane or lift (pieces of lower weight).

The installation of new elements shall be performed as follows:

- » vertical transportation using electric winch or lift;

- » horizontal transportation using carts or manually to the location of installation;
- » alignment and welding of new elements for the existing pipeline or piece.

Hand cranes will be used as temporary support for securing old and new elements from falling and for better alignment.

#### **PROTECTIVE MEASURES DURING THE EXECUTION OF ASSEMBLY AND DISASSEMBLY WORKS**

##### **≡ Protective measures during loading, unloading and transportation of elements**

At construction sites like this one, where the same workspace has to be shared and there are more contractors, different activities and where the works are being executed at several levels, indoors and outdoors, at height, on stairs etc. special attention should be paid to protective measures during mechanized transportation, manual transfer, proper disposal, lifting and lowering load, carried out at stairs, ladders, platforms and ancillary and temporary supports, props, access points and passages.

When performing all activities before commencing the work, the workers are obliged to check if they have endangered the work of other workers and if it is necessary to warn them or to install a warning board, fence the area etc. For manual lifting of materials and equipment you should first check the shape and the surface of the objects to ensure that there are no sharp edges, nails etc.

When transporting load of higher length and weight and working in a group or when using auxiliary means (pads, levers etc.), only one of the experienced workers shall manage the works and give orders for simultaneous and balanced lifting.

If there are loads of different lengths, you should first load larger and heavier objects, and than the rest of the objects in order to provide for stability. When removing the load form an underlay, it is important to take into consideration the stability of the under layer and the loads should be uplifted in such a way to ensure safety and to prevent collapse of the load.

During the mechanized loading and uploading, other works shall not be near the machine except of the workers necessary for that purpose.

If the head of works didn't appoint any workers for giving signals, the load driver shall be responsible for giving signals. The signals for lifting and lowering the load of larger size and weight may be given only by the direct head of works who must be familiar with the data on the weight in order to select a proper cable and supporting elements and properly to deploy the workers.

The locations of assembly and disassembly connections, if possible, shall be secured with



receding platforms or safety nets for preventing the workers from falling.

During the lifting-lowering, transferring and removing/placing elements, it is forbidden for the workers to stand on the element, on the lifting device, the hanging tools or to stand in the dangerous zone, under the load. It is forbidden for the workers to move over the removed/placed element and in its vicinity until it has been secured against collapsing and displacement, except for the workers who perform the removal/-placement.

Directing and stabilizing the hanging object shall be performed from a safety distance, using ropes or in another indirect way. Moving the newly placed element on the support shall be performed indirectly, by using auxiliary devices, provided that the element is tied to the crane with tight accessories. The element shall be released and untied from the crane when safely placed on the support and ensured against collapsing.

The lowering and lifting procedure may not begin until:

- » a safe access has been provided to the location of removing/placing the element,
- » supports have been installed and until the tools and accessories for removing and fixing have been prepared,
- » it has been checked whether all accesses to the assembly-disassembly zone have been closed for the workers and other persons who don't participate in those works and whether in the endangered zone there are any persons present who must leave the endangered zone,
- » the workers who participate in the works have left the area and are standing at a safe distance,
- » it has been verified whether the static and mechanical characteristics of the lifting equipment and the distance between the element and the crane is in accordance with the design.

The responsible worker (signaling worker) shall give a signal for starting the lifting/lowering and transferring procedure of the element after making sure that all of the above stated requirements have been met.

Workers at height, who are installing the working platforms or workers who accept the prefabricated elements at locations where there is no possibility for installation of scaffolding for protection against falling, must have safety belts with the shortest possible connection, depending on the necessary radius of movement, to solid parts of the facility or installed constructions and their safe places.

The person fastening the load, the person giving the signals and the crane operator shall be responsible for the proper and safe transportation of the load,

because if the load hasn't been properly fastened and connected, the person giving the signals must not give any signal for moving and transporting the load. The crane operator is also not allowed to start the procedure of transporting the improperly fastened load.

When fastening the load on sharp edges, the person fastening the load shall protect the load by putting items under the load in order to prevent its deformation. It is forbidden to use damaged and unmarked ropes and tapes whose load capacity is unknown. The person fastening the load shall be responsible for selecting the recourses, tapes, ropes and cables. The person fastening the load must follow the load and warn the other workers on time that the load is approaching, and after finishing the transport, the piece shall be released, i.e. uncoupled. When using overhead cranes or any other cranes, regardless of that that was supposed to work or provide crane operator according to the contract, it is necessary to comply with the legal regulations on safety at work. The basic requirement is not to exceed the permitted load capacity, especially for cranes with variable capacity, as well as to fasten the load properly.

For fastening the load, only the specified and appropriate equipment (ropes, chains, tapes) shall be used, on which the capacity data are permanently affixed. All our tools and equipment have been delivered to the construction site, together with the expert findings (the documents are at the disposal of the head of works and the project director). An expert finding (attest or certificate) must be available for any lifting equipment (crane, electric winch puller, cable winch, crane with galvanized chains electric cable puller and other equipment with load capacity over 1 t).

The access to the crane and its operation is allowed only for the authorized person, i.e. crane operator, who is medically fit and qualified for safe work and proper crane operations.

The crane operator may not:

- » lift load of unknown weight,
- » stress the crane with heavier load than the permitted load capacity,
- » lift load with inclined ropes, lower load by swinging on location that is outside the manipulation area of the crane,
- » leaves the load hanging without having any reason for that,
- » lift load that is not free, i.e. that is placed under another load or pull out load which has been covered up or frozen in the ground,
- » transfer load over the workers and over transportation vehicles that are moving,

- » operate the crane near unprotected live overhead lines. The operation near overhead lines can be permitted if the value of the horizontal and vertical distance meets the specified values,
- » operate the crane when receiving signals from two workers at the same time, as there is only one worker authorized for giving signals,
- » before leaving the workplace, the crane operator must release the crane completely, to lift up the hook and to leave the crane at the specified location and in the specified position,
- » continue with the operation if it has noticed that some part of the crane is not working properly.

The hand cable winch shall be installed only by hanging a hook in a vertical or horizontal position. The crane shall be attached on a stable construction, and it may not be hung on the structure via steel cable or reclined on the hand winch housing. These requirements must be met due to the housing deformation, as the housing is not provided to carry load, but it serves only as protection of the hand cable winch mechanism.

The position of the bar in the housing, as well as the joints of the clamps must be always inspected. The clamps used for a longer period must be replaced, as the rope can slip under load. It is not allowed to extend the arm in order to achieve greater pulling power. The crane with galvanized chain must be properly used. When using cranes for tensioning and yielding parts of the construction, it is not allowed that the hook is attached to holes or other openings or the edge of the profile and different protrusions. For that purpose rings and ropes must be used so that the hook can properly lift the load and in order to prevent deformations.

The chains composed of steel elements must always be greased in order to prevent corrosion. It is not allowed to increase the tensile force by extending the pipe sin order to prevent overload. The electric winch must be anchored before use, namely it must be properly fixed on the surface in order to avoid shifting and tipping. The direction of the dragging rope must be taken into account and it shall be determined by using a pulley.

At the lowest position of the hook, the rope must be wrapped at least twice around the drum. When wrapping the rope, it must be checked whether the wrapping is performed uniformly in order to avoid skipping and sudden movements when lifting and lowering the load.

The electric winch must have safe breaks that have been checked before putting the device into operation, so that the load can be stopped at any height. The electrical cable for the engine of the electric winch must be inserted using clamping collars. Against electric shock a neutralization

systems is applied since the electric installation at the construction site has been neutralized as well.

When installing the pulley, the installation, i.e. its fastening at the construction, as well as the bearing capacity of the construction must be taken into consideration. The electric winch operator must be an experienced and qualified worker, appointed by the head of works.

Loading, transportation and unloading of prefabricated elements using transportation means (trucks, forklifts etc.) shall be performed by applying safety measures and regulations during the loading and unloading procedure.

When transporting the elements, the following requirements must be met:

- » during loading or unloading of the elements each vehicle must be secured against movement,
- » the group of workers who perform the loading or unloading of prefabricated elements must be managed by the responsible worker, appointed for that purpose,
- » no workers may be transported in the storage unit of the vehicle,
- » the vehicle drivers are obliged to respect all traffic signs at the construction site,
- » the transportation of large and bulk elements must be performed by securing them from falling out of the means of transportation.

The forklift operator must be a qualified person, having a certificate from an authorized institution, appointed by the authorized person at the construction site to perform the duties of a forklift operator.

The responsibilities of the forklift operator are the following:

- » before each operation, it must inspect the control mechanism, lifting mechanism, the level of oil in the engine, the water level in the radiator, filter, the bars for attaching the lifting device, greasing etc.,
- » it must not start with the operation if the rest of the workers are not standing at a proper safe distance,
- » movement on flat and solid ground,
- » moving on slopes of less than 16%, i.e. 26% (depending on the type of the forklift),
- » when the engine is on, it may not leave the forklift unattended,
- » after finishing the works, it shall leave the fork in a low position, lift the hand brake, turn off the engine, take the contact key and keep it.

The following is forbidden: transportation of workers with the forklift, workers supporting the load with their hands during the transportation, standing over the load or having the role of

counterweight, standing on the forks and performs work at height. The forklift operator shall be responsible for the safe operation with and around the forklift.

≡ **Protective measures during working at height**

Work at height means performing work standing on supports at the height of 3.0 m and solid surfaces whereby the workspace hasn't been secured from falling from height.

While working at height, the worker must comply with the following:

- » using protective equipment while performing the work,
- » always fastened with protective belt, attached, if possible, above his head, and the safety of that location shall be checked before moving to the next support,
- » moving and standing on the next support occurs after checking its safety conditions,
- » the next temporary support shall not be stressed with additional load (materials, tools etc.), if the worker is not sure that the support can take the additional load,
- » it shall not use the temporary support with another worker at the same time,
- » hand tools and other accessories that are necessary for performing the work shall be placed within reach, at places they will not fall from or tied if necessary,
- » no leaning to a position of unstable balance, holding the object or carrying it,
- » the relocation of the protective belt rope from one place to another shall be performed in a position in which the worker is standing on a reliable and safe support, or if there is another rope, when fastened to a safe support,
- » it shall not step over an empty space and shall have no sudden movements,
- » it follows the approaching prefabricated elements and steps out of its possible path of movement,
- » if it is not possible to perform the work in a manner and in the order specified by the project or in agreement with the head of works, the workers shall not continue working, but standing in a safe position, it shall wait and receive new instructions by the responsible worker. After receiving the instructions, it shall continue working.

Work at height can be performed only by workers who are trained for safe work and are medically fit for performance of such works. The worker may not start working, or work at height if tired, sleepy, mentally deranged, under influence of drugs, sedatives, and alcohol and other narcotics. The work

at height may be performed only under direct and constant supervision of a professional worker.

The following measures shall be taken when working at height and for prevention of objects falling from great height:

- » the passages for workers and the paths for mobile equipment shall be placed at a safe distance,
- » the temporary works of the workers that are not directly related to the execution of works at a high building is allowed only in the period of termination of the work at high buildings,
- » the accesses and the workplaces that cannot be relocated from the endangered zone shall be secured from falling of materials and tools, using protective galleries and canopies,
- » when working at a high building, under the working platform, receiving scaffolds or nets shall be constructed, which are normally an integral part of the scaffold or the device and they shall be relocated together with them,
- » the access to workplaces at height shall be executed and organized in such manner that there is no possibility of falling objects on the workers who go up or down, or accidental falls caused by their movement outside the secured zone (zone in which safety measures for falling objects have been carried out),
- » the transportation of materials and equipment to the facility, from the facility and through the facility must be performed in such a manner, that does not endanger the parts of the construction site outside the secured zone,
- » the zone around the high facility, within which there is a possibility of accidental fall of an object, shall be fenced, and at the entrances warning signs and stuff-only-signs shall be installed.

**CONCLUSIONS**

The main aim of this paper is to find out the occupational hazards and accidents in thermal power plant, during modernization and revitalization activities especially during the execution of assembly and disassembly works of parts under pressure. We are hope that our experiences about detecting the critical point (working places) and activities during the work in the power plant REK Bitola of whole period of maintenance the equipment, recognize the most dangerous activities of the workers, shall improve and increase the workers safety. Finally, we made some very important recommendations and order to workers for Health and Safety at Work with the practical and proven solutions and procedures crucial for the workers safety.



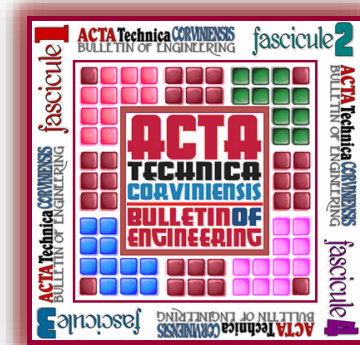
During the period of the intensive modernization and revitalization activities of the power plant equipment, statistical parameters shows that the totally safety of the workers who respect the established HSS (Health & Safety Security) procedure. The only incident happened on worker who didn't respect the HSS procedure and falling down on high during the work, with seriously injures. So, we strongly recommended established HSS procedures for the workers in power plants described in this paper.

#### Note

This paper is based on the paper presented at The Vth International Conference Industrial Engineering and Environmental Protection 2015 – IIZS 2015, University of Novi Sad, Technical Faculty „Mihajlo Pupin”, Zrenjanin, SERBIA, October 15-16th, 2015, referred here as[4].

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## USING OPEN-SOURCE HARDWARE FOR SOLAR POWERED WIRELESS SENSOR STATION RESEARCH

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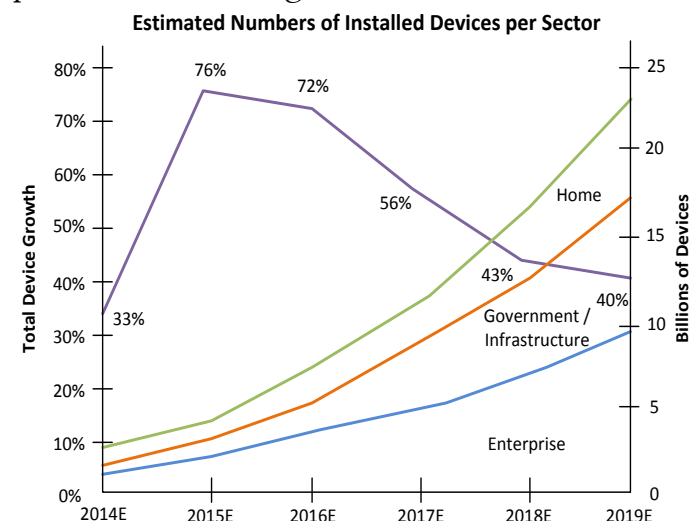
**Abstract:** In recent period we are witnesses of the growing importance of Internet of Things, Wireless Sensor Networks and similar technologies. All these technologies have in common deployment of a large number of outdoor stations and nodes in certain scenarios. Because of the outdoor location of the nodes, as well the need for efficient energy consumption, the very important question, which emerged together with the implementation of these scenarios, is the question of sensor station power supply. The solar powered sensor stations show itself as the most efficient, economical, and practical and sometimes only possible solution for outdoor environments. In this paper is presented approach in using open-source hardware for building prototypes of solar powered wireless sensor stations. The sensor station platform is also presented in this paper, as well as the analyses of presented platform usage in academic institutions for research and teaching.

**Keywords:** solar powered sensor station, open-source hardware, wireless sensor station

### INTRODUCTION

In variety of emerging technologies in modern days we are witnesses of the growing importance of IoT (Internet of Things) [1,2,3], WSN (Wireless Sensor Networks) [4,5] and similar technologies. Those technologies opened wide range of new possible usage scenarios such as smart cities, smart home, smart agriculture, smart environment, smart water, etc. All these technologies have in common one thing - the deployment of a large number of outdoor stations and nodes in certain scenarios. According to the prognosis in 2020 in world will be around 26 billion of intelligent devices [6]. The growth of IoT devices is presented in the figure (Fig. 1). Considering the large projected number of IoT devices the question of power supply for these nodes becomes more important. Importance of this question increases because it is realistic to expect that the large number of projected 26 billion of devices will be deployed at outdoor locations. So, the efficient energy consumption of sensor stations and need for avoidance of frequent battery changes in order to ensure enough supply power becomes main motivation for this research. The idea is to find the way to provide low-cost, efficient and flexible platform to be used in academic institutions for research and even teaching of these topics. Using this approach, the possibility to make experiments with application of solar powered sensor stations becomes

reality in academic and research institutions with no pressure to their budgets.



**Figure 1.** Estimated number of installed IoT devices in the World until 2019 [7]

In this paper is presented an approach of using open-source hardware platforms for solar powered sensor nodes in teaching and research at academic institutions. The paper is structured as follows: after the introduction, in the second chapter is presented the platform with its main components, together with the open-hardware principles. In the third chapter is presented the experience in usage of the proposed platform. The conclusion and the further work are given in the last chapter.

**PLATFORM BUILT ON OPEN-SOURCE HARDWARE**

**Open-source hardware**

According to the [8] Open Source Hardware (OSHW) Statement of Principles 1.0 - open source hardware is hardware whose design is made publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design. The hardware’s source, the design from which it is made, is available in the preferred format for making modifications to it. Ideally, open source hardware uses readily-available components and materials, standard processes, open infrastructure, unrestricted content, and open-source design tools to maximize the ability of individuals to make and use hardware. Open source hardware gives people the freedom to control their technology while sharing knowledge and encouraging commerce through the open exchange of designs.

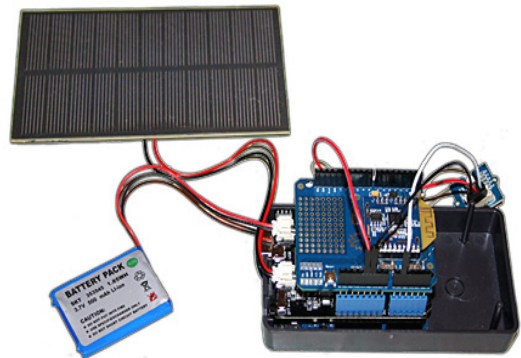
Generally, this approach in defining the open-source hardware principles provided creation of the largely supported market with compatible and low-cost products. These principles also made those components more available and allowed the development of small electronic devices, especially in the field of IoT, accessible to everyone. In a way, open-source hardware principles powered up the development and expansion of IoT.

**Solar powered Wireless Sensor Network platform**

Platform presented in this research is build upon the Arduino Uno microcontroller board [9,10]. The components of the platform are presented in Table 1 and on Figure 2. The basic component of the platform is Arduino UNO. Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, etc. It is one of the most popular microcontroller board open-source platforms in the world. Considering it open design, there is variety of clone boards or similar boards of other producers that are available on the market. Due its wide popularity and number of variants it is hard to estimate how much copies are sold in the world up to date. Before, in our institutions, some research related to usage of this platform in academy courses [11,12] were made as well as on other academic institution throughout the world.

The solar charger shield is a stackable expansion board that enables battery power to the Arduino UNO. It allows usage of various batteries with voltage of 3.0V to 4.2V to shift it up for 5V output needed to Arduino. This shield is also designed to be used in combination with Li-ion battery and solar panel to form an autonomous sensor unit. The maximum current provided by the board can get up to 600mA which is more than enough for all Arduino configurations, a three times more than the power consumption of the presented sensor station. A micro

USB connector, on the shield, is also useful to charge the battery connected directly to the PC via USB cable.



**Figure 2.** The solar powered platform based on Arduino UNO and solar shield

**Table 1.** Platform for solar powered wireless sensor station

No.	Item No.	Description
1	Arduino UNO Rev 3	Microcontroller board based on Atmel AT386
2	Solar Charger Shield v2.2	Expansion module designed to enable power from various batteries that has the voltage of 3.0V-4.2V to shift up for 5V output needed for Arduino, or to be used in combination with Li-ion battery and solar panel to form an autonomous sensor unit.
3	Solar panel	1.5W solar panel with dimensions 81x137mm
4	500mAH LiPo Battery	Polymer Lithium Ion battery 500mAh
5	XBee shield	Expansion module for Arduino designed for mounting communication modules based on Bee socket
6	Mesh Bee	Communication module design for ZigBee protocol
7	Temperature and humidity sensor	DHT22

Solar shield in this example is used in combination with the 1.5W solar panel with dimension 81 x 137mm. Solar panel is attached to the shield with 2-pin JST 2.0 PH connector. The solar panel is used to supply Arduino Uno and charge battery attached to the same board. The attached battery has smaller capacity - 500mAh and it is polymer Li-on battery. With the two LEDs on the board it can be seen if the battery is charged (red light) or if the battery is full (green light). With above components the autonomous power supply is provided, but the sensor station still lacks the communication and sensing capabilities.

In order to make this station outdoor sensor node, this station needs communication module and sensor. The communication module which is included in the configuration is Bee socket based module Seedstudio Mesh® Bee [13,14]. MeshBee® is a 2.4 GHz wireless ZigBee RF module. It uses



microchip JN516x from NXP that enables several different standards-based ZigBee mesh networking [15,16]. It supports ZigBee Pro stack. It has indoor/urban range up to 30m and outdoor line-of-sight range up to 100m. Its receive sensitivity is ~ 95dBm, working frequency is 2.4 GHz and it operates at following data transmission rate: 4800, 9600, 19200, 38400, 57600 and 115200 bps. It has socket compatibility with well known Digi International XBee communication modules [4,17] (2 x 10-pin sockets). Its connectivity with Arduino solar platform is allowed using Tinysine XBee shield v2.

The Seedstudio Mesh® Bee communication module on this solar station is configured as Router [4] and it has wireless communication with central network module with a role of Coordinator [4] attached to PC. This configuration with one Coordinator and one Router is needed in order to establish ZigBee network or ZigBee PAN. In this way, solar powered station transmits sensor collected data to the computer.

In order to make this station the sensor station, at least one sensor should be used. In this particular scenario is used digital temperature and humidity sensor – DHT22. This sensor collects the data and station send its every 10 seconds to the ZigBee Coordinator device directly attached to PC (Figure 3). The time period is determined with the program uploaded to the station. On a PC is installed simple prototype application for collecting the data with logging the received temperature and humidity values together with the code of the sending station, data and time of the data retrieval.

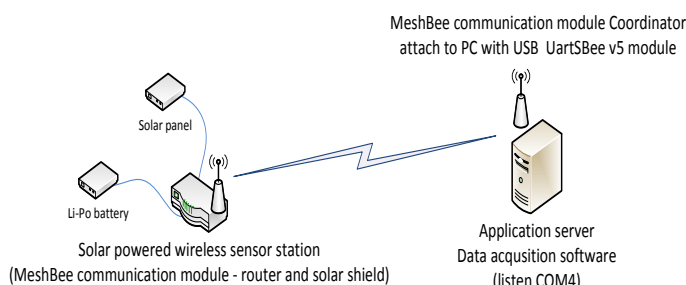


Figure 3. Network made with solar powered wireless sensor station

## RESULTS AND DISCUSSION

The goal of this paper was to show the possibilities of using the open-source hardware in academic institution for the research related to solar powered wireless sensor stations. The platform presented in the second section of the paper is tested for a short time and it worked well during the testing period. The station is power supplied combining Li-Po battery and solar panel. The collected and successfully sent temperature data are presented at Figure 4.

During the operation, station collected temperature and humidity data and sent it via ZigBee network to the remote PC station. In this test conditions, the

station is located only 5m from the sensor station. The longer ranges are possible as well up to 30m in indoor/outdoor non-line-of-site environment and up to 100m in line-of-sight conditions in outdoor environment. These ranges are declared by the manufacturer and they are proved by the experiments taken at our institution for indoor usage [18].

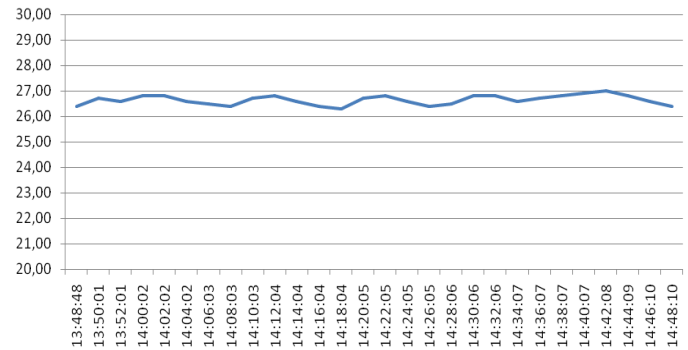


Figure 4. The measured values for temperature during the station test work

In this stage of the research, the process of monitoring and analyzing of solar charging, battery drain and behavior of the station under the different conditions connected to UV radiation intensity are not performed. One of the major obstacles for accurate and useful measurements is caused by two factors. One factor is that in this stage only one small capacity battery is available for the research. The second factor is rather high energy consumption needed to establish and maintain ZigBee connection. In order to continue the research on this topic, the power consumption of the solar sensor station should be measured and optimized as well. After that, the experiments with the higher capacity battery should be made as well as with the larger size and higher power solar panels.

Nevertheless, considering that Arduino platform is specially designed for DIY (Do It Yourself) projects and prototyping, all components are easy to assemble. This is a solder less platform which makes these stations easy to improve, reprogram and reconfigure. These capabilities make proposed platform very suitable for usage in the research at academic institutions. Also, this platform can be used in teaching process, because it will allow students much space for hand on labs and making experiments with different configurations.

## CONCLUSION

In this paper it was presented the possible usage of open-source hardware at academic institutions for researches connected to the solar powered wireless sensor stations. This research is motivated with the growing importance of WSN and IoT platforms, and it has the special focus on outdoor deployed autonomous sensor stations.

Considering the enormous expansion and growth of the number of such stations projected for the next 5

years and beyond, the research connected with the most economic and most manageable power supply for such stations becomes important for the academic institutions and their researchers in multidisciplinary fields.

The open-source hardware offers low cost, well designed electronic components. One set of these components is used to assembly ZigBee based solar powered sensor station. Also, open-source hardware platform is used to form complete network for sensor data acquisition consisting in this case only with two nodes (Figure 3).

The created platform worked well during testing period and proved itself as a platform functional enough to be used in research facilities. Considering that this platform is easy to be reconfigured and that with additional equipment it may be used for monitoring and experimenting with the solar power wireless sensor stations and IoT devices, we can say that the proposed platform is useful and suitable environment for the research and teaching in academic institutions.

#### Note

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## THE TECHNO-ECONOMICAL AND ENVIROMENTAL RESULTS OF GASIFICATION IN THE SLAVONIA REGION (Croatia)

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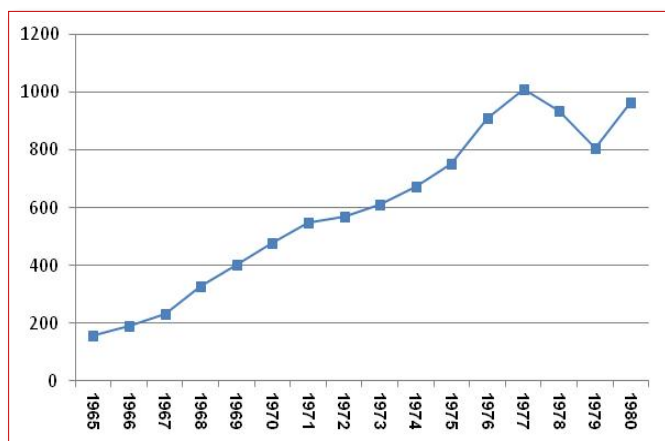
<sup>2</sup>. Josip Juraj Strossmayer University of Osijek, Faculty of Electrical Engineering, Osijek, CROATIA

**Abstract:** The paper provides a brief historical overview of the beginning of the use of natural gas in Slavonia, construction of main and distribution pipelines, the number of consumers and consumption in this Croatian region. It implies a change of consumption structure of substitutional energy and increased share of natural gas in total energy consumption in the region. Especially indicated techno-economical and the environmental importance of the completion of the gasification of the region started 40 years ago and emphasized new opportunities for better energy supply with renewable energy sources.

**Keywords:** gas distribution, gas pipelines, gas consumption, natural gas, Slavonia

### INTRODUCTION

Usage of Natural gas in Slavonia started after the discovery of oil fields Beničanci (1968) and gas field Boksic-Lug. (1973), [1], [2]. Production (and usage) of natural gas in Croatia at the time was not developed, system of main gas pipelines were missing. Production of natural gas in that period is presented on Figure 1, which emphasizes the importance of the contribution of gas from the Slavonian field since 1972, and especially since 1975.



**Figure 1.** Natural gas production in Croatia from 1965 up to 1980 (10<sup>6</sup>m<sup>3</sup>), [3]

Balance between production and consumption of natural gas in the first years of usage (1972-1985) in Slavonia is presented with data in Table 1.

**Table 1.** Production and consumption of natural gas in Slavonia from 1972 up to 1985 (10<sup>6</sup> m<sup>3</sup>); [2]

Year	Production	Consumption	Difference (delivered to in system)
1972	60.0	0.5	burned
1973	57.7	3.4	burned
1974	56.5	3.4	burned
1975	175.9	14.0	161.9
1976	312.4	74.4	236.0
1977	387.2	82.4	304.8
1978	358.1	106.4	251.7
1979	318.5	149.5	169.0
1980	507.2	152.4	354.8
1981	589.8	176.7	413.1
1982	485.7	213.6	272.1
1983	433.1	232.0	201.1
1984	442.7	239.4	203.3
1985	440.0	240.0	200.0

### GASIFICATION PROCESS IN SLAVONIA

The first natural gas consumer in Slavonia the Brickyard “Slavonia” in Našice was connected to fields Beničanci in 1972. On this source from end of 1975 Kombinat “Belišće” is also connected. At that time the production and consumption of gas from fields Beničanci was balanced. At the end of 1975 on natural gas from the gas field Boksic Lug connected the brickyard “Graditelj” Sladojevci (P. Slatina), which is located next to the main gas pipeline Boksic – Zagreb.



The company “Elektroslavonia” Osijek join to the process of gasification in the region a few months after discovery of the gas field Boksic Lug thru:

- a) the construction of gas turbine power plant in Osijek, and
- b) the appointment (by local authorities) for holders of gasification activities at the regional level.

By appointment for holders of gasification activities in the area of Slavonia and Baranja - in the summer of 1975 “Elektroslavonia” established the Department for the development of gasification in 1979, “Gas distribution” grown-up and in 1981 became legal business entity. Gas turbine power plant in Osijek consumes natural gas from February 1976. In 1977 to the gas network of Osijek are connected: a brickyard “Opeka” and the Agricultural Institute for seed drier and for heating of residential buildings in the Settlement of solidarity. In Miholjac street gas network (10 km) was built and put into operation in 1977. At mid-year of same year pipeline for wood combine “Đurđenovac” was commissioned and the first section of (3 km) street pipeline in Nasice,[2] [5].

Experts of “Elektroslavonia” created in 1978 and “The program of gasification areas Slavonia in the period 1979 - 1985” was adopted during the 1979. Assembly of all 14 municipalities in the region and the Assembly of the Slavonia region. This program analyzed introduction of natural gas problems in 25 cities and municipal centers and have established priorities and stages of gasification of the region, [6]. Since that time, continuously expansion of regional gas pipelines gradually leads to the creation of Croatian gas-supply system.

### THE CONSTRUCTION OF MAIN GAS PIPELINES AND DISTRIBUTION NETWORKS

The main gas pipeline was financed and constructed by “INA-Naftaplin”, Zagreb (Figure 2) and distribution network was built by local investors (Figure 2). The development of gasification Slavonia describe data on: construction of gas networks, the number of consumers and consumption of natural gas in the region.

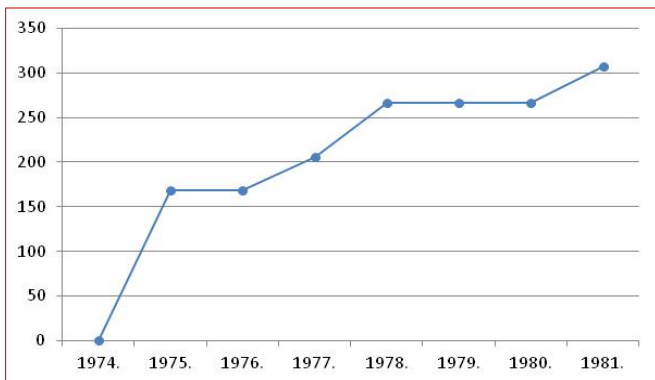


Figure 2. The length of main gas pipelines built in Slavonia from 1975 to 1981 (km) [7]

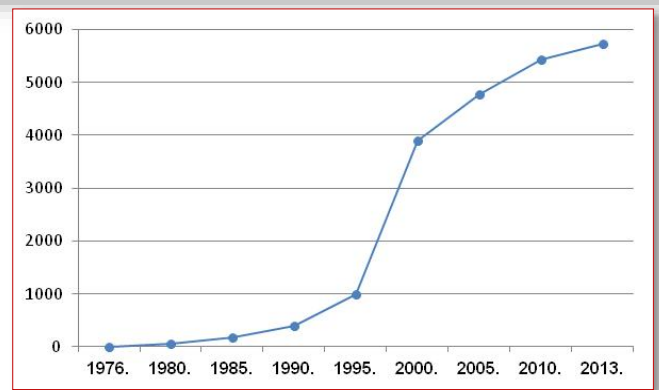


Figure 3. The length of distribution gas networks in Slavonia from 1976 to 2013 (km) [8]

### THE DEVELOPMENT OF NATURAL GAS CONSUMPTION

Number of natural gas consumers in the Slavonia region in the period from 1976 to 1991 is shown in Table 2 from which exponential growth of number of consumers in the industrial and utility organizations (service and public sector) and households can be seen. Connection of new consumers depended primarily on the amount of available natural gas, connection between local consumption with the main network, size of consumption and state of construction of locally funded distribution network.

Table 2. Number of consumers of natural gas in Slavonia from 1976 to 1991 [1] [4] [9]

	1976	1977	1978	1979	1980	1981
Total	2	386	812	1,380	2,186	3,218
Ind. & comunall.	2	16	38	63	99	207
Households	0	370	774	1,317	2,087	3,011
	1983	1985	1987	1989	1991	
Total	5,383	6,672	8,372	15,473	20,093	
Ind. & comunall.	356	497	578	694	894	
Households	5,017	6,175	7,794	14,749	19,219	

Available quantities of natural gas were not sufficient at that time, and the “Program of gasification of Slavonia” did not achieve planned dynamics and capacities due to lack of gas consumption and distribution pipelines gas was directed to the existing large customers in other parts of the Croatia (Zagreb and surroundings). From a total of 14 Slavonian municipalities in 1991 gas used 9. Without access to gas were: Beli Manastir, Đakovo, Nova Gradiska, Vukovar and Županja. However, during period of time intensive work was done on the preparatory work for the installation of gas on their territories; for the municipality Nova Gradiska recorded potential gas consumption, and for municipality Beli. Manastir, Đakovo and Županja made the conceptual designs of connection to the gas system and the outcome of gas pipeline network in

municipal centers with associated cost estimates, while in Vukovar was already made and detailed design of the main distribution pipeline. [1] [4] [9] [10]

In addition to natural gas consumption in Slavonia through distributors “Elektroslavonija” natural (free and water intake) gas used and the so-called direct consumers: it is a large industrial facilities to which the gas was delivered “INA - Naftaplin”.<sup>1</sup>

Bringing the exploitation of oil and gas fields Ilača, Đeletovci and Privlaka enabled during 1984 continued construction of the gas network. About ten million m<sup>3</sup> of gas captured from these fields is spent (since 1986) in Vinkovci building materials industry “Dilj” and PIK Vinkovci (1987). However, this amount of gas is not just paying the annual needs “Dilj” and the gas network until 1991 did not spread to other consumers in Vinkovci.

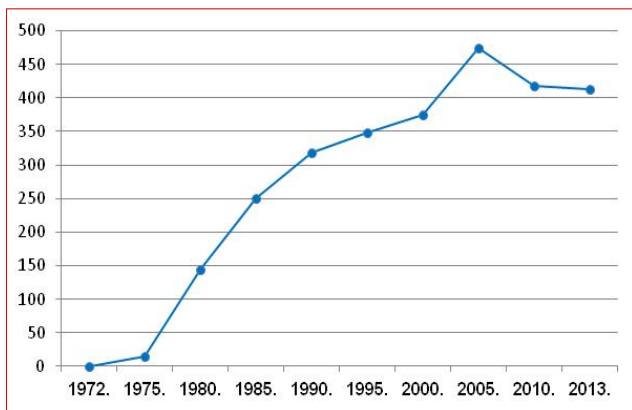


Figure 4. Total consumption of natural gas in Slavonia and Baranja 1996-2014 (10<sup>6</sup> m<sup>3</sup>) [4][8][11][12][13]

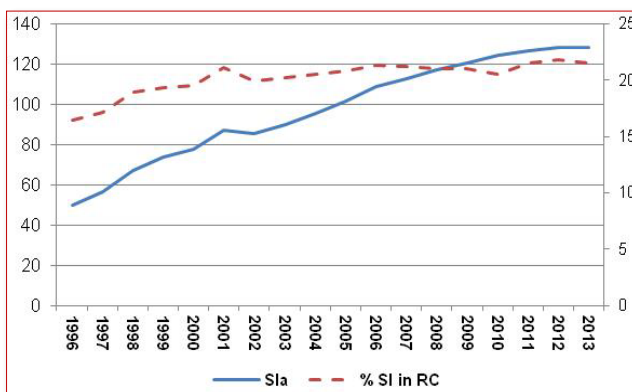


Figure 5. Number of households of natural gas consumers in Slavonia for period 1996-2014 (000) [4][8][11][12][13]

From 1991 up to 1995 damage from military destruction to the gas system were repaired and process of gasification of the region of Slavonia was continued - so in the period from 1996 to 2014 was

built about 4,000 km of new distribution pipelines. Natural gas consumption in Slavonia and Baranja has been increasing from 1996 until 2009 when - because of the economic downturn - industrial production was reduced, and in the public sector and household consumption is reduced or rationalized due influenced of the implementation of energy efficiency measures. Figure 5 shows the changes of natural gas consumption in the region of eastern Croatia.

### SIGNIFICANCE OF GASIFICATION IN ENERGY SUPPLY OF SLAVONIA

Significant advantages of natural gas in energy consumption compared to other energy sources can be classified in three groups:

- Energy benefits of natural gas
- Environmental benefits of natural gas
- Economic advantages of natural gas

Benefits of using natural gas in relation to other energy forms can be seen in: [9], [12] and [13]. General conclusion is that usage of natural gas in the energy sector brings to the significant energy, environmental and economic benefits / advantages compared to the same amount of energy required from other energy forms, and ultimately increase social functionality of energy consumption, ie. lower energy costs per GDP.

### CHANGES IN THE STRUCTURE OF ENERGY CONSUMPTION IN SLAVONIA

Energy consumption of industry (households and communal consumption) in the region of Slavonia and Baranja in the early days of gasification essentially was based on coal, table 3 and table 4.

Table 3. Energy consumption of industry in the Slavonia area, [1] [2] [9]

Nº	Energy source	Unit	1972	1977	1978	1979
1.	Electricity	MW h	281,593	432,458	495,539	503532
2.	Anthracite	t	0	605	17	4
3.	Coke	t	16,679	21,168	23,847	22,273
4.	Stone coal	t	4,962	0	400	465
5.	Brown coal	t	247,201	174,445	169,495	145,310
6.	Lignite	t	59,381	44,904	50,614	41,315
7.	Fuel oils	t	19,690	22,525	27,034	25,629
8.	Oil fuel	t	75,503	93,212	111,967	112,520
9.	Natural gas	10 <sup>3</sup> m <sup>3</sup>	500	84,830	104,527	129,141
10.	LPG	t	3,094	3,512	2,850	3,751
Total: (recalculated)		10 <sup>3</sup> m <sup>3</sup>	300,518	382,582	435,211	444,185

<sup>1</sup> Direct consumers of natural gas were then: Kombinat Beliše, Cementara Našice, „Dilj“ Vinkovci, IGM „Slavonija“ - Našice, „Graditelj“ - P. Slatina, „Radnik“ - Donji Miholjac, PIK „Đuro

Salaj“ - Valpovo, Holding „Đuro Đaković - Slavonski Brod, „Domin“ - Sl. Brod i PIK Vinkovci;

The development of the gas network and the use of natural gas almost kicked out coal from Slavonia. So at the beginning of XXI c. hundreds of thousands of tons of coal were replaced by natural gas. Natural gas reduced transportation costs, enable more efficient management of technological processes, raise living standards and community and reduced greenhouse gas emissions.

**Table 4.** Consumption of substitutable energy in Slavonia in 1982 [14]

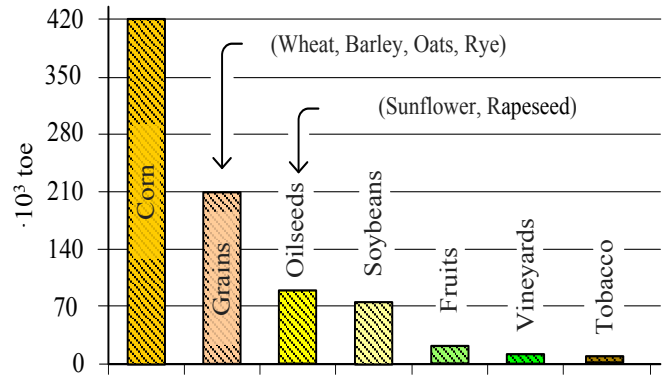
N <sup>o</sup>	Energy source	Unit	C o n s u m p t i o n			
			Economy	Utility	Households	Total
1.	Coke	t	25,217	-	-	25,217
2.	Stone coal	t	159	-	-	159
3.	Brown coal	t	259,037	7,706	42,515	309,318
4.	Lignite	t	72,745	4,475	171,845	249,072
5.	Wood and wood wastes	t	115,491	11,715	405,581	532,785
6.	Fuel oils	t	23,800	36,400	27,800	88,000
7.	Oil fuel	t	82,629	20,040	-	102,669
8.	LPG	t	5,900	3,012	8,000	16,952
9.	Natural gas	10 <sup>3</sup> m <sup>3</sup>	197,512	8,279	7,749	213,540

### BIOMASS FOR HEATING

Heating is a sector that can benefit the most biomass. Abandoning the use of fossil fuels and switch to renewable energy is a worldwide trend. Development of technology enabled the cheap fuel from cellulose waste material by mechanical means, without the use of a binder. Briquette burns evenly with a little smoke and no fly ash (a 10 times less ash than coal). Combustion practical environmental friendly compared with other solid fuels, as it contains little sulfur (100 times less than coal). Manufacturing of briquettes is developed so that it can be applied to different materials - from the waste material in the industry to bulky cellulosic combustible residues grains from agricultural fields. The use of biomass create new and maintain existing employment, increase local and regional economic activity, create additional income in agriculture, forestry and wood industry through the sale of biomass-fuel. In addition - outflow of funds for the purchase of fossil fuels is reduced and cash flows in the local community are established (investments - profit - taxes). The impact on employment and socio-economic aspects represents the biggest advantage of using biomass.

Our research of biomass potential from crop residues, fruit and grape growing Slavonia and Baranja [10] [16] determine the energy potential of this type biomass amounting to over 800,000 tons of oil equivalent per year (Figure 6). So, this is a very

significant potential that can be used for heating in households, but also in other sectors.



**Figure 6.** Total energy potential of biomass from crop residues, fruit and grape production in the area of Slavonia [16]

### CONCLUSIONS

- The process of gasification of Slavonia began with oil discovery in the region Beničanci (1968) and gas discovery in Boksic-Lug (1973). In the past 43 years a respectable system of main and distribution pipelines has built. Gas consumption includes all consumption sectors: industry, agriculture and services, public institutions, households, boiler and heating plants. Process of gasification of the region was stopped in 1991 and started again in 1995 after eliminating significant damage from sever military destruction. In the period from 1996 to 2014 development of gasification was continued with new dynamics, more than 4,000 km of new distribution pipelines was built, which allowed the gasification of a number of settlements in the region in all sectors of consumption from industry to households.
- Natural gas consumption in Slavonia and Baranja has been increasing from 1996 until 2009 when - because of the economic downturn - industrial production was reduced, and in the public sector and household consumption is reduced or rationalized due influenced of the implementation of energy efficiency measures.
- Our analysis of gasification of Slavonia and consumption of natural gas emphasize the economic and ecological importance of the introduction of natural gas as energy supply for region. Instead of several hundred thousand tons of coal a year Slavonia and Baranja is now using natural gas. gasification, reduced transportation costs of energy supply, enable more efficient management of technological processes, raise living standards and community and reduced greenhouse gas emissions.
- Along with the good performance of gasification of the region paper emphasized strategic importance of utilization of large biomass



potential for households and public institutions heating. The use of biomass for heating reduce imports of natural gas, reduce CO<sub>2</sub> emissions and contribute to local economic development through local employment and local cash flows.

#### Note

This paper is based on the paper presented at The Vth International Conference Industrial Engineering and Environmental Protection 2015 – IIZS 2015, University of Novi Sad, Technical Faculty „Mihajlo Pupin”, Zrenjanin, SERBIA, October 15-16th, 2015, referred here as [17].

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## LEARNING MATHEMATICS USING MULTIMEDIA IN ENGINEERING EDUCATION

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**Abstract:** Multimedia learning of mathematics encompasses learning from instructional material, both traditional (paper, blackboard, etc.) and computer based (graphs, animations, etc.), that combine words and pictures in the domain of mathematics. This paper has both a theoretical and practical orientation. On one hand, our aim was to present how students of two engineering faculties learn with multimedia and how to design multimedia environments that promote learning. In this study we present some of the most important principles of multimedia learning and design. We provide a definition of multimedia learning and multimedia presentation, present distinction between two approaches to multimedia design. On the other hand, the practical aim of this paper, based on the above factors of multimedia learning and design, was to prepare multimedia lessons (selected examples) in mathematics and present them to the students of two engineering faculties: the Faculty of Architecture and the Faculty of Civil Construction Management of the UNION "Nikola Tesla" University, Belgrade, Serbia. The main information source in multimedia lectures was software created in Macromedia Flash, with definitions, theorems, examples, tasks as well as in traditional lectures but with emphasized visualisation possibilities, animations, illustrations etc. Besides that, survey carried out at the end of this research clearly showed that students were highly interested in this way of learning.

**Keywords:** Multimedia learning, Multimedia presentation, Multimedia design, Multimedia example in mathematics, Engineering education

### INTRODUCTION

#### Multimedia learning and multimedia presentation

Multimedia refers to the presentation of instructional material using both words and pictures [5, 6]. According to this, words – or the verbal form of the instructional material – can be either printed or spoken, while pictures – or the pictorial form of instructional material – can encompass static graphics, such as illustrations, graphs, maps, or dynamics graphics, such as animation or video. Multimedia instructional message or multimedia instructional presentation involving words and pictures that is intended to faster learning.

The case of multimedia uses the premise that learners can better understand an explanation when it is presented in words and pictures than when it is presented in words alone.

Cognitive theory, emphasises the importance of visualisation in learning, too. The principle of this theory is that there are two qualitatively different methods of learning: verbal and visual. Words, on

the one hand, enable the description of the matter even from the abstract aspect, while pictures, on the other hand, enable the visual experience of the matter. These two methods of learning are complementary and not exclusive, so the overall conclusion is that the students should combine text and picture and, in this way, learn more readily, which is actually the final objective.

During past few years, multimedia learning has become very important and interesting topic in the field of teaching methodology. Mayer's and Atkinson's researches resulted in establishing the basic principles of multimedia learning and design, which were confirmed in our paper, too [1, 5, 6]. Nowadays, usage of different kinds of multimedia is largely included in the education because it allows the wider spectrum of possibilities in teaching and learning. Visualisation is very useful in the process of explaining mathematical ideas, abstract terms, theorems, problems, etc.



Modern methods in multimedia approach to learning include the whole range of different possibilities applicable in mathematics lectures for different levels of education and with different levels of interactivity [4], [7], [8], [9], [10].

This paper has both a theoretical and practical orientation. On one hand, our aim was to present how students of two engineering faculties learn with multimedia and how to design multimedia environments that promote learning.

**Two metaphors of multimedia design and learning**

According to the information acquisition view, learning involves adding information to one’s memory. This view entails assumptions about nature of the learner, the nature of the teacher, and the goals of multimedia presentation. First, learning is based on information, an objective item, that can be moved from place to place (such as from the computer screen to the human mind). Second, the learner’s job is to receive information; thus, the learner is a passive being who takes in information from the outside and stores it in memory. Third, the teacher’s job, or, in the case, the multimedia designer’s job, is to present information. Fourth, the goal of multimedia is to delivery information as efficiently as possible. The underlying metaphor is that multimedia is a delivery system. According to this metaphor multimedia is a vehicle for efficiently delivering information to the learner. Table 1 summarizes the differences between the two views of multimedia learning with explanations of starting points, goals and issues [5], [6].

**Table 1.** Two views of multimedia design

Design approach	Starting point	Goal	Issues
Technology-centered	Capabilities of multimedia technology	Provide access of information	How can we used cutting-edge technology in design multimedia presentation?
Learner-centered	How the human mind works	Aid human cognition	How can we adapt multimedia technology to aid human cognition?

The goal of multimedia is to help people develop an understanding of important aspects of the presented material. Table 2 summarizes the differences between the two views of multimedia learning [5], [6]. In this paper we favour a knowledge instruction because it offers a more useful conception of learning when the goal is to help people to understand and to be able to use what they learned.

**Table 2.** Two metaphors of multimedia learning

Metaphor	Definition	Content	Learning	Teacher	Goal of multimedia
Information acquisition	Adding information to memory	Information	Passive information receiver	Information provider	Deliver information; act as a delivery vehicle
Knowledge construction	Building a coherent mental structure	Knowledge	Active sense maker	Cognitive guide	Provide cognitive guidance; act as a helpful communicator

**Design of multimedia lessons**

Multimedia learning can be effective only if multimedia lessons are adequately designed.

For many years, the investigations on multimedia learning and their results have been rather unconnected and without a concrete effect on learning. But, today there are numerous studies that define clearly the factors affecting the multimedia learning and the principles of successful multimedia design.

There are twelve factors, each with a theoretical background, which can be defined as variable. The student's style is an independent variable, whilst learning is the dependent variable. Other elements are visual knowledge, audio knowledge, student control, attention, working memory, motivation, cognitive engagement, intelligence, transfer and length of data storage. All the factors are interrelated and have a complex effect on multimedia learning and design [3].

Some of the most significant principles of multimedia learning were established by [5], [6]:

- 1) Multimedia Principle: Students learn better from words and pictures than from words alone.
- 2) Spatial Contiguity Principle: Students learn better when corresponding words and pictures are presented near rather than far from each other on the page screen.
- 3) Temporal Contiguity Principle: Students learn better when corresponding words and pictures are presented simultaneously rather than successively.
- 4) Coherence Principle: Students learn better when extraneous words, pictures, and sounds are excluded rather than included.
- 5) Modality Principle: Students learn better from animation and narration than from animation and on-screen text.

- 6) Redundancy Principle: Students learn better from animation and narration than from animation, narration, and on-screen text.
- 7) Individual Differences Principle: Design effects are stronger for low-knowledge learners than for high-knowledge learners and for high-spatial learners rather than for low-spatial learners.

Table 3 shows in short the factors that make a multimedia presentation effective.

**Table 3.** Factors affecting the success of a multimedia presentation

Characteristics	Description
Multimedia	Present the text and picture together
Unity	Present the text and picture close to each other
Conciseness	Exclude the superfluous text and picture
Structure	Include textual and visual explanations of the presented, step by step

**MATERIAL AND METHODS**

**Aim and questions of the research**

The practical aim of this paper, was based on the above factors of multimedia learning and design, to prepare multimedia lessons on definite integral and to present one selected example. Thanks to the experiences of some previous researches and results, some of the questions during this research were:

- 1. What do students think about multimedia lectures and presentations? Do they prefer this or traditional way and why?
- 2. Do students think it is easier to understand and learn the matter individually and during the classes by multimedia lectures?

**Participants of the Research**

The research was conducted on two groups of 50 students of the first year: at the Faculty of the Architecture (25 students) and the Faculty of Civil Construction Management (25 students) of the UNION University, Belgrade, Serbia.

**Multimedia learning of mathematics. Example**

Lectures in both groups of students included exactly the same information on the finite integrals, i.e. axioms, theorems, examples and tasks like on the traditional class of math, but the main information source was software created in Macromedia Flash 10.0, which is proven to be very successful and illustrative for creating multimedia applications in mathematics lectures [2]. Our multimedia lecturing material was created in accordance with methodical approach, i.e. cognitive theory of multimedia learning [5], [6], as well as with principles of multimedia teaching and design based on researches in the field of teaching mathematics [1]. This material includes large number of dynamic and graphic presentations of definitions, theorems, characteristics, examples and tests from the area of

the finite integrals based on step-by-step method with accent on visualisation. Important quality of making one’s own multimedia lectures is possibility of creating combination of traditional lecture and multimedia support in those areas we have mentioned as the ‘weak links’ (finite integral definition, area, volume, etc.).

**Example:** Determining the volume of body by revolving.

**Task:** Determine the volume of a right circular cone with altitude h and base radius r.

**Solution:** The cone is generated by revolving the right-angled triangle OAB around the Ox-axis, which can be clearly shown by using animation (Figure 1).

Animation parts which represents the given task and the triangle revolution.

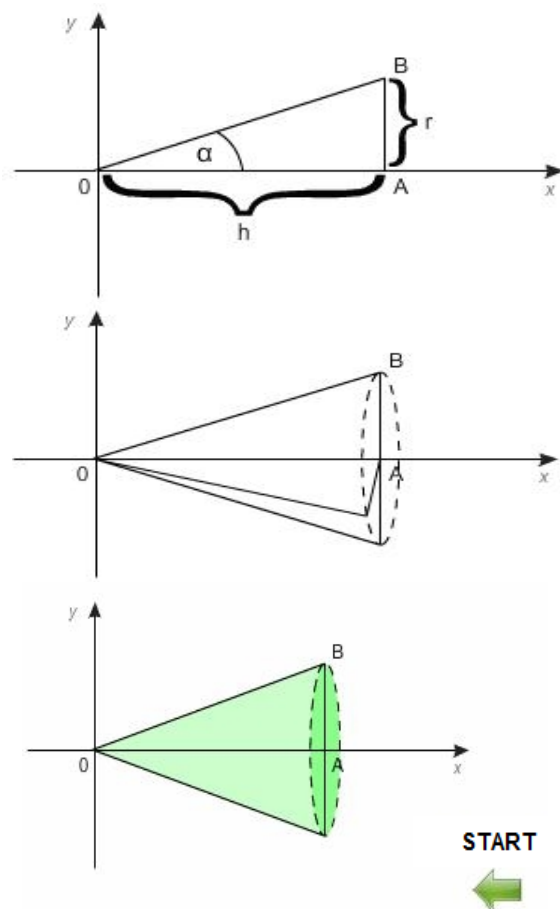
Numerical solution of given problem is also shown step-by-step, by using animation.

Slant height of the cone is defined as line:

$$y = x \cdot \operatorname{tg} \alpha = \frac{r}{h} \cdot x$$

Therefore, according to the formula for calculus of volume:

$$V = \pi \int_0^h \left(\frac{r}{h} \cdot x\right)^2 dx = \frac{\pi \cdot r^2}{h^2} \cdot \frac{x^3}{3} \Big|_0^h = \frac{\pi \cdot h \cdot r^2}{3}$$



**Figure 1.** Example: Determining the volume of body by revolving

**RESULTS**

In summary, multimedia learning helps to promote a better understanding of how to foster meaningful learning through the integration of words and pictures (printed or spoken text and illustrations, graphs, maps, animation or video).

When asked whether they prefer classical or multimedia way of learning, 12% (3 students) answered classical and 82% (22 students) answered multimedia at the Faculty of Architecture, while at the Faculty of Civil Construction Management 20% (5 students) answered classical and 80% (20 students) answered multimedia, explaining it with the following reasons:

- » ‘It is much easier to see and understand some things, and much easier to comprehend with the help of step-by-step animation.’
- » ‘Much more interesting and easier to follow, in opposite to traditional monotonous lectures with formulas and static graphs.’
- » ‘More interesting and easier to see, understand and remember.’
- » ‘I understand it much better this way and I would like to have similar lectures in other subjects, too.’
- » ‘This enables me to learn faster and easier and to understand mathematical problems which demand visualisation.’
- » ‘Quite interesting, although classical lectures can be interesting – depending on teacher.’

When asked whether it was easier for them to learn, understand and solve problems after having lectures and individual work with multimedia approach, students answered the question as shown in Figure 2.

**DISCUSSION AND CONCLUSIONS**

During past few years, multimedia learning has become very important and interesting topic in the field of teaching methodology. Mayer’s and Atkinson’s researches resulted in establishing the basic principles of multimedia learning and design, which were confirmed in our research, too [1], [5], [6]. Our multimedia lessons about the finite integrals, created in accordance with these principles, proved to be successful. According to the students’ reactions, highly understandable animations from multimedia lessons are the best proof that a picture is worth a thousand words. Their remark, and consequently one of this research’s conclusions, was that there should be much more of this kind of lessons in education, made – of course – in accordance with certain rules and created in the right way.

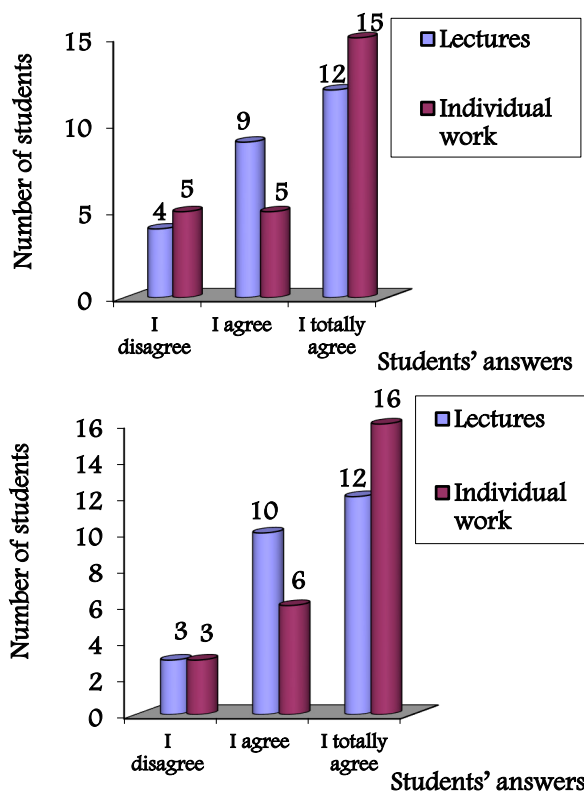
Many researches in different scientific fields, including mathematics, have proven that multimedia makes learning process much easier.

Researches on learning the finite integrals with software packages Mathematica and GeoGebra have shown that students who had used PC in learning process had higher scores on tests [4]. Although this research was conducted with different multimedia teaching tools for the same subject – the finite integral as one of the most important areas in mathematical analyses – our results only proved the universality of multimedia in the process of teaching mathematics.

Wishart’s research included analyses of comments on how much multimedia approach affects teaching and learning processes [13]. Teachers emphasized that multimedia lectures have made their work easier and have proved to be motivating for students, while students said that multimedia lessons, in comparison with traditional methods, have offered better visual idea about the topic. As shown in Graph 2, great number of them insisted that multimedia tools enabled easier understanding, learning and implementation of knowledge.

Their remark, and consequently one of this research’s conclusions, was that there should be more multimedia lessons, i.e. that multimedia is an important aspect of teaching and learning process.

One of this research’s conclusions can be put in the way one student did it during the survey (by answering the question: What is multimedia learning): ‘Multimedia learning is use of multimedia as an addition to the traditional way of learning. Multimedia enables us to have better understanding



**Figure 2.** Students’ answers to the question: Should PC be used in lecturing and learning mathematics? (a – Architecture, b – Civil Construction Management)



of many mathematical problems and to experiment with them.’

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<sup>1</sup> Adrian Laurențiu POPOVICI

## ESTABLISHING A RECURRECNY PERIOD AND IDENTIFIYNG THE MAIN FOREST SPECIES WITHIN THE AVALANCHE PATHS IN LALA VALLEY, NATIONAL PARK OF RODNEI MOUNTAINS

<sup>1</sup> “Ștefan cel Mare” University, Silviculture Department, Suceava, ROMANIA

**Abstract:** The purpose of the present paper focuses upon the importance of the establishment a recurrence period for avalanches and the identification of the main forestry species, due to the juvenile vegetation found in the avalanches paths. During measurements, there were registered a series of characteristics which proved the existence of a major event (scars, changings in wood reactions, deviated tree-rings etc.). Based on the results reported through the presence of the events on dead wood but also on the present vegetation in the area, we shall realize a relative chronology of high-magnitude avalanches in the studied area, for every avalanche path considered. As our research advanced, we noticed that beyond the enhancements brought in the specialty field, the establishment of a recurrence period for avalanches may have a scientific impact, from the perspective of understanding which pioneer species are going to install in the juvenile forestry vegetation, localized in the avalanches paths. All data (dendro-chronological and susceptibilty analysis) indicate that in 2006 occurred a high-magnitude avalanche, destroying trees from slopes but also a cottage. The cottage was nearly built and was localized in path I.

**Keywords:** avalanches, chronology, avalanche patch, susceptibilty, pioneer species, progression dynamics

### INTRODUCTION

The silviculture has a colossal importance at a global scale. With a history evolving from the role of raw material easy to procure in the ancient times, until the role of endangered resource, the forests had and will have a major impact upon all important domains: industry, economy, health or tourism etc.

In Romania, the avalanche entered into the attention of the scientists much more lately than in the rest of the Europe. The firsts observing and making researches on avalanches were researchers of the sylvan domain. (Gaspar, Munteanu, 1968; Bădescu, 1972; Alexa, 2005).

The avalanches' action generate a fragmentation and the partial destruction of the vegetation in the area. The poor frequency of avalanches allows a partial reconstruction of the path in the period between two events. However, each event implies an important force of movement, fact proved by the trees which lose their peaks or high diameter trees tilted. The colonization in these extreme conditions is characterized by a slow growth of species and by the presence of periods of species domination. In

addition to this, it increase the vegetal propagation mainly in the distal area of the accumulation.

The identification of data obtained from more than one dendro-ecologic indicator is essential for the calculation of avalanches frequency. Three of the most useful indicators in dating avalanches are: abrasion scars, reaction wood and the traumatic resin ducts. The first two indicators are recognized as the best in calculating the snow avalanches. (Potter, 1969; Smith, 1973; Burrows & Burrows, 1976; Shroder, 1980). The largest annual rings supplied complementary information. With respect to tight rings, their dating did not allowed the utilization of the data obtained, because of other indicators, their sensibility being too high in front of many other risk environment factors.

On the other hand, prudency is required in the general utilization of abrasion scars in the areas affected by avalanches, because there are other factors generating scars, for instance the fire, the detritus or animal behavior. (Carrara, 1979; Johnson, 1987).



According to Marion et al. (1995), traumatic resin ducts constitute the best indicators, as they correspond to the years of scars formation and are visible on the larger longitudinal side of the trunk. Yet, those anomalies may appear as response to other stressful conditions, especially in case of insect pestilences. Moreover, during an avalanche, the trees basis is often protected by snow, a fact which explains the absence of scars and damages on trunks basis. However, in 1985 Ward reported a concentration of basal scars in some avalanche paths. According to the same author, these scars underestimate the intensity of an avalanche, which makes that the scars height being a factor difficult to utilize as an intensity indicator.

#### RESEARCHES LOCALISATION

Rodnei Mountains present the highest altitudes in the Oriental Carpathian Mountains, dominating the landscape, and the biggest level differences are recorded reported to Maramureş depression, situated at north. The National Park of Rodnei Mountains is situated in the central area of Rodnei Mountains, on the area of Maramureş and Bistriţa Năsăud counties. Internationally, it is designed as Reservation of the Biosphere by UNESCO Committee “the human and the biosphere” based on Ministry Order no. 7 of 1990 issued by the Ministry of Waters, Forests and Environment protection and confirmed by Law 5 of 2000. From a geographic perspective, it extends between 47°25'54” and 47°37'28” northern latitude and 24°31'30” - 25°01'30” eastern latitude, having a total surface of 46,399 ha. (Anonymous, 2010)

Three avalanche paths were considered, situated in Rodnei Mountains, more precisely in the subcompartment 18B, on the Northern versant of Gajei peak, closely to Ineu peak.

#### MATERIAL AND METHOD

Upon taking off the drill cores, a series of characteristics was noted, like: current number, basal diameter, broken limbs, damages, broken peaks, presence of wounds.

For dating extreme events (herein, avalanches) wood discs were taken off from final areas of the avalanches and drill cores of the trees situated in the proximity of the avalanche paths.

The counting of annual rings was realized with the LINTAB 6 system, having a precision of 1/1000 mm. Drill cores and discs were counted from bark to medulla. Discs were taken off from dead trees situated in the storage area of the avalanche paths, and based on the information offered by the National Park of Rodnei Mountains we find that in 2006, in the area was a high magnitude avalanche, bearing down those trees. During the measurements, the characteristics relieving the existence of a major event were highlighted (clogged bark, changing the

appearance place for reaction wood, deviated annual rings etc.).

After noting these characteristics, an identification of forest species localized in the vegetation permanently juvenile, was developed.

#### RESULTS

In order to determine the versants susceptibility on Lala Valley upon the production of extreme snow events (avalanches) the following parameters were considered: exposition, slope, vegetation coverage, lithology and soil conditions.

Concerning the susceptibility degree on producing avalanches, we identified that the production of avalanches is increased by the northern exposition (shaded), which helps the snow to persist a longer time. The slopes of 31-53° generate the extension of avalanche intensity. The presence of subalpine grazing vegetation (juniper trees) even in the detachment area of the avalanches, leads to the production of extreme events, even if there is a coniferous forest in the paths basis. The soil conditions influence the production of avalanches even if in a small measure, the soil being composed of micaschist and paragneise.

These mentioned parameters are essential, according to the specialty literature, bringing forward the production of avalanches.

In order to elucidate the hypothesis issued on the dynamics of radial growth, a close analysis of drill cores and was performed, with the precise purpose to register all traces left by disrupting factors (scars, clogged bark, annual rings deviations etc.). This analysis was performed on each avalanche path, both based on biotic trees, dead wood and on a global analysis.

To obtain an overview of the snow events in the studied area, a common graphic was performed, which integrates the events both from drill cores and from discs.

Based on the results from above, we will realize a statistics of avalanche production in the studied area, considering the results procured from biotic trees.

In the path I snow events (with reaction upon more than five trees) were registered in the years: 1923, 1936, 1947, 1950, 1957, 1962, 1987, 2006 and 2009. It is interesting that in 2006 there are no data recorded by dead wood, because it was borne down by the avalanche of that year. The eliminated trees have no longer recorded the avalanche of 2006, because they were in vegetative dismissal in the moment of its production. (Figure 1)

In the path II, we found out that in the years: 1924, 1928, 1930, 1931, 1934, 1935, 1937, 1946, 1947, 1950, 1952, 1953, 1954, 1957, 1959, 1963, 1965, 1970, 1987, 2006, 2007, 2009 extreme snow events were registered by a large number of trees (more than five trees). We also noticed that in the years

2006, 2007 and 2009 there are no data recorded by dead trees, because they were borne down by the avalanche of April 2006.

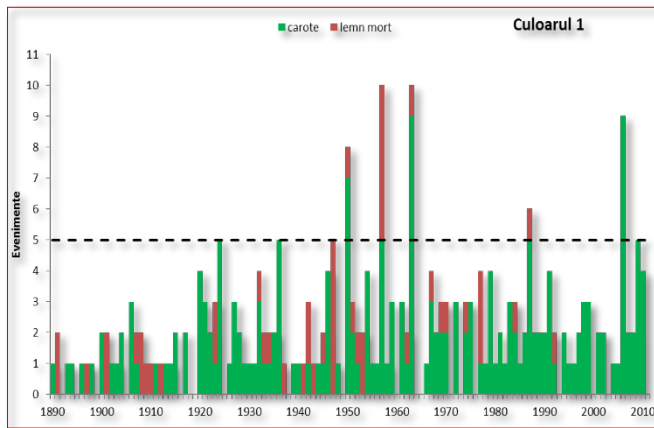


Figure 1. The number of events per year (in the path I)

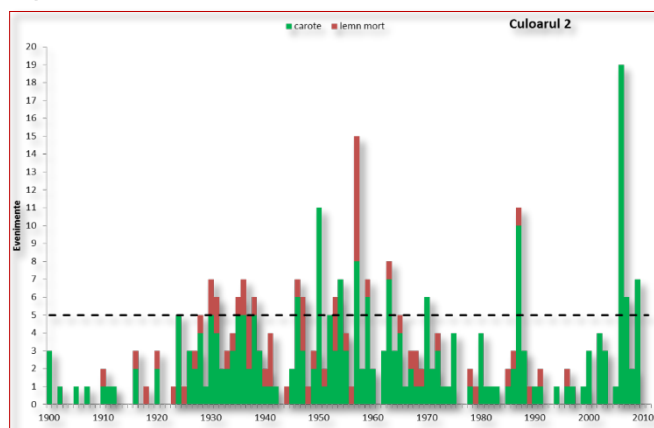


Figure 2. The number of events per years (in the path II)

In path III, over five events were registered in the years 1947 and 1950, with traces mainly on the dead trees.

Hereinafter we will present the recurrence period for the avalanches produced in the study area, considering the material available for the dead and biotic wood (calculated according to each path). Therefore, for the path I the recurrence period is of 5.5 years, for path II it is of 5 years and for path II it was of 55.5 years. The probability to produce an avalanche in a year on path I is of 18.2 %, on path II is of 19.8 % and on path III is of only 1.8 %.

Table 1. Recurrence period and the probability of avalanches production in one year in Ineu Peak

	No. of years	No. of avalanches	Recurrence period (years)	Production probability (%)
Path I	121	22	5.5	18.2
Path II	111	22	5	19.8
Path III	111	2	55.5	1.8

The path III is on a reduced altitude, in the detachment area being installed a compact forest of *Picea Abies* and *Pinus Cembra*.

These statistic data present an especial practice importance, offering essential information for the studies in the field of avalanches production. The low recurrence period of an avalanche indicates a high susceptibility of versants of the right technique side of Lala Valley. The importance of knowing this parameter may be utilized within reforestation planning and prevention of these events.

Concerning the reforestation planning, the focus must be on quickly growing species, with high elasticity coefficients and with taproots.

*Pinus Cembra* is an example of a specie very well adapted to the conditions imposed by avalanches. Using this specie, a stabilization of the versant face to avalanches production may be obtained. However, these solutions cannot be applied in our study area, because of the high degree of protection, but it might be utilized for similar areas situated outside of protected areas.

The constitution of compact forests composed of *Pinus Cembra*, especially in the detachment area, will have a beneficial effect, by retaining the snow and avoiding the deposal of a consistent blanket of snow.

Table 2. Forest species identified in the study area

no.	Family	Specie
1	Caryophyllaceae	Arenaria procera L
2	Caryophyllaceae	Arenaria montania
3	Caryophyllaceae	Dianthus carthusianorum L.
4	Campunulaceae	Campanula abietina L.
5	Ranunculaceae	Caltha palustris L.
6	Brassicaceae	Cardamine pratensis L.
7	Cyperaceae	Carex ovalis
8	Poaceae	Deschampsia caespitosa L.
9	Poaceae	Phleum alpinum L.
10	Poaceae	Trisetum flavescens L.
11	Dryopteridaceae	Dryopteris austriaca
12	Dryopteridaceae	Dryopteris carthusiana (Vill.)
13	Onagraceae	Epilobium angustifolium L.
14	Rosaceae	Geum montanum L.
15	Rosaceae	Rubus idaeus L.
16	Cistaceae	Helianthemum nummularium
17	Hypericaceae	Hypericum maculatum Crantz
18	Hypericaceae	Hypericum perforatum L.
19	Cupressaceae	Juniperus communis L. Subsp. communis
20	Asteraceae	Leucantemum waldsteini
21	Juncaceae	Luzula albida
22	Juncaceae	Luzula luzuloides
23	Juncaceae	Luzula sylvatica L.
24	Pinaceae	Picea abies (L.) Karst.
25	Pinaceae	Pinus cembra L.
26	Polytrichaceae	Polytrichum commune L.
27	Polygonaceae	Rumex alpinus L.
28	Salicaceae	Salix caprea L.
29	Saxifragaceae	Saxifraga stellaris L.
30	Fabaceae	Trifolium repens L.
31	Ericaceae	Vaccinium myrtillus L.
32	Violaceae	Viola biflora L.

The avalanches patches generate a rich floristic diversity being appreciated by the fauna of the forest. The previous biocenosis was mainly formed by *Picea Abies*, which after an avalanche is replaced by a richer biocenosis. At a first ascertainment, the last one is composed of 22 families, with 32 species which enrich the forest vegetation (table 2). At this point, we may make reference to the succession dynamics, by which we understand the replacement of some biocenosis with others. When some species are replaced, modifications are produced in the biocenosis too. The secondary succession in our country occupies a top place compared to the primary succession, because a new biocenosis is installed in the same place where a different one which has been destroyed by natural or artificial causes.

The species composing the new biocenosis are mainly semi-shaded species, due to the 4 main parameters (exposition, slope, vegetation coverage, lithology), factors generating avalanches. (table 3)

**Table 3.** The classification of forest species depending on their different requirement of light

Species	heliophile	helio-sciofile	sciofile
	6	24	2

The vegetation inside the avalanches paths represent a rich source of food for wild animals, but unfortunately it is a source of food for domestic animals too, and they represent for human valuable product accessories. For example, *Vaccinium myrtillus L.*, is highly appreciated by *Ursus Arctos*.

### CONCLUSIONS

We considered an avalanche when the presence of some traces was identified upon a number of minimum five trees. For the dead wood in the path I, scars were identified in years 1947 and 1957, in path II these are observed in year 1957 and in path III the majority of events were registered in 1947, with four events.

Based on the results signaled by the presence of events in dead and biotic wood, we will realize a statistics of avalanches production in our study area, per avalanches paths. Over five snow events were registered in path I in years 1923, 1936, 1947, 1950, 1957, 1962, 1987, 2006 and 2009, in path II snow events were recorded in years 1924, 1928, 1930, 1931, 1934, 1935, 1937, 1946, 1947, 1950, 1952, 1953, 1954, 1957, 1959, 1963, 1965, 1970, 1987, 2006, 2007, 2009, and for path II, the years 1947 and 1950 are probative.

The recurrence period for avalanches produced in the study area for dead and biotic wood for path I is of 5.5 years, for path II it is of 5 years and for path II it was of 55.5 years. Thus, the probability of producing an avalanche in a year on path I is of 18.2 %, on path II is of 19.8 % and on path III is of only 1.8 %.

In a first analysis, 32 species were identified as part of the juvenile vegetation inside the avalanches paths.

### Acknowledgement

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1. Vikas GUPTA, 2. Sahil SHARMA, 3. Sunny NARAYAN

## REVIEW OF WORKING OF STIRLING ENGINES

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**Abstract:** For past years the primary goal of clean energy industry has been to analyze ways to harness novel ways of energy conversion. Stirling engines are one of such devices. These can be constructed with minimum costs and operated using cheap sources of heat. However a major backlog of these devices is low power output as well as low system efficiency. In this work working of this engine has been analyzed with potential future recommendations for use to harvest solar energy.

**Keywords:** stirling engines, clean energy industry, energy conversion

### INTRODUCTION

A thermal engine is a device which converts heat energy into mechanical energy. The operation of a heat engine can be described by a simple thermodynamic cycle as follows:

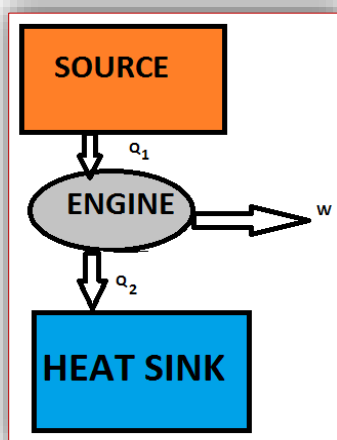


Figure 1: Heat engine [1]

Efficiency of cycle may be expressed as:

$$\frac{W}{Q_h} = \frac{Q_h - Q_c}{Q_h}$$

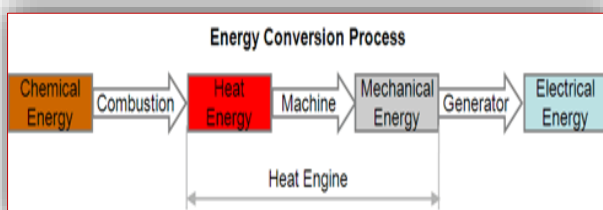


Figure 2: Energy conversion in a Heat Engine [1]

Heat engines can be further classified as external combustion engine or internal combustion engine.

An engine where fuel is burnt outside the engine is an external combustion engine, whereas in the internal combustion engine, the fuel is burnt inside the engine. An engine operating on a Carnot or Stirling cycle is an example of an external combustion engine while one operating on an Otto or Diesel cycle is an internal combustion engine. Comparison of these cycles is presented below.

Table 1: Comparison of various engines [1]

Cycle	Compression	Expansion	Heat addition	Heat Removal
Carnot	Adiabatic	Adiabatic	Isothermal	Isothermal
Stirling	Isothermal	Isothermal	Isometric	Isometric
Otto	Adiabatic	Adiabatic	Isometric	Isometric

### BACKGROUND

During the industrial revolution of 18<sup>th</sup> century, steam engine became a primary source of power. But this device has its own drawbacks. Its maximum efficiency is at the most 2% and there were many accidents involving explosions. This prompted engineers to look for alternative sources of power like Stirling engines.

A Stirling engine is a hot air engine operating on the principle that air expands on being heated and contracts on being cooled. These devices have zero exhaust and are external combustion engines, hence wide variety of fuels can be used to run a Stirling engine which include alcohol, bio-products or waste gases etc. These engines are suitable for operations which have following needs [2].

- Constant power output.
- Noise less operation.
- Long startup period.
- Low speeds.

Development of Stirling engine is widely attributed to the Scottish scientist Sir Robert Stirling. The first version of this engine developed in 1815 was heated by fire and air cooled. Figures of some of these early versions are presented in coming sections.

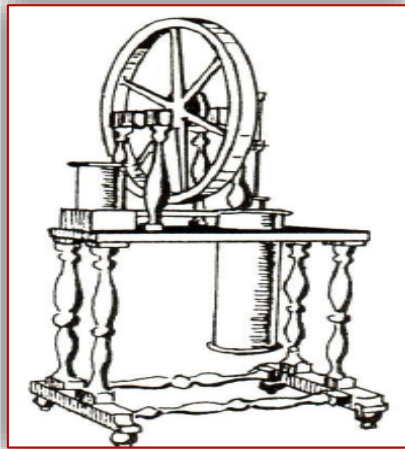


Figure 3: Earliest version of a Stirling engine developed by Stirling brothers [3]

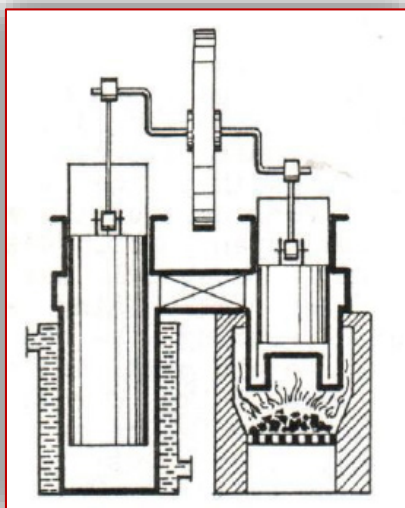


Figure 4: Alpha type Stirling engine developed in 1875[4]

Later Erickson in the year 1864 invented the solar powered engine to heat the displacer tube at hot side. The heat was obtained by use of solar reflectors. First alpha type engine was built in the year 1875 by Rider. Reader and Hooper proposed the first solar powered heat engine for irrigation purposes in the year 1908. Following this Jordan and Ibele designed a 100W solar powered engine for pumping of water. In year 1983 a low temperature difference Stirling engine was patented by the White having an efficiency of about 30%. Colin later presented a design with a low temperature difference of 15°C & Senft published specifications of an engine with very low temperature difference of 5°C between hot and cold ends[5].

Some of following events can be considered as important milestones in the design and development of a Stirling engine for use as a pump:

- » 1688: Thomas Savery develops a drainage pump which was a liquid piston machine.
- » 1909: Development of Humphrey pump.
- » 1931: Malone designed and developed an engine with regenerative cycle similar to a Stirling engine.
- » 1965: Philips Company patented a Stirling engine.
- » 1977: The metal box company develops Stirling engine for irrigation purposes in Harwell lab.
- » 1985: McDonnell designed an engine with parabolic reflectors to focus solar energy thus achieving a high temperature of 1400°C.

### STIRLING ENGINES

In a Stirling engine the fluid is contained in a confined space, hence there are no problems of contamination. In order to reduce the heat losses, the mass flow rate must be low which can be maintained by low viscosity fluid or high working pressures. These engines are 30 to 40% efficient in a temperature range of 923–1073 K [6].

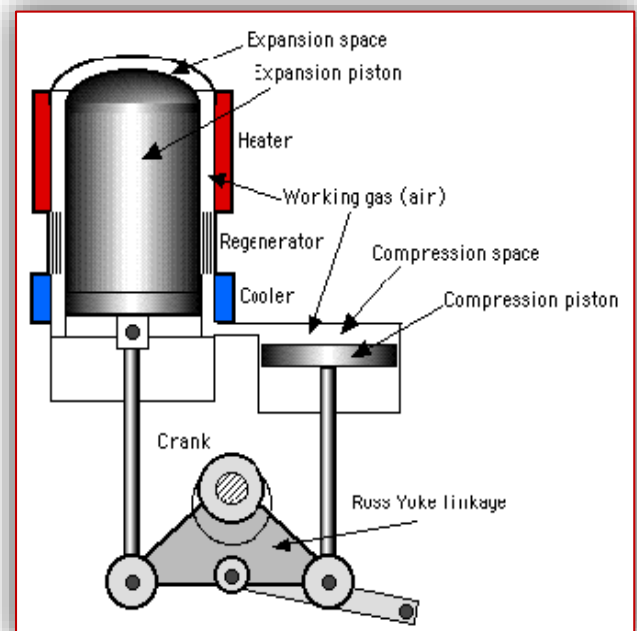


Figure 4: Stirling engine [7]

A Stirling engine consists of following components:

1. Heat source - as fuel does not come in direct contact with the working fluid, Stirling engines can work on fluids which may damage parts of a conventional engine.
2. Regenerator - the function of regenerator is to use the waste heat from being lost to environment by storing it temporarily, thus helping to achieve high efficiencies close to an ideal Carnot cycle. A simple configuration consists of fine mesh of metallic wires.

In an ideal Stirling cycle, the connecting space between hot and cold ends acts as regenerator.

3. Heat sink - typically the ambient environment acts as an ideal heat sink, otherwise the cold side can be maintained by iced water or cold fluids like liquid nitrogen.

4. Displacer piston - it causes the displacement of working gas between hot and cold regions so that expansion and contraction occurs alternatively for operation of engine.

5. Power piston - transmit's the pressure to crankshaft.

In a Stirling engine, hot air expands when heated and contracts when cooled. This principle of operation was most properly understood by Irish scientist Robert Boyle from his results on experiments on air trapped in a J shaped glass tube.

Boyle stated that pressure of a gas is inversely proportional to its volume and product of pressure and volume occupied is a constant depending on temperature of gas.

$$\text{Hence } PV = NRT \quad [2]$$

Various assumptions are made in this cycle are: [8]

- 1) Working fluid is an ideal gas.
- 2) Conduction and flow resistance is negligible.
- 3) Frictional losses are neglected.
- 4) Iso-thermal expansion and contraction.

This cycle can be described by following stages: [9]

1) Phase C-D: -the working fluid undergoes an iso-thermal expansion absorbing the heat from source. The power piston moves out, hence increasing the volume and reducing the pressure. The work done in expansion of gas is given by:

$$W_e = RT \log\left(\frac{V_D}{V_C}\right) = \int P dV \quad [3]$$

$$= NRT_c \log\left(\frac{V_D}{V_C}\right) \quad [4]$$

2) Phase D-A: Power piston now reaches the outermost position and stays there so that volume is constant. The working fluid is passed through the regenerator where it gives up heat for use in next cycle. Hence its temperature and pressure falls. No work is done during this phase.

3) Phase A-B: The power piston starts moving inwards, reducing its volume and increasing its pressure the working fluid gives up heat to cold sink. The work done in compressing the gas is given by:

$$W_c = RT \log\left(\frac{V_B}{V_A}\right) = \int P dV \quad [5]$$

$$= NRT_H \log\left(\frac{V_B}{V_A}\right) \quad [6]$$

4) Phase 2-3: The power piston is at its most inwards point and stays there to keep volume constant. Working fluid passes again through the regenerator, recovering the heat lost in 2<sup>nd</sup> phase, hence its pressure and temperature goes up.

$$W_{net} = W_e - W_c \quad [7]$$

$$= NR [T_h - T_c] \log\left(\frac{V_{max}}{V_{min}}\right) \quad [8]$$

But

$$V_B = V_C, V_A = V_D \quad [9]$$

Hence efficiency of system may be expressed as –

$$\frac{W}{Q_h} = \frac{NR [T_h - T_c] \log\left[\frac{V_{max}}{V_{min}}\right]}{NR [T_h] \log\left[\frac{V_{max}}{V_{min}}\right]} \quad [10]$$

$$\frac{W}{Q_h} = \frac{[T_h - T_c]}{[T_h]} \quad [11]$$

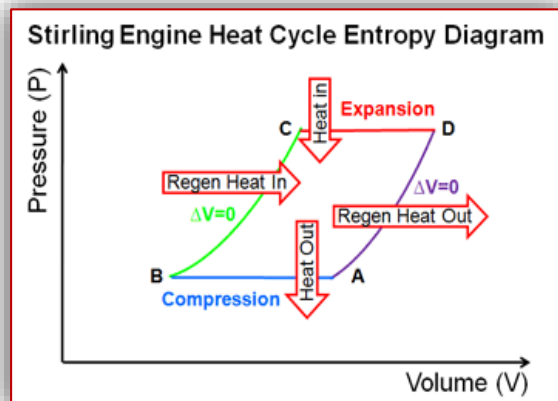
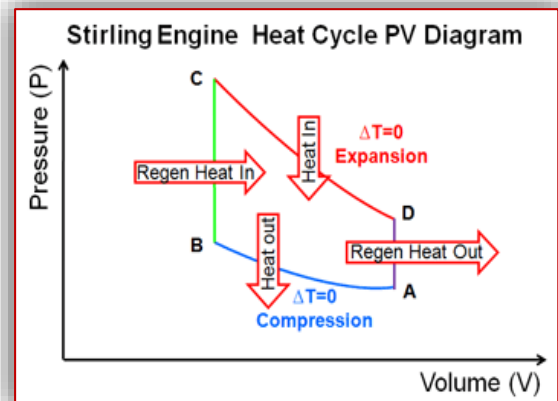


Figure 5: P-V & T-S plot of a Stirling cycle [9]

In Stirling cycle, two Isochoric processes replace the two Iso-entropic processes in an ideal Carnot cycle. Hence more work is available than a Carnot cycle as net area under P-V curve is more. Thus there is no need for high pressures or swept volumes. This can be seen in the figures presented below.

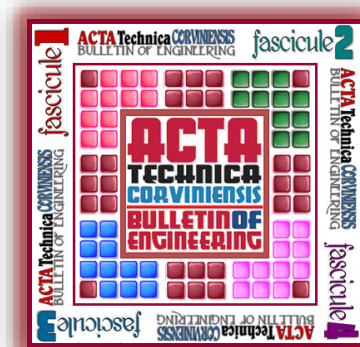
#### CONCLUSION

Most common application of the Stirling engines is as a liquid piston system for use in irrigation pumping. Other important applications include use as drainage pumping, fail safe cooling of nuclear reactors, cooling of combustion engine with waste heat, circulation of water in remote areas without use of electricity. These devices are simple to construct and can be used easily for demonstrations and teaching purposes.



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## SELECTING EQUIPMENT AND SUPPLIES FOR SELF-REPLICATING 3D PRINTER

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**Abstract:** A RepRap 3D Printer machine is built in the University of Debrecen, Building Mechatronics Research Centre. The 3D Printer technology will start a second industrial revolution and reforming our everyday life. There are a number of different types of 3D printers, is a Fused Deposition Modelling (FDM) rapid prototyping open-source and low-cost 3D printer machine. All parts of our 3D Printer model are basic materials and available everywhere in the world. The Building Mechatronics Research Centre in the University of Debrecen, as intelligent building provides research infrastructure for building 3D Printers to print out of our 3D model prototypes. The technology guarantee that further robot research projects will be completed. In this context, this paper focuses on the optimization and the construction method of the 3D Printer.

**Keywords:** 3D printer; building automation; self-replicating; extruder; life cycle

### INTRODUCTION

Nowadays, the development of science is very rapid process. Many new technology devices, programs and methods are appeared. One of these new invention is the 3D printing. The 3D printer technology is broad and relatively new scientific field that has been developed in the framework of the Computer Aided Design field. The CAD has revolutionized the engineering design process, and the next step are going to start a new revolution.

The 3D printing is a high level additive manufacturing process of making three dimensional objects from CAD files. The technology has been opened many options to create and test our brand new mechanics or robot tools, this is particularly important nowadays, when unique productions are done industrially. From now on the design and production method can be done by single person.

There is a growing demand for the optimized use of the conventional forms of energy. The main key is building mechatronics which can develop and optimize further the 3D printer technology.

In the University of Debrecen, Faculty of Engineering, Department of Electrical Engineering and Mechatronics, the Building Mechatronics Research Centre as intelligent building provides research infrastructure for researches and becomes a knowledge base.[1] Our department has been established a new laboratory for young mechatronic researchers who have completed the Bachelor of Science degree. [2]

The main goal of the activity of the laboratory is the study 3D printer technology and the programming as well.

International researches carried out in the laboratory promote the activity of designers, to use more efficient the 3D printers, and filaments in production aspect.

The aim of the article is to propose the Building Mechatronics Research Centre as Energy Aware Intelligent Space and present recent researches in connection with the additive manufacturing, 3D printer solutions, and building mechatronics systems.

The paper is organized as follows: Section II is about the Building Mechatronics Research Centre as Energy Aware Intelligent Space. Section III presents the self-replicating 3D printer. Section IV describes the right selection of equipment. Section V. includes the summary. Section VI provides giving thanks.

### BUILDING MECHATRONICS RESEARCH CENTRE AS INTELLIGENT SPACE

In the University of Debrecen, the Building Mechatronics Research Centre is equipped with surveillance and security system. Two heat pump systems provide energy for the education and living premises. [3] The surveillance and security system retrieves data about the number of residents staying in the rooms.

As Hashimoto [4] writes in his paper: “The Intelligent Space is an area (room, public space, etc.) that has networked distributed sensors, which can

be used for observing and gathering information from the space.” The camera system within the building is capable of cooperative object tracking. It allows gathering information not only about the space but also the people staying in it. Morioka [5] states, it is important to track target objects and get the positional information of them in intelligent environments.

In our case, the target objects are residents and 3D printer whose position is of high importance for the security system of the building. 3D printing is a disruptive force in manufacturing, but with the benefits come safety risks. The Building Mechatronics Research Centre has a unique security system with object tracking IP cameras and sensors as well. Previously we used the system to study higher energy consumption awareness through the examination of the consumer’s behaviors and stored every data of the Building Automation System (BAS) in data bases. [6] The system focuses now the observation of the 3D printer laboratory during the printing process to avoid accidents. All kind of Fused Deposition Modelling (FDM) printers extrude above 150 Celsius and the heated bed at least 60 Celsius. [7] Beyond these obvious safety hazards, there is growing concern with preventing accidents. Therefore reasons our laboratory is under 24-hour surveillance by TCP/IP cameras. [8]

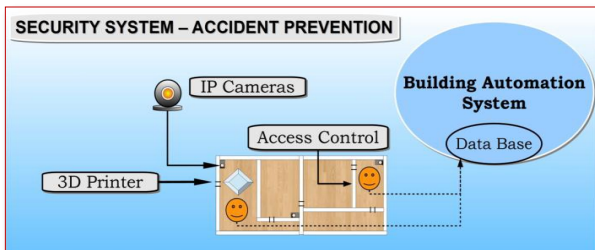


Figure 1. Security system – accident prevention  
Source: Compiled by authors

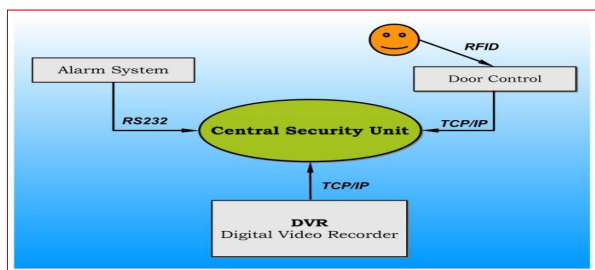


Figure 2. Surveillance system of the building mechatronics research center  
Source: Compiled by authors

The primary idea is to focus on system operation with auto– detect mechanism such as alarm system, door control and vision sensors. The building administrator can control the security system and report all suspicious events that appeared. The high resolution TCP/IP cameras can

be reached anytime through the internet. Communication is realized with Modbus and M–bus technology. The advanced controls store every data in a data base for surveillance. [9]

### THE SELF-REPLICATING 3D PRINTER

The Rapid Prototyping (RP) was the first 3D printing technology in 1980’s. It provided more cost effective method for creating prototypes from 3D CAD models. In 1986 Charles Hull [10] was issued the first patent for stereolithography apparatus. From that day many new 3D Printer machines have been invented. One of the first commercial 3D printer machine was the RepRap Darwin project in March 2007. The RepRap and other entry–level machines are Fused Deposition Modelling (FDM) printers. [11]

In the University of Debrecen, Faculty of Engineering, Department of Electrical Engineering and Mechatronics, the Building Mechatronics Research Centre provided research infrastructure to build a low–cost 3D printer. The optimal choice was the Prusa Mendel iteration 2 FDM type of RepRap. This model is an improvement of the Prusa Mendel iteration 1, and it was realized in November 2011. The main reasons why we chose this model of RepRap are as follows:

- ≡ Open source philosophy
- ≡ Self–replicating
- ≡ Cost–effectiveness
- ≡ Fused Deposition Modelling (FDM)
- ≡ Reliable printing
- ≡ Available components

Our self–replicating RepRap Prusa Mendel i2 model was built in October 2014 and from than can be found in the 3D Printer Laboratory of the Building Mechatronics Research Centre.

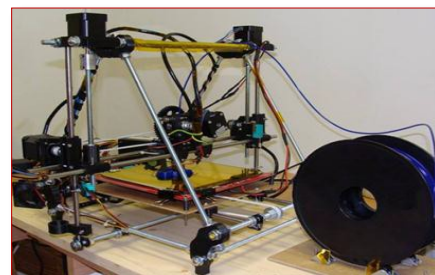


Figure 3. Self–replicating 3D printer – FDM type  
Source: Photographed by authors

The external dimensions of the self–replicating 3D printer are 44x47x37 centimetres. We can print precise 3D objects up to 120mm x 100mm x 100mm. [12] Generally we use to print thermoplastic materials like Polylactic acid (PLA) or Acrylonitrile Butadiene Styrene (ABS) plastics.

The printing is a very complicate process and it starts with a 3D CAD file designed in program or



scanned. After that we take 3D CAD model, slice it into layers and send that G-code to the 3D printer. [13] The manufacture process works by melting thermoplastic filament that is go through the “Hot End” of the extruder. The extruded material falls onto the heated bed and layer by layer the self-replicating machine creates predetermined 3D object. [14]

The speed of the process depends on size and the complexity of 3D CAD model. In the 3D printer laboratory we printed many 3D components for our further researches in robotics such as KUKA KR5, and Maki Robot. [15] Generally all models represents a high level of quality. One of our printed gears for replacement part of the 3D printer.



Figure 3. Self-replicating 3D printed gears

Source: Photographed by authors

The self-replicating printer is a unique machine, because most parts of the frame can be downloaded and printable.

#### SELECTING EQUIPMENT AND SUPPLIES FOR SELF-REPLICATING 3D PRINTER

The standard Prusa Mendel iteration 2 printer kit includes stepper motors, Pololu motor controllers, end stops, Arduino Mega2560, Ramps 1.4. etc. [16] The parameters of the parts determines the precision of self-replicating 3D printer. Therefore we tried to choose the parts with the best available parameters. A majority of the components were purchased such as extruder, polylactic acid, stepper motors and motor controllers.

The most important part of the machine is an Arduino based modular RepRap board, which designed to fit the entire electronics. The RepRap Arduino Mega Pololu Shield (RAMPS) [17], interfaces an Arduino MEGA 2560 development platform. The modular design of the RAMPS includes plug in Pololu A4988 stepper motor drivers. The assembled board can control the stepper motors, extruder and the heating system. [18]

The main parts of 3D printer electronic:

- ≡ RepRap Arduino Mega Pololu Shield 1.4 (RAMPS)
- ≡ Arduino MEGA 2560 Rev.3
- ≡ NEMA17 High Torque Hybrid Stepper motors
- ≡ Pololu A4988 stepper motor drivers
- ≡ Extruder assembly
- ≡ MK3 heated bed

The latest version of the RAMPS is 1.4 which contains better capacitors and resistors. Furthermore it has short-circuit protection. The NEMA17 Hybrid Stepper motor the most commonly used parts of the self-replicating 3D printer. This type of stepper motor rated 1.5A to 1.8A and 1.8 or 0.9 degrees per step. [19] After assembly phase we have to upload the current firmware to Arduino MEGA 2560 Rev.3 board and start calibration. Forasmuch as we selected the appropriate devices for the self-replicating 3D printer, than we can achieve the predetermined precision of the printed 3D object. The first printed 3D CAD model was a 20mm cube, the difference was only 0.01 millimetres.

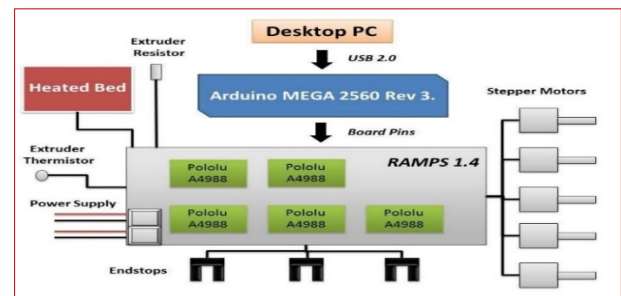


Figure 4. Self-replicating 3D printer – block diagram

Source: Compiled by authors



Figure 5. Self-replicating 3D printed – 20mm cube

Source: Photographed by authors

As mentioned before the self-replicating 3D printer benefits come with safety risks. It extrudes above 180 Celsius and the temperature of the heated bed is 60 Celsius. The Fused Deposition Modelling (FDM) types of printers can cause easily fire during the manufacture process.

In the University of Debrecen, the Building Mechatronics Research Centre is equipped with surveillance and security system [20] that we can reach and control via internet. In the 3D printer laboratory we installed a high resolution IP camera to reduce fire-related accidents.

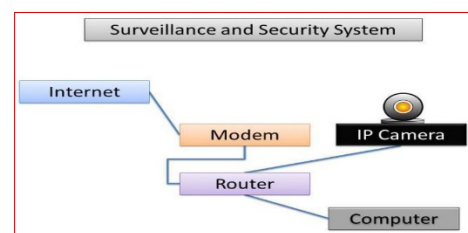


Figure 6. Surveillance and security system – block diagram. Source: Compiled by authors

The camera is used as vision sensor that can recognize the environment. First of all, we determined the influence and optimal position from the self-replicating printer. In the controlling and monitoring center we can follow the 3D printing and terminate the process. This method provides a chance to prevent the accidents related to 3D printer.

### CONCLUSION

The reference self-replicating 3D printer and the surveillance and security system are important starting points for further researches in robotics and building automation system. In our case, the target objects are residents and 3D printer whose position is of high importance for the security system of the building. The Building Mechatronics Research Centre has a unique security system with object tracking IP cameras and sensors as well. The camera is used as vision sensor that can recognize the environment. First of all, we determined the influence and optimal position from the self-replicating printer. In the controlling and monitoring center we can follow the 3D printing and terminate the process. Previously we used the system to study higher energy consumption awareness through the examination of the consumer's behaviors and stored every data of the Building Automation System (BAS) in data bases. 3D printing is a disruptive force in manufacturing, but with the benefits come safety risks.

### Acknowledgement

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## REVERSE LOGISTICS AND GREEN LOGISTICS WAY TO IMPROVING THE ENVIRONMENTAL SUSTAINABILITY

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**Abstract:** To survive in today's competitive and changeable marketplace, companies need not only to engage in their products and/or services, but also to focus on the management of the whole supply chain. Effectively managing and balancing the profitability and interconnection of each player and function in the supply chain with including the new trends will improve the overall supply chain as well as individual profit. Logistics are an important function of modern business systems. Consideration of environmental and economic aspects in supply chain design is required to reduce negative impacts on the environment caused by the increasing levels of industrialization. Also, reasons why companies choose to “go green” is that it gives the company a competitive advantage as the customers are demanding now a days that the businesses go green. In this paper, an overview of new trends such reverse logistics and green logistics, as part of green supply chain, is given with analysis of its significance in modern day systems.

**Keywords:** Reverse Logistics, Green Logistics, Supply Chain, Sustainability

### INTRODUCTION

Logistics is a big part of companies' actions. More focus is put on logistics and methods that are practiced within logistics. This is because money can be saved and give a competitive advantage to the company. Another factor that is affecting logistics is the pressure that comes from governments and customers. Governments are putting pressure on companies to be green and choose green options within logistics through legislations and laws. Meanwhile customers are getting more and more aware of greenness. So the importance with logistics and the methods behind are getting more attention than before. Practices such as reverse logistics give companies a competitive advantage when used effectively, and it can also protect the company. It is also a method that is considered to be green and is a part of green logistics.

According to Waters, 2007 [1], logistics can be defined as a: “Function responsible for all movements of materials through the supply chain”. A definition for supply chain management from [1] is: “A supply chain is the series of activities and organizations that materials both tangible and intangible– move through on their journeys from initial suppliers to final customers. Some say that the difference between

supply chain management and logistics is that supply chain management considers the whole chain.”

The Institute of Logistics [2] separates logistics and supply chain management in these definitions: “Logistics is the time related positioning of resources or the strategic management of the total supply chain.” Meanwhile, the supply chain is a sequence of events intended to satisfy a customer. It can include procurement, manufacture, distribution and waste disposal, together with associated transport, storage and information technology.

New trends, reverse logistics and green logistics are subjects that are getting more important in the business world. This paper gives an overview of characteristics and opportunities of those trends. Here are given general introduction on those aspects. According to Mitra (2009) [3], planning and implementing a suitable reverse logistics network could bring more profit, customer satisfaction and a nice social picture for the companies. As a result, a good reverse logistics model in the company gives the company a good competitive advantage and also helps the company to save money and make a better profit. Even though reverse logistics has an important part of the supply chain management,



many companies still use outdated processes that contributes to the supply chain inefficiencies and excessive inventory and costs. But most of the logistics networks are not equipped to handle the return products in reverse channels. An increasing trend is also outsourcing the reverse logistics, since companies do not have the expertise in the subject themselves.

Green logistics is becoming very important in the corporate world, since the demands on companies are getting stricter and the green logistics have to be considered throughout the process in the business. In the late 1980s and in the early 1990s greenness became a catchword in the industry. Since the World Commission on Environment and Development set an establishment of environmental sustainability as a mission for international action, it gave the green issue a remarkable push in the economical and political fields. Then, logistics was a developing subject seen by many as an opportunity to adopt a more green and environmental face [1,2,3].

### CONCEPTS OF LOGISTICS AND SUPPLY CHAIN

#### » Logistics

Logistics is the terminology used to describe the transportation, storage and handling of products as they move from the source of raw materials, through the production system to their final point of sale or consumption.

Starting from the early '60s, many factors, such as deregulation, competitive pressures, information technology, globalization, profit leverage, etc., contributed to the increase of logistics science in the form we know it today. Its core activities have been fundamental to economic development and social life, but during the past 50 years that logistics has come to be regarded as one of key determinants of business performance, subject for professional and academic study with objectives to organize logistics in a way that maximizes profitability. The calculation of profitability, however, has included only the economic costs that companies directly incur. The wider environmental and social costs, traditionally excluded from the balance sheet, have been largely ignored, until recently. Over the last few years, those costs have become logistics' components of interest. Logistics management tries to have the "right product", in the "right quantity", at the "right place", at the "right time", with the "right cost". Logistics management must balance two basic targets: quality of service and low cost. According to Council of Logistic Management, logistics is defined as: "process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements."

The logistics activities can be classified into a) core and b) supporting.

The core activities take place in every supply channel and those are: goods transport, storage, inventory management, overall material handling and related information processing. They contribute the most to the total cost of logistics or they are essential to the effective coordination and completion of the logistics task.

Support activities vary from company to company and a comprehensive list includes:

1. Warehousing (Space determination, stock layout, configuration, stock placement)
2. Materials handling (equipment selection & replacement policies, order-picking procedures, stock storage & retrieval)
3. Purchasing (supply source selection, purchase timing, purchase quantities)
4. Protective packaging (designed for handling, storage, protection from loss/damage)
5. Cooperate with production/operations (specify aggregate quantities, sequence & time production output, schedule supplies)
6. Information maintenance (info collection, storage & manipulation, data analysis, control procedures)

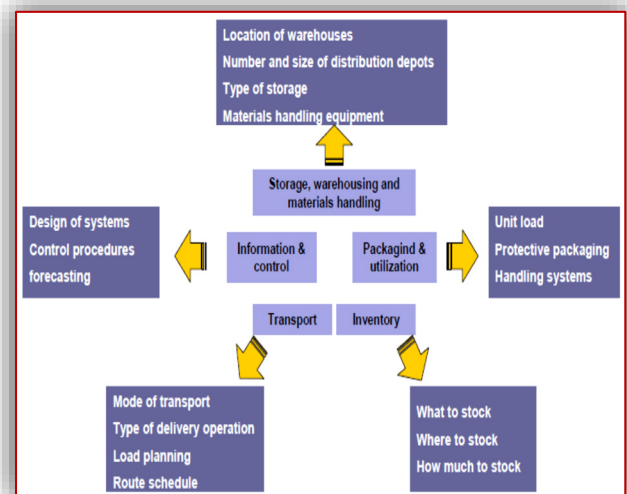


Figure 1. Key components of Logistics

Illustrative presentation of key components of logistics is given at the Figure 1, according to Rushton all (2014) [4]:

#### » Supply Chain

A supply chain is a network consisting of a chain of activities, facilities, people and other resources directly or indirectly involved in fulfilling goods to customers. The main objective of supply chain is to satisfy the customer requirements. This term "supply chain" came when Cooper et al. [5] addressed it as the extension of logistics.

Supply chain consists of all stages involved directly or indirectly in fulfilling a customer request [5]. It is

a multistage system involving a constant flow of information, material and product between different stages. Each stage of the supply chain performs different functions. The complexity of the chain may vary from industry to industry and from company to company. Supply chain performance has become a critical issue in many industries due to increased competition. Supply chain has its own unique set of market demands, operating challenges and issue remains essentially the same in every case.

A typical supply chain consisting of different levels e.g. supplier, manufacturer, distributor, retailer and customer, who work together in an effort to acquire raw materials, convert these raw materials into specified final products and deliver these final products to retailers (shown in Fig. 2). It is, therefore, a network of companies which influence each other [6].

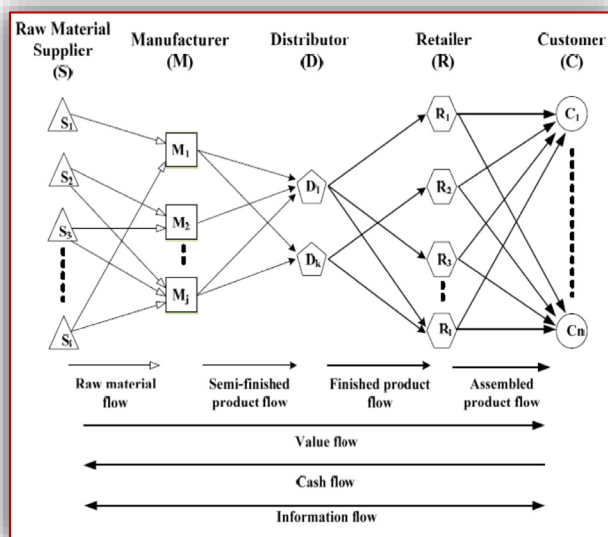


Figure 2. Supply Chain Network

As demonstrated in Figure 2, the materials flow and products flow start from raw material suppliers to final customers. This is called supply flow or value flow across downstream side. In the upstream side [4], the cash flow occurs when stakeholders of supply chains exchange their products or services for some form of payment to satisfy customer needs [8]. The information flow occurs in both directions and is related to materials, customer demands, facilities, cash etc.

Supply chain management is a combination of activities, approaches, and knowledge utilized to efficiently integrate raw material suppliers, manufacturers, distributors, retailers, and customers, so that goal is produced and distributed in right quantities, to the right locations and at the right time while minimizing system-wide costs and satisfying service level requirements. Additionally, these activities can be analyzed at strategic, tactical, and operational levels that concern the different

decision-makings about the source, location, production, inventory and transportation from a time perspective (Strategic – Long term, Tactical – Medium term, Operational– Short term) [37].

#### » Differences between logistics and SC

Supply chain management is different from the traditional concept of logistics [9]. Logistics typically refers to activities that occur within the boundaries of a single organization and supply chain refers to a network of companies that work together and co-ordinate their actions to deliver a product to market. Logistics focuses its attention on activities such as procurement, distribution, maintenance and inventory management. Supply chain management (SCM) acknowledges all of traditional logistics and also includes activities such as marketing, new product development, finance and customer service. SCM is the planning and execution of supply chain activities, ensuring a coordinated flow within the enterprises and among integrated companies. These activities include the sourcing of raw materials and parts, manufacturing and assembly, warehousing and inventory tracking order entry and order management, distribution across all channels and ultimately deliver to the customer. The primary objectives of SCM are to reduce supply cost, improve product margins, increase manufacturing throughput, and improve return on investment.

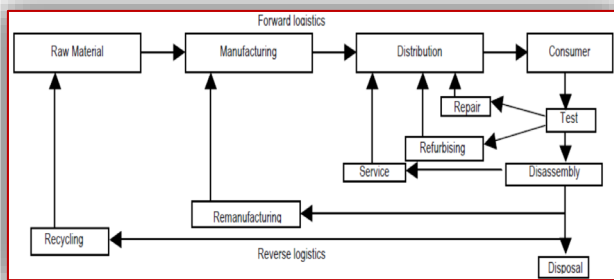
#### CONCEPTS OF REVERSE LOGISTICS AND GREEN LOGISTICS

##### » Concept of Reverse Logistics

The business concept of Reverse Logistics (RL), as a new trend, has received growing attention in the last decades, mostly due to the environmental and regulatory impacts, competition, marketing motives and direct economic motives. With the legislative measures go up, there are not many options left with the companies, than to go to RL practices. New organizational paradigms have been created as environmental issues play a more important role in cooperative strategies, according to presentation of Gonzalez-Torre et al., 2004 [10]. The various aspects in integrative collaboration can be a valuable source of increased performance for organizations willing to consolidate their RL processes (Ravi et al., 2005) [12].

In following paragraph, are given few definitions for good presentation of this new trend in logistics. Definition according to [10] is as follows: “Reverse logistics is a process in which a manufacturer systematically accepts preciously shipped products or parts from the point for consumption for possible recycling, remanufacturing or disposal.” Another definition by [11] is that RL is “the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related

information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal.” Ravi et al. (2005) [12] indicates that RL refers to a set of programs or competencies aimed at moving products in the reverse direction in the supply chain (i.e., from consumer to producer). A growing number of companies start to focus a lot more on the reuses, remanufacturing, recycling and disposals of products and materials in their environmental management practices. RL involves planning, implementing, and controlling an efficient, cost effective flow of raw materials, in-process inventory, finished goods, and pertinent information from consumption to retrieval or proper disposal of the product. Figure 1 is a representation of forward logistics and reverse logistics flows.



**Figure 3.** Forward logistics and reverse logistics Flows [14]

With the progressive increase in environmental concerns, the efficiency focus, importance of value delivery through co-creation and co-production as well as the need for improving core competencies while strategically positioning in the global competitive market, the understanding of RL shifts towards the “coordinated”, “centralized”, “consolidated” and “integrated” network value chain. Although RL have large potential for increased performance and improved customer relationship, the potential value of effective RL is often underestimated. RL leads to the fear of losing control over the organizational processes with the extra work involved in its multi-layer steps and results in the reluctance to pioneer a new organizational structure. But it is underestimated that if RL is used effectively it results in improved firm outcomes such as improved customer satisfaction, decreased resource investment levels, and reductions in storage and distribution costs.

= **RL benefits**

In references [11,12,14], they identify five ways that proactive reverse logistics can have a positive impact on profitability:

1. Increased revenues realized from secondary sales
2. Offering new products in place of unsold or slow selling stock
3. Shareholder goodwill from acting with social and environmental responsibility

4. Reduced operating costs from reuse of recovered products and components
5. Higher asset turnover due to better management of returns inventory

= **RL challenges**

Within the reverse logistics there are challenges that differ from the forward flow of materials and products. These are challenges according to Srivastava (2008) [14]:

1. Large variations in timing, quality and quantity of product returns
2. Lack of formal product returns procedures
3. Delayed product returns reducing their market value
4. Lack of local competence in inspection, evaluation and disposition of returns
5. Risk of cannibalizing new product markets
6. Lack of performance measurement for return process efficiency

Issues that make it difficult to forecast and allocate resources to return systems in reverse logistics are factors such as timing, quality and the quantity of product returns.

= **RL areas**

According to Kaynak et al. (2014) [11], there are five different key areas for reverse logistics

1. Returns prevention and warranty/repair policies
2. Logistics
3. Repair operations
4. Recycling and reuse
5. Product design for environment and service

» **Concept of Green Logistics**

Over the past 10–15 years, against a background of increasing public and government concern for the environment, companies have come under mounting pressure to reduce the environmental impact of their logistics operations [19]. The distribution of goods impairs local air quality, generates carbon emissions, noise, and vibration, causes accidents and makes a significant contribution to global warming. The impact of logistics on climate change has attracted increasing attention in recent years, partly because controls on pollution.

According to analyzes literature, here are given few definition for green logistics. Sbihi at all (2007) [15] defined green logistics as: “Green logistics is concerned with producing and distributing goods in a sustainable way, taking account of environmental and social factors”. According to other definition, the green logistics by Seuring at all (2009) [16] is: “Efforts to measure and minimize the environmental impact of logistics activities, these activities include a proactive design for disassembly”. Activities that are dealt with in green logistics is measuring the environmental impact of different distribution strategies, reducing the energy usage in logistics



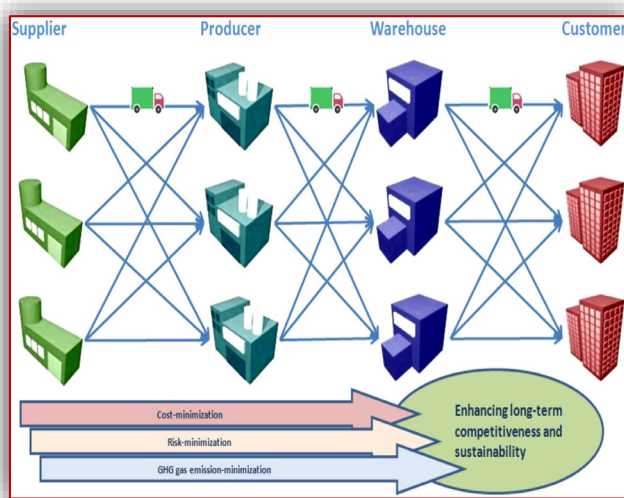
activities, and reducing waste and managing its treatment. In order to be able to deal with these topics companies are now days measuring their carbon footprints, so that the environmental impact of the company's activities can be monitored.

**Green logistics** is a form of logistics which is calculated to be environmentally and often socially friendly in addition to economically functional. It describes all attempts to measure and minimize the ecological impact of logistics activities. This includes all activities of the forward and reverse flows of products, information and services between the point of origin and the point of consumption. It is the aim to create a sustainable company value using a balance of economic and environmental efficiency. A business can gain the following benefits from getting into 'green logistics':

- ≡ Reduction in CO2 emissions
- ≡ Unlocking significant cost savings
- ≡ Heightened supply chain optimization
- ≡ Boosted business performance

= **Theoretical framework on Green Logistics into Green Supply Chain**

Theoretical framework of a general three-stage forward and green supply chain is formulated in Figure 4.



**Figure 4.** Theoretical framework of a green supply chain

As shown in the figure, the proposed theoretical supply chain network is comprised of four levels of entities: supplier, producer, warehouse and customer, and those entities are communicated and connected through three flows: material flow, information flow and capital flow. The material flow in this supply chain network starts from upstream raw material suppliers and moves via intermediate production plants and warehouses towards end customers. The information and capital flow in opposite direction from end customers towards suppliers.

Conventionally, the focus of green supply chain is to simultaneously minimize the costs, risk and GHG emissions of a supply chain. Therefore, in order to tackle this challenge, the optimal trade-off among cost-minimization, risk-minimization and GHG emission-minimization will be focused so that long-term competitive competence, profitability and sustainability can be achieved.

= **Drivers for Green Logistics**

In this section, there are described the various drivers for Green Logistics.

**Mounting energy costs**

Increasing power and fuel costs, together with the cost of related raw materials used in infrastructure building and functioning has led to chances for looking into green alternatives that can significantly lead to a reduction in the price. Reducing the power consumed by IT apparatus, energy efficient lighting and cooling, substitutive energy sources, recycling can help develop the business financial issues.

**Worldwide alarms among over GHG (Green House Gases) emissions and climate change**

Many corporate policies now consist of targets for decreasing their impact on the surroundings, according to the environmental protection policies for green gases emissions and climate change. With green initiatives in IT equipment, infrastructure and people having a significant footprint in any business today, identifying and lowering its impact is becoming very important. Green IT initiatives are important for industrial manufacturer and services organization concerning to the environmental issues along with sharing the best procedures in companies across the supply chain.

**Environmental regulations**

The environmental policies in diverse geographies can be largely classified as regulatory (bans, permits and standards), financial (gains for adherence and reduction) and educational (environmental reporting, audits, product labeling etc.). Green initiatives are leading to the development of legislations along all these areas, such as: controlling the carbon trace, implementation of carbon credits, interchangeable sources to make up for some of the savings costs etc.

**Improved community awareness of environmental issues**

Green initiatives are reliant on an end-to-end across supply chains, along-with sharing the best procedures in companies across the supply chain.

**Impact on the environment at various stages of Supply Chain**

The diagram given at the Figure 5, shows Product Lifecycle from the conception to the disposal stage of a typical CPG (Consumer Product Green) company. The early stages of conceptualization and design of a product happens within closed doors. This is

followed by the usage of water and energy. In stages such as raw material extraction, manufacturing, transportation and disposal, the output (air, water and waste) impacts the surroundings.

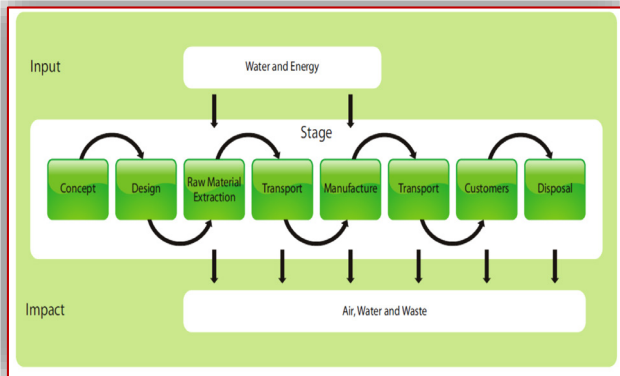


Figure 5: Product Lifecycle and its Impact on Environment

= **Impact of the environment at various stages of supply chain**

The major CPG companies are looking for a greener supply chain to reduce the environmental impacts and offer an eco-friendly service to end consumers. In this chapter of the paper, the focus is done of one of the areas in green supply chain, Green Logistics. With follow four aspects, a successful green logistics implementation can have a positive impact on the overall Supply Chain of the organization:

- ≡ Network Optimization – is the most fundamental type of modeling that can be done to optimize the hierarchy and inter related transportation flows that can bring considerable cost and carbon reduction in the supply chain processes of a consumer packaged goods company.
- ≡ Packaging Reduction – Packaging is an extremely noticeable marketing tool, but it is also a momentous cost to the supply chain, accounting for high percent of the charge of many typical consumer products. This grouping creates an ultimate opening for Consumer Product companies to move towards a greener supply chain and force brand growth by moving to a more sustainable methodology for packaging strategy.
- ≡ Sustainable Procurement – The approach for 'green' procurement should include organization, people, process and technology. It should be treated as a vehicle that provides value, achieves better economics, enhances the brand image and benefits the environment. Through various sustainable initiatives, procurement organizations can realize incremental savings up to 12 % of cost.

These initiatives can include energy, supply, operations and logistics.

- ≡ Warehouse Layout Optimization – Warehousing forms an important part in the CPG industry and is a key to the logistics space. A surplus of techniques and green technologies are available today to warehouse owners to drastically reduce the impact of their buildings on the environment.

= **Environmental Benefits of Green Supply Chain Best Practices**

Adopting Green Supply Chain practices results with positive impact in multiple environmental benefits (Figure 6). These benefits are visible across retail chains, Consumer Products manufacturers, Consumer Products logistics and Transportation Service providers. These benefits include improvements in energy and waste reduction, less packaging in related activities, and decreased GHG emissions. Consumer Products manufacturers can decrease GHG emissions and waste by investing in LEED (Leadership in Energy & Environmental Design) certified green buildings and retrofitting their distribution centers to be more environments friendly.

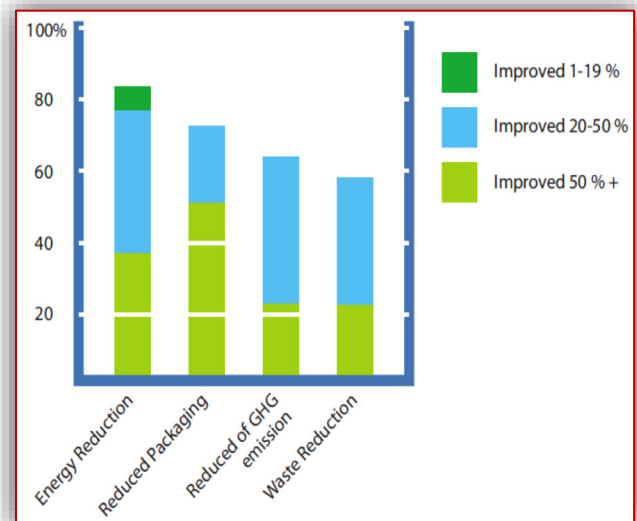


Figure 6. Positive Environmental Impact – Best CPG companies

The above mentioned processes will enable the CPG companies to access carbon credits, where unused credits could be sold to other organizations worldwide.

= **Paradoxes of Green Logistics**

When adapting green logistics, there could be some inconsistencies that might arise [17,18]. The issue is that green logistics is supposed to be environmental friendly, but logistics, in itself, is not very green because of pollution and waste that it creates. So when adapting green logistics, there are some paradoxes that arise as given below:

- ✓ **Cost:** Companies want to get the cheapest way to do things but at the same time they should choose options that are green, which sometimes are more costly to the company. The purpose of logistics is to minimize costs, notably transport costs. The cost-saving strategies that are pursued by logistics operators are often at variance with environmental considerations.
- ✓ **Time/Flexibility:** The modern integrated supply chains provide competent physical distribution systems but on the other hand extended production, distribution and retailing models are consuming more space, energy and generate more emissions.
- ✓ **Reliability:** At the heart of logistics is the overriding importance of service reliability. Its success is based upon the ability to deliver freight on time with the least threat of damage while the least polluting modes are generally regarded as being the least reliable in terms of on-time delivery. The logistics industry is built around air and truck shipments, the two least environmentally-friendly modes.
- ✓ **Warehousing:** A reduction in warehousing demands is one of the advantages of logistics. This means however, that inventories have been transferred to a certain degree to the transport system, especially the roads. Inventories are actually in transit, contributing still further to congestion and pollution.
- ✓ **E-commerce:** The information technology growth has led to new dimensions in retailing, e-commerce. However, changes in physical distribution systems by e-commerce have led to higher levels of energy consumption.

## CONCLUSIONS

The research finds that logistics is a significant part of the company's operations. This is because logistics can be costly and harmful for the environment. From that reason, specialized logistics companies are finding a match between environmental considerations and profitability. It is becoming acceptable within the industry to adopt green logistics measures. Sometimes they reduce costs, but more often than not they lead to more intangible benefits such as image and reputation enhancement. Reverse and Green Logistics has a still a long way to go ahead.

This paper has given an overview of analyzed literature in our research of what the reverse and green logistics are and what their definitions are. Reverse logistics has been explained as the process where the company takes back the goods for some reason, and green logistics is when the company tries to adapt environmental friendly ways to the logistics chain.

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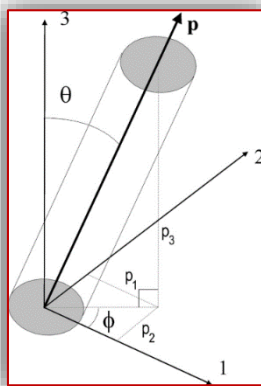
## COMPARISON OF FIBRE ORIENTATION USING SIMULATION SOFTWARE AND MATERIALOGRAPHY

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**Abstract:** The models are validated by finite element simulation of the performed characterization tests. Finally, the methodology is applied to an injection moulded component with complex geometry. Fiber orientation data predicted with Moldflow software has been used to determine the local effective elastic stiffness and strength coefficients. A FE simulation of the functional behaviour of the component has been carried out. Results indicate that the degree of orientation in real samples approximately equals to degree of orientation in simulation software.  
**Keywords:** Fibre orientation, Composites, Numeric simulation, Finite element analysis, Stereology

### INTRODUCTION

This paper deals with the numerical modelling of the fiber orientation of reinforced thermoplastics. These materials show non-homogeneous orientation of the reinforcement, hence developing a local anisotropic behavior. This is the case, for instance, of short fiber reinforced thermoplastics (SFRT) in which, unlike laminated composites, the orientation of the reinforcement is not predefined, but it is the uncontrolled result of the manufacturing process: the fiber orientation varies in an injected part because of the flow pattern inside the mould, the processing conditions and the rheological properties of the material itself.



**Figure 1.** The orientation of a single fibre can be expressed in polar coordinates by the two angles ( $\theta, \Phi$ ) and in Cartesian coordinates by the components of a vector  $p$ , ( $p_1, p_2, p_3$ ).

The orientation of simple fiber may be defined by the two angles  $\theta$  and  $\Phi$  illustrated in Figure 1. In a SFRT component there are frequently millions of fibers, therefore determine the orientation of each fiber is very impractical [1]. The fibers orientation in space can be described by the probability distribution function (PDF),  $\Psi(\theta, \Phi)$  [2].

Orientation of a single fiber may be defined by the Cartesian components of a vector  $p$ , also. The components of  $p_i$  are described with the angles  $\theta$  and  $\Phi$ , as follows:

$$\begin{aligned} p_1 &= \sin\theta \cdot \cos\Phi \\ p_2 &= \sin\theta \cdot \sin\Phi \\ p_3 &= \cos\theta \end{aligned} \quad (1)$$

### ORIENTATION TENSORS

The PDF function describes the fibre orientation direction (FOD) which in complete form holds a lot of information, making any numerical calculations based on these data highly computationally intensive. In some applications where there exists a simplified FOD distribution, the density function,  $\Psi(p)$  may in turn be simplified. But in many applications, it is not possible to make such a simplification [3].

The tensor description of FOD has become the most used system of characterization [4]. This tensor gets a concise description of the FOD, without the need for any a priori assumption of a simplified orientation. For the second-order tensor, it has nine components but only six of these are independent because of the symmetry condition. The components

of the second-order tensor for a group of n fibres are calculated as follows:

$$a_{ij} = \frac{1}{n} \left( \sum_{k=1}^n p_i^k p_j^k \right) = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}$$

$$i, j = 1, 2, 3 \quad (2)$$

Six independent components for an individual fibre are as follows:

$$\begin{aligned} a_{11} &= \sin^2 \theta \cdot \cos^2 \phi \\ a_{22} &= \cos^2 \theta \cdot \cos^2 \phi \\ a_{33} &= \cos^2 \theta \\ a_{12} &= a_{21} = \sin^2 \theta \cdot \cos^2 \phi \cdot \sin \phi \\ a_{13} &= a_{31} = \sin \theta \cdot \cos \theta \cdot \cos \phi \\ a_{23} &= a_{32} = \sin \theta \cdot \cos \theta \cdot \sin \phi \end{aligned} \quad (3)$$

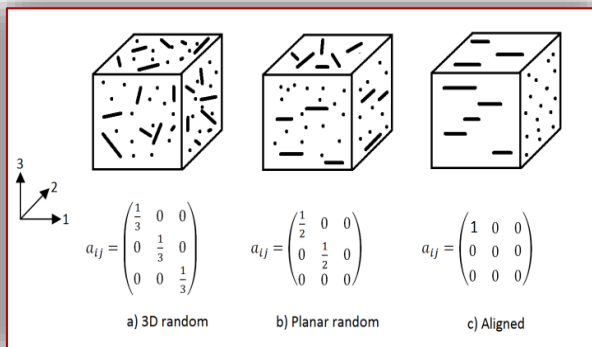


Figure 2. Example of different orientation states and corresponding orientation tensors.

Orientation tensor components have a physical interpretation. Figure 2(a) shows isotropic state, with equal orientation distribution in all directions. If all the fibres lie in the 1-2 plane (see Figure 2(b)), it corresponds to 2D isotropic (planar random) orientation state. Perfectly aligned orientation in 1 direction is shown in Figure 2(c).

#### EXPERIMENTAL MATERIAL AND MEASUREMENT

Good simulation software, for example Moldflow in this case, allows to view results of fibre orientation as an orientation of the X direction, Y direction, Z direction, the total orientation and orientation at surface. These first three orientations are relevant for the establishment of second-order orientation tensor. They belong to tensor's values  $a_{11}$ ,  $a_{22}$  and  $a_{33}$ , which are shown in Figures 3, 4 and 5.

Degree of orientation, which can be compared to orientation evaluated using stereological metallography, can be calculated as:

$$O = \frac{a_{ii} - a_{jj}}{a_{ii} + a_{jj}} \quad (5)$$

#### QUANTITATIVE ANALYSIS OF COMPOSITE STRUCTURES

Only total examination of the structure and properties of materials carried out in the production and processing conditions should be related with macroscopic properties of the material. In the isometric structures microparticles are randomly

oriented in all directions. In oriented structures, microparticles have a preferential orientation.

In the case of short glass fibres reinforced thermoplastics it's structure consist of thermoplastic matrix and reinforcing fibres, which has some preferred orientation in most of cases – the structure is anisotropy. The way of scalar measurement of structure anisotropy is determination of degree of orientation. The anisotropic microstructure is decomposed into isotropic, planar or linear oriented components using stereology methods.

Length of oriented fibres can be divided to isometric and oriented parts and degree of orientation is ratio of oriented part of length to total length. Oriented test plane method can be used. Test planes are placed perpendicular and parallel to the orientation direction [5]. The equations refer to the oriented  $(L_v)_{OR}$  portion of the system of lines and to the total  $(L_v)_{CE}$  length per unit volume [6]. They are [7]:

$$(L_v)_{OR} = (P_A)_O - (P_A)_P \quad (6)$$

$$(L_v)_{CE} = (P_A)_O + (P_A)_P, \quad (7)$$

where:

$(P_A)_O$  is number of cross-sections between test perpendicular plane and fibres per unit test area,  $(P_A)_P$  is number of cross-sections between test parallel plane and fibres per unit test area.

Degree of linear orientation  $O$  is:

$$O = (L_v)_{OR} / (L_v)_{CE} \quad (8)$$

#### EXPERIMENTAL MATERIAL

For an example, an analysis of injection moulding part of pendant arm used in RC car. The arm material is LUVOCOM® 1/CF/15/HS polyamide PA66 with 15% reinforcing carbon glasses.

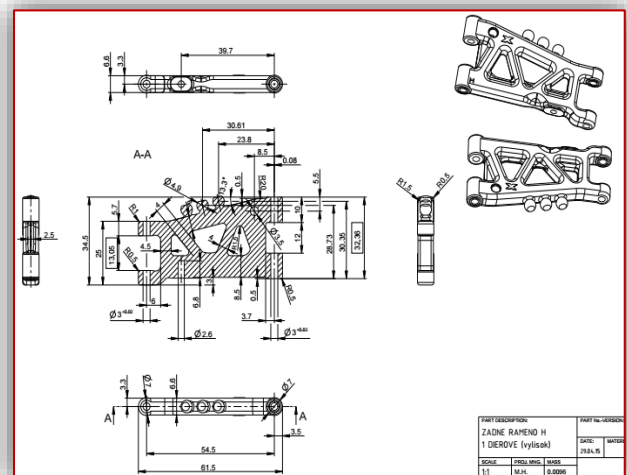


Figure 3. Design of pendant arm used in RC car (injection moulding part)

The software Moldflow Insight was used, which belongs to the top of software for injection moulding simulation. This software is supplied by Autodesk Company. Moldflow software is a simulation product which can be used for mold and plastic design. This software helps to decrease cost of



physical prototypes and prevent potential manufacture defects.

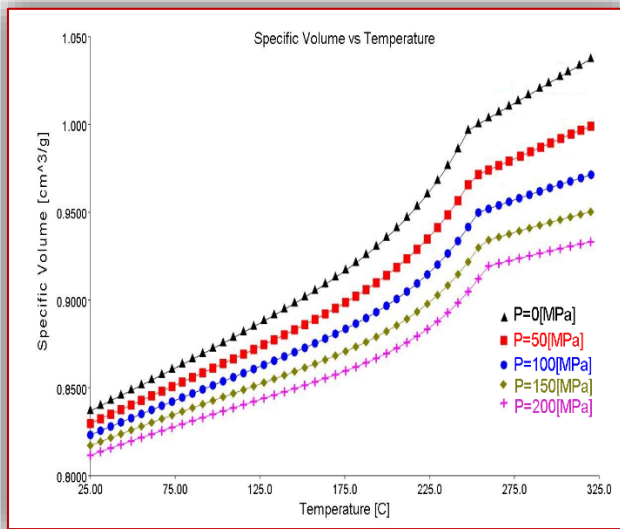


Figure 4. PVT Diagram

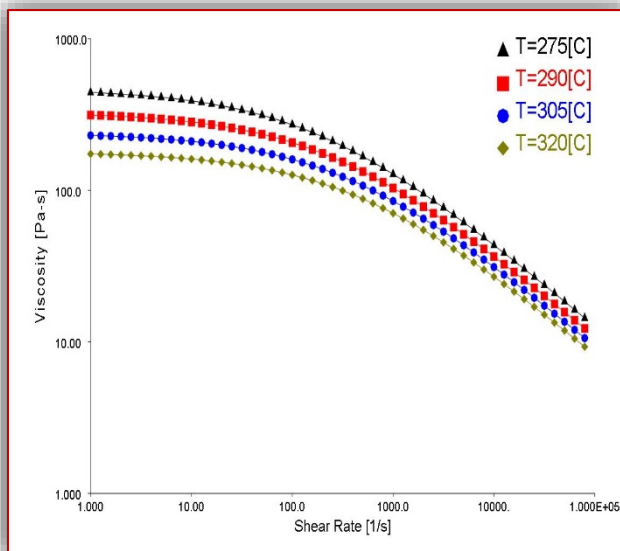


Figure 5. Rheological diagram



Figure 6. Injection moulding part

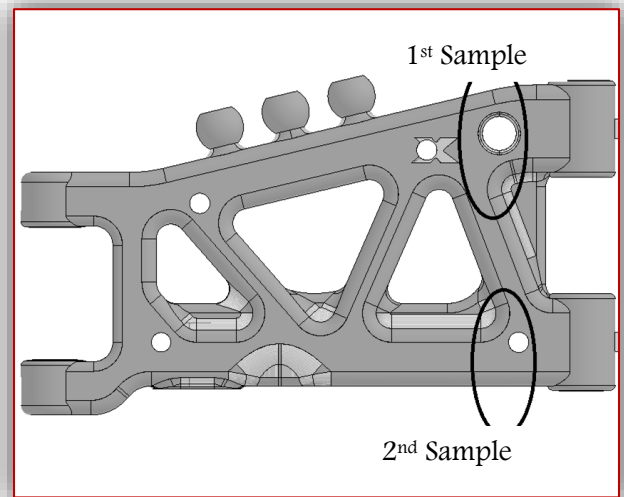


Figure 7. Samples in injection moulding part  
**EXPERIMENTAL RESULTS**  
1<sup>st</sup> sample, Parallel plane and orthogonal plane:  
Parallel section at the edge in first sample is shown in Figure 8 and tangential cross-section is shown in Figure 9.

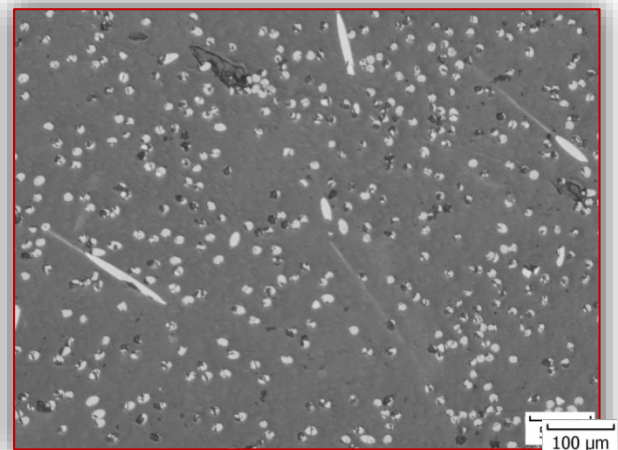


Figure 8. Cross section of fibres in 1<sup>st</sup> sample, parallel cut

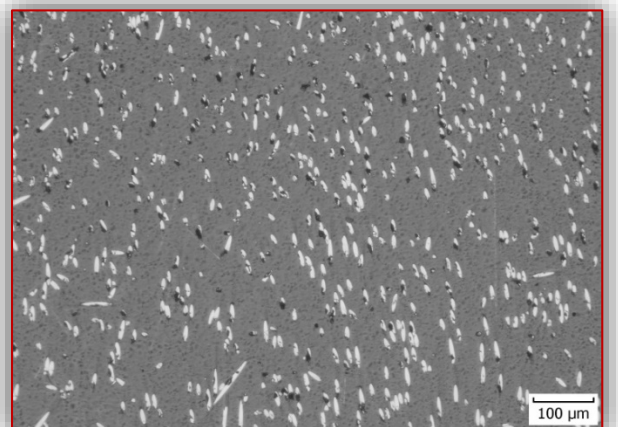


Figure 9. Cross section of fibres in 1<sup>st</sup> sample, tangential section (orthogonal direction)

In parallel direction are 490 cross-section of carbon fibers and in the tangential direction are 633 cross-section of carbon fibers. For the calculation of fiber orientation was used method for determinate the length of the elements of lines in the volume  $V_v$ . Number of cross-sections between test parallel plane and fibers is 490. Number of cross-sections between test orthogonal plane and fibers is 656. Degree of orientation between parallel plane and orthogonal plane is ~12.51% Sample in the X direction is shown in Figure 10 and sample in the Z direction is shown in Figure 11. Orientation of simulation is calculating by the second order tensor.

calculation of fiber orientation was used method for determinate the length of the elements of lines in the volume  $V_v$ .

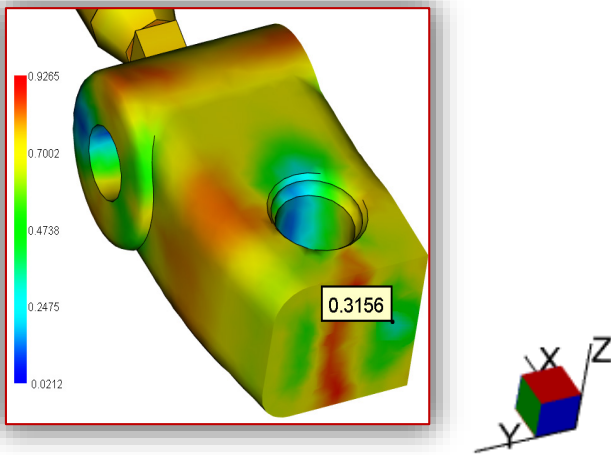


Figure 10. Fibre orientation in 1<sup>st</sup> sample, in X direction

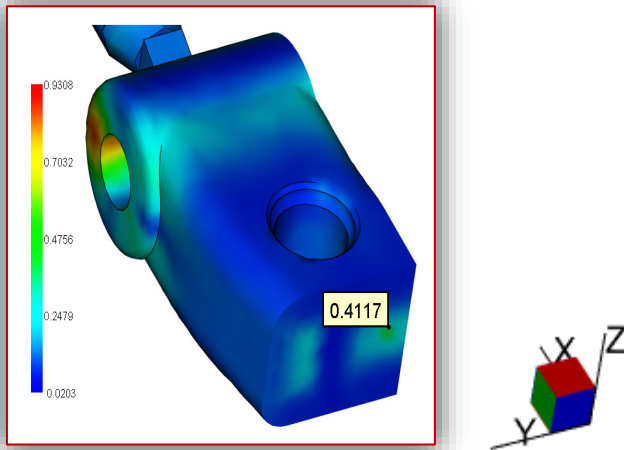


Figure 11. Fibre orientation in 1<sup>st</sup> sample, in Z direction

Degree of orientation between  $a_{11}$  and  $a_{33}$  plane is -13.21%

**1st sample, Parallel plane and longitudinal plane:**

Parallel section at the edge in first sample is shown in Figure 12 and longitudinal cross-section is shown in Figure 13. In parallel direction are 827 cross-section of carbon fibers and in the longitudinal direction are 633 cross-section of carbon fibers. For the

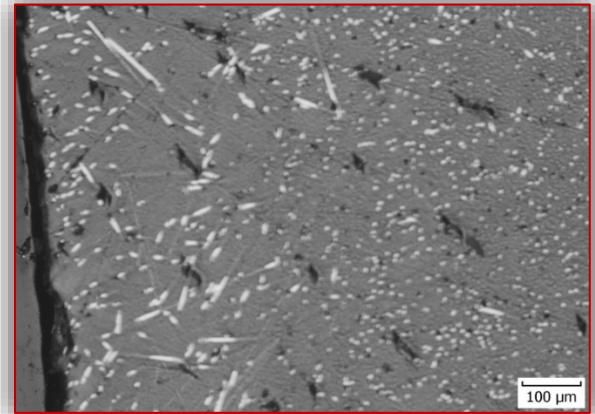


Figure 12. Cross section of fibres in 1<sup>st</sup> sample, at edge, parallel section

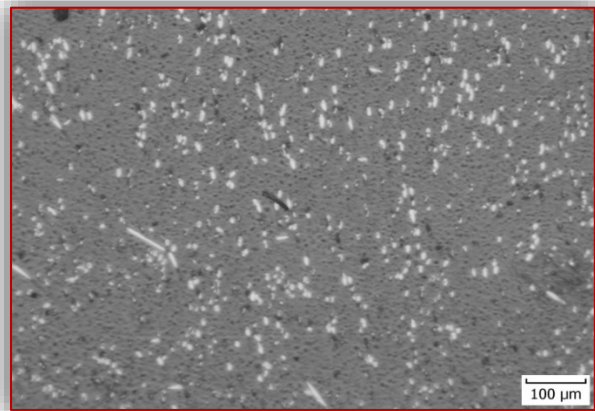


Figure 13. Cross section of fibres in 1<sup>st</sup> sample, at edge, longitudinal section (orthogonal direction) Number of cross-sections between test parallel plane and fibers is 827. Number of cross-sections between test longitudinal plane and fibers is 633. Degree of orientation between parallel plane and longitudinal plane is 13.28%.

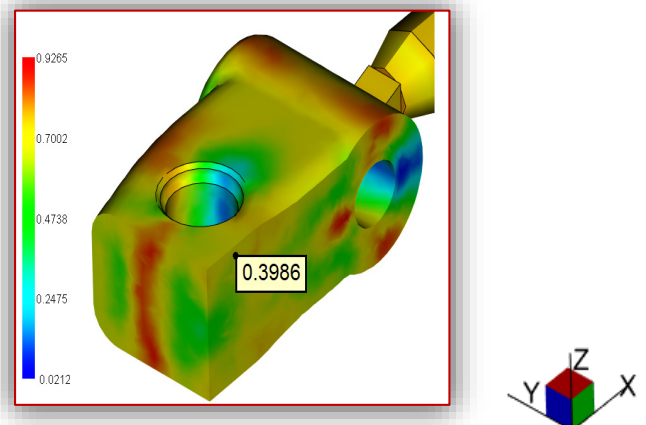
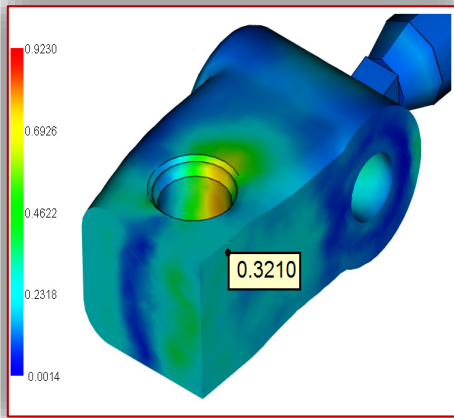


Figure 14. Fibre orientation in 1<sup>st</sup> sample in X direction



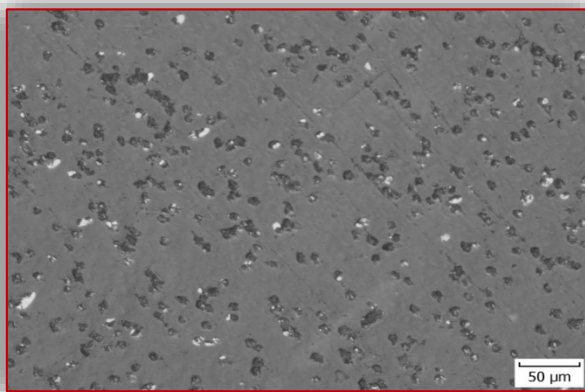


**Figure 15.** Fibre orientation in 1<sup>st</sup> sample in Y direction. Sample in the X direction is shown in Figure 14 and sample in the Y direction is shown in Figure 15. Orientation of simulation is calculating by the second order tensor.

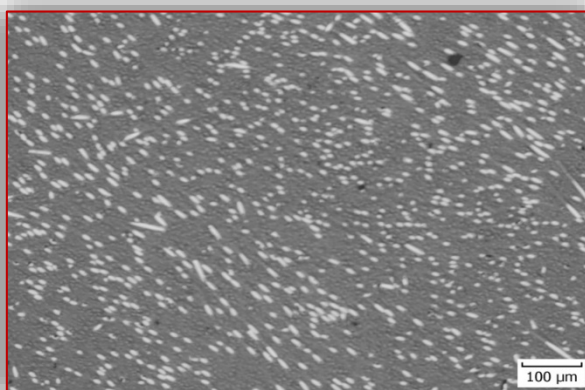
Degree of orientation between  $a_{11}$  and  $a_{22}$  plane is 10.78%

**2<sup>nd</sup> sample, Parallel plane and longitudinal plane**

Parallel section at the edge in first sample is shown in Figure 16 and tangential cross-section is shown in Figure 17.



**Figure 16.** Cross section of fibres in 2<sup>nd</sup> sample, parallel section



**Figure 17.** Cross section of fibres in 2<sup>nd</sup> sample, longitudinal section (orthogonal direction)

In parallel direction are 409 cross-section of carbon fibers and in the tangential direction are 1052 cross-section of carbon fibers. For the calculation of fiber orientation was used method for determinate the length of the elements of lines in the volume  $L_v$ .

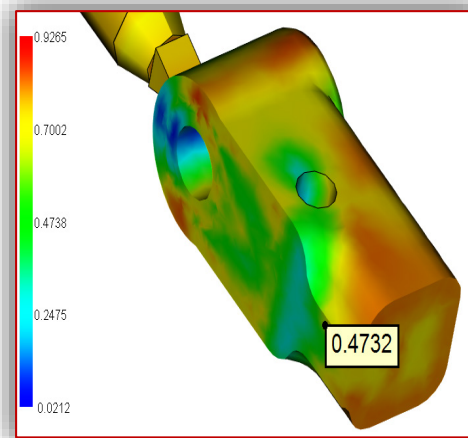
Number of cross-sections between test parallel plane and fibers is 409.

Number of cross-sections between test longitudinal plane and fibers is 1052.

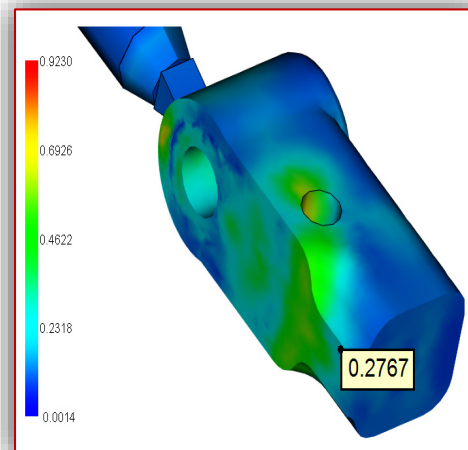
Degree of orientation between parallel plane and longitudinal plane is 21.72%

Sample in the X direction is shown in Figure 18 and sample in the Y direction is shown in Figure 19.

Orientation of simulation is calculating by the second order tensor.



**Figure 18.** Fibre orientation in 2<sup>nd</sup> sample in X direction



**Figure 19.** Fibre orientation in 2<sup>nd</sup> sample in Y direction. Degree of orientation between  $a_{11}$  and  $a_{22}$  plane is 26.19%

**2<sup>nd</sup> sample, Longitudinal plane and tangential plane:**

Longitudinal section at the edge in first sample is shown in Figure 20 and tangential cross-section is shown in Figure 21. In longitudinal direction are 555 cross-section of carbon fibers and in the tangential direction are 384 cross-section of carbon



fibers. For the calculation of fiber orientation was used method for determinate the length of the elements of lines in the volume  $V_v$ .

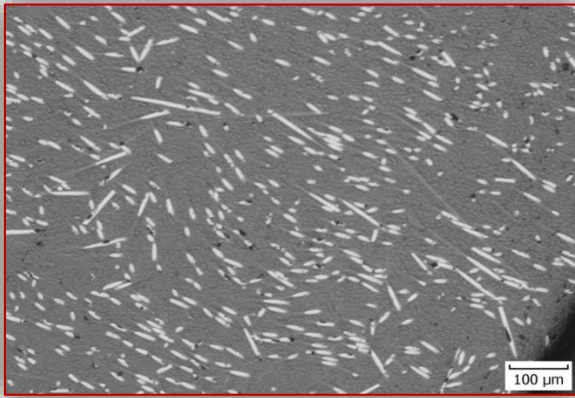


Figure 20 .Cross section of fibres in 2<sup>nd</sup> sample, at edge, longitudinal section

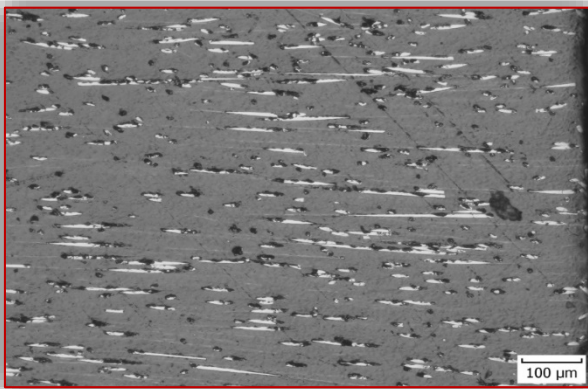


Figure 21. Cross section of fibres in 2<sup>nd</sup> sample, at edge, tangential section (orthogonal direction)

Number of cross-sections between test longitudinal plane and fibers is 555.

Number of cross-sections between test tangential plane and fibers is 384.

Degree of orientation between longitudinal plane and tangential plane is 18.21%.

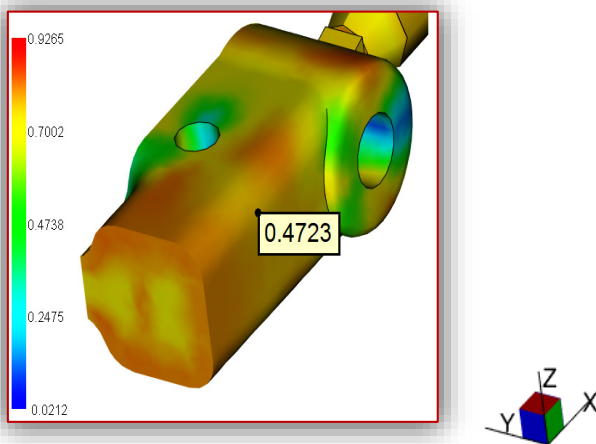


Figure 22. Fibre orientation in 2<sup>nd</sup> sample in X direction

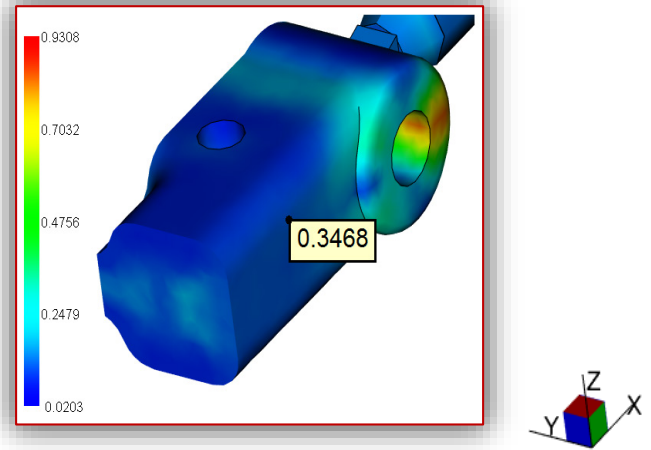


Figure 23. Fibre orientation in 2<sup>nd</sup> sample in Z direction Sample in the X direction is shown in Figure 22 and sample in the Z direction is shown in Figure 23. Orientation of simulation is calculating by the second order tensor.

Degree of orientation between  $a_{11}$  and  $a_{33}$  plane is 15.34%

#### DISCUSSION OF RESULTS

Degree of orientation the 1<sup>st</sup> sample, parallel plane and orthogonal plane is negative. It means in fact, that orientation has the same value, but it is perpendicular to assumed one. This orientation is not desired and mechanical properties are decreased. However it is not so critical, because it is situated in the surface layer. In surface layer (1<sup>st</sup> sample-parallel plane- longitudinal plane and 2<sup>nd</sup> sample – both measurement) the fiber orientation is favorable and mechanical properties (crack propagation resistance) increase.

Table 1. Comparison of orientation at samples

Measuring	Orientation at real sample [%]	Orientation of numerical simulation [%]	Difference of orientations [Δ%]
1 <sup>st</sup> sample Parallel plane and orthogonal plane	-12.51	-13.21	0.7
1 <sup>st</sup> sample Parallel plane and longitudinal plane	13.28	10.78	2.5
2 <sup>nd</sup> sample Parallel plane and longitudinal plane	21.72	26.19	-4.47
2 <sup>nd</sup> sample Longitudinal plane and tangential plane	18.21	15.34	2.87

Difference of orientation has been calculated by subtraction orientation at real sample and orientation of numerical simulation. These differences are low – less than 5%.

#### CONCLUSION

To exploit the capabilities of the composites is necessary to have detailed information on the fiber orientation in the component. In general, the only way to have this information for injection moulding parts is to use process simulation results including fiber orientation prediction. To determine the accuracy of a numerical simulation, model must be compared with experimentally determined fiber orientation distributions.

Stereological metallography enables simple and effective experimental estimation of short fiber orientation by measuring the relative length of fiber orientation in different places of injection moulding parts.

In one case orientation is negative which means, that orientation has the same value, but it is perpendicular to expected direction. This orientation is not desired and mechanical properties are decreased, but it is not so critical because it is situated in the surface layer. Numerical simulation allows to view of fiber orientation in these parts. Ratio of these simulated values can be compared with previous orientations. The fiber orientation can be control by injection moulding parameters, but it is empirical method only [8]. A new way to improvement of injection moulding precision parts mechanical properties is an advanced technology – shear-controlled orientation in injection mouldings (SCORIM) [9].

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## LAPLACE TRANSFORM SOLUTIONS FOR MAGNETO-HYDRODYNAMIC BOUNDARY LAYER FLOW AND HEAT TRANSFER IN A POROUS MEDIUM WITH THERMAL RADIATION EFFECT

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**Abstract:** A mathematical model is developed for unsteady Magnetohydrodynamic boundary layer flow and heat transfer through a Darcian porous medium bounded by a uniformly moving semi-infinite isothermal vertical plate in presence of thermal radiation. The flow model is considered as an viscous, incompressible, electrically-conducting Newtonian fluid which is an optically thin gray gas. Suitable transformations are used to convert the partial differential equations corresponding to the momentum and energy equations into nonlinear ordinary differential equations. Analytical solutions of these equations are obtained by Laplace transform. The effects of Hartmann number ( $M$ ), porosity parameter ( $K$ ), thermal radiation parameter ( $R_a$ ), and Prandtl number ( $Pr$ ) on flow velocity, fluid temperature, velocity and temperature gradients at the surface are studied graphically. Velocity is reduced with Hartmann number but enhanced with thermal radiation and porosity parameter. An increase in porosity/thermal radiation parameter is found to strongly enhance flow velocity values. Velocity gradient at  $y=0$  is increased with porosity parameter. Applications of the study arise in engineering and geophysical sciences like magnetohydrodynamic transport phenomena and magnetic field control of materials processing, solar energy collector systems.

**Keywords:** optically thin gray gas; Hartmann number; porous media; heat transport; unsteady boundary layer flow

### INTRODUCTION

Fluid flow through a porous media has been studied theoretically and experimentally by numerous authors due to its wide applications in various fields such as diffusion technology, transpiration cooling, hemodialysis processes, flow control in nuclear reactors, etc. In view of geophysical applications of the flow through porous medium, a series of investigations has been made by Raptis et.al (1981-1982), where the porous medium is either bounded by horizontal, vertical surfaces or parallel porous plates. Singh et.al (1989) and Lai and Kulacki (1990) have been studied the free convective flow past vertical wall. Nield (1994) studied convection flow through porous medium with inclined temperature gradient. Singh et al. (2005) also studied periodic solution on oscillatory flow through channel in rotating porous medium. Further due to increasing scientific and technical applications on the effect of radiation on flow characteristic has more importance in many engineering processes occurs at very high temperature and acknowledge radiative heat transfer

such as nuclear power plant, gas turbine and various propulsion devices for aircraft, missile and space vehicles. The effect of radiation on flow past different geometry a series of investigation have been made by Hassan (2003), Seddeek (2000) and Sharma et al (2011). The combined radiation-convection flows have been extended by Ghosh and Be'g (2008) to unsteady convection in porous media. Hossain and Takhar (1996) studied the mixed convective flat plate boundary-layer problem using the Rosseland (diffusion) flux model. Mohammadein et al. (1998) studied the radiative flux effects on free convection in the Darcian porous media using the Rosseland model. The transient magnetohydrodynamic free convective flow of a viscous, incompressible, electrically conducting, gray, absorbing-emitting, but non-scattering, optically thick fluid medium which occupies a semi-infinite porous region adjacent to an infinite hot vertical plate moving with a constant velocity is presented by Ahmed and Kalita (2013). Raptis and Perdakis (2004) have also studied analytically the transient convection in a highly

porous medium with unidirectional radiative flux. Ghosh and Pop (2007) studied indirect radiation effects on convective gas flow. Ahmed and Kalita (2013) investigated the effects of chemical reaction as well as magnetic field on the heat and mass transfer of Newtonian two-dimensional flow over an infinite vertical oscillating plate with variable mass diffusion. Ahmed (2014) presented the effects of conduction-radiation, porosity and chemical reaction on unsteady hydromagnetic free convection flow past an impulsively-started semi-infinite vertical plate embedded in a porous medium in presence of thermal radiation. The thermal radiation and Darcian drag force MHD unsteady thermal-convection flow past a semi-infinite vertical plate immersed in a semi-infinite saturated porous regime with variable surface temperature in the presence of transversal uniform magnetic field have been discussed by Ahmed et al. (2014).

The present paper is to investigate the effect of magnetic field and radiation on unsteady free convection heat transfer flow of viscous laminar electrically conducting Newtonian radiating fluid past an impulsively started semi-infinite vertical surface in a Darcian porous medium. The analytical solution is obtained using Laplace Transform technique and discussed graphically for various flow parameters.

### MATHEMATICAL FORMULATION

Considering the magneto-hydrodynamic unsteady free convection and heat transfer flow of a viscous, incompressible, electrically conducting Newtonian fluid past a semi-infinite isothermal vertical plate embedded in a porous media under the influence of the thermal buoyancy.

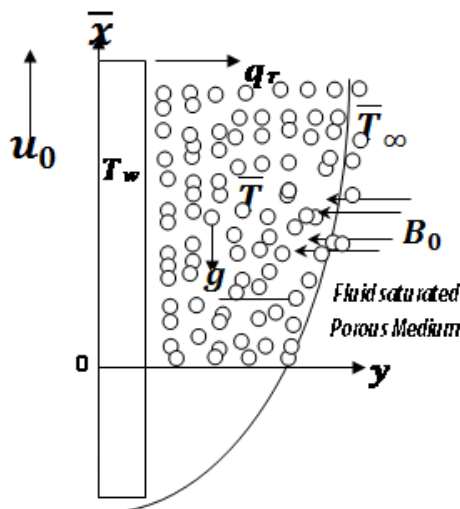


Figure 1: Physical model and coordinate system

A uniform magnetic field of uniform strength  $B_0^2$  is assumed to be applied normal to the surface. The flow is assumed to be in the  $\bar{x}$ -direction, which is taken along the plate in the upward direction and  $\bar{y}$

-axis is normal to it. Initially it is assumed that the plate and the fluid are at the same temperature  $\bar{T}$ . At time  $t > 0$ , the plate temperature is instantly raised to  $\bar{T}_w > \bar{T}_\infty$  and, which is thereafter maintained constant, where  $\bar{T}_\infty$  is the temperature outside the boundary layer. The induced magnetic field and viscous dissipation is assumed to be negligible as the magnetic Reynolds number of the flow is taken to be very small. Assuming that the Boussinesq and boundary-layer approximations hold, the governing equations to the problem are given by:

$$\frac{\partial \bar{u}}{\partial t} = g\beta(\bar{T} - \bar{T}_\infty) + \nu \frac{\partial^2 \bar{u}}{\partial \bar{y}^2} - \frac{\sigma B_0^2}{\rho} \bar{u} - \frac{\nu}{K} \bar{u}, \quad (1)$$

$$\rho C_p \frac{\partial \bar{T}}{\partial t} = \kappa \frac{\partial^2 \bar{T}}{\partial \bar{y}^2} - \frac{\partial q_r}{\partial \bar{y}}. \quad (2)$$

The initial and boundary conditions are

$$\left. \begin{aligned} \bar{u} = 0, \bar{T} = \bar{T}_\infty, \forall \bar{y}, \bar{t} \leq 0 \\ \bar{u} = u_0, \bar{T} = \bar{T}_w \text{ at } \bar{y} = 0, \bar{t} > 0 \\ \bar{u} = 0, \bar{T} = \bar{T}_\infty, \text{ as } \bar{y} \rightarrow \infty, \bar{t} > 0 \end{aligned} \right\} \quad (3)$$

The local radiant absorption for the case of an optically thin gray gas is expressed (Cogley et al. (1968)) as

$$\frac{\partial q_r}{\partial \bar{y}} = -4\bar{a}\bar{\sigma}(\bar{T}_\infty^4 - \bar{T}^4), \quad (4)$$

where  $\bar{\sigma}$  and  $\bar{a}$  are the Stefan-Boltzmann constant and mean absorption co-efficient respectively. We assume that the differences within the flow are sufficiently small so that  $\bar{T}^4$  can be expressed as a linear function of  $\bar{T}$  after using Taylor's series to expand  $\bar{T}^4$  about the free stream temperature  $\bar{T}_\infty^4$  and neglecting higher order terms. This results in the following approximation:

$$\bar{T}^4 \cong 4\bar{T}_\infty^3 \bar{T} - 3\bar{T}_\infty^4, \quad (5)$$

$$\rho C_p \frac{\partial \bar{T}}{\partial t} = \kappa \frac{\partial^2 \bar{T}}{\partial \bar{y}^2} - 16\bar{a}\bar{\sigma}\bar{T}_\infty^3(\bar{T} - \bar{T}_\infty). \quad (6)$$

Introducing the following non-dimensional quantities:

$$\left. \begin{aligned} y = \frac{\bar{y}u_0\sqrt{G}}{\nu}, u = \frac{\bar{u}}{u_0}, M = \frac{\sigma B_0^2 \nu}{\rho u_0^2 G}, K = \frac{u_0^2 KG}{\nu^2}, \\ G = \frac{g\beta\nu(\bar{T}_w - \bar{T}_\infty)}{u_0^3}, \theta = \frac{\bar{T} - \bar{T}_\infty}{\bar{T}_w - \bar{T}_\infty}, Pr = \frac{\mu C_p}{\kappa} \\ t = \frac{\bar{t}u_0^2 G}{\nu}, Ra = \frac{16\bar{a}\bar{\sigma}\nu^2 \bar{T}_\infty^3}{\kappa u_0^2}, v = \frac{\mu}{\rho} \end{aligned} \right\} \quad (7)$$

Using the transformations (7), the non-dimensional forms (1), (3) and (6) are

$$\frac{\partial u}{\partial t} = Gr\theta + \frac{\partial^2 u}{\partial y^2} - (M + K^{-1})u, \quad (8)$$

$$\frac{\partial \theta}{\partial t} = \frac{1}{Pr} \frac{\partial^2 \theta}{\partial y^2} - \frac{R_a}{Pr} \theta. \quad (9)$$

The corresponding initial and boundary conditions transformed to:

$$\left. \begin{aligned} u=0, \theta=0, \forall y, t \leq 0 \\ u=1, \theta=1 \text{ at } y=0, t > 0 \\ u=0, \theta=0, \text{ as } y \rightarrow \infty, t > 0 \end{aligned} \right\} \quad (10)$$

### METHOD OF SOLUTION

The unsteady, non-linear, coupled partial differential equations (8) and (9) along with their boundary conditions (10) have been solved analytically using Laplace transforms technique and their solutions are as follows:

$$u(y,t) = \frac{1}{2} \left[ \begin{aligned} & \left( 1 - \frac{1}{\psi} \right) \left\{ e^{2\eta\sqrt{\xi t}} \operatorname{erfc}(\eta + \sqrt{\xi t}) + e^{-2\eta\sqrt{\xi t}} \operatorname{erfc}(\eta - \sqrt{\xi t}) \right\} \\ & + \frac{1}{\psi} e^{\lambda t} \left\{ e^{2\eta\sqrt{(\xi+\lambda)t}} \operatorname{erfc}(\eta + \sqrt{(\xi+\lambda)t}) + e^{-2\eta\sqrt{(\xi+\lambda)t}} \operatorname{erfc}(\eta - \sqrt{(\xi+\lambda)t}) \right\} \\ & + \frac{1}{\psi} \left\{ e^{2\eta\sqrt{R_a t}} \operatorname{erfc}(\eta\sqrt{Pr} + \sqrt{R_a t}) + e^{-2\eta\sqrt{R_a t}} \operatorname{erfc}(\eta\sqrt{Pr} - \sqrt{R_a t}) \right\} \\ & - \frac{1}{\psi} e^{\lambda t} \left\{ e^{2\eta\sqrt{(R_a+\lambda)t}} \operatorname{erfc}(\eta\sqrt{Pr} + \sqrt{(R_a+\lambda)t}) + e^{-2\eta\sqrt{(R_a+\lambda)t}} \operatorname{erfc}(\eta\sqrt{Pr} - \sqrt{(R_a+\lambda)t}) \right\} \end{aligned} \right], \quad (11)$$

$$\theta(y,t) = \frac{1}{2} \left[ \begin{aligned} & e^{2\eta\sqrt{R_a t}} \operatorname{erfc}(\eta\sqrt{Pr} + \sqrt{R_a t}) \\ & + e^{-2\eta\sqrt{R_a t}} \operatorname{erfc}(\eta\sqrt{Pr} - \sqrt{R_a t}) \end{aligned} \right], \quad (12)$$

where  $\xi = M + K^{-1}$ ,  $\eta = \frac{y}{2\sqrt{t}}$ ,  $\psi = \xi - R_a$ ,  $\lambda = \frac{\Psi}{Pr-1}$ .

### SKIN FRICTION AND NUSSELT NUMBER

The non-dimensional skin friction and Nusselt number is given as follows:

$$\tau = - \left[ \frac{\partial u(y,t)}{\partial y} \right]_{y=0}$$

$$= \left( 1 - \frac{1}{\psi} \right) \left\{ \frac{e^{-\xi t}}{\sqrt{\pi t}} + \sqrt{\xi} \operatorname{erf}(\sqrt{\xi t}) \right\} + \frac{1}{\psi} e^{\lambda t} \left\{ \frac{e^{-(\xi+\lambda)t}}{\sqrt{\pi t}} + \sqrt{(\xi+\lambda)} \operatorname{erf}(\sqrt{(\xi+\lambda)t}) \right\} + \frac{1}{\psi} \sqrt{Pr} \left\{ \frac{e^{-R_a t}}{\sqrt{\pi t}} + \sqrt{R_a} \operatorname{erf}(\sqrt{R_a t}) \right\} - \frac{1}{\psi} \sqrt{Pr} e^{\lambda t} \left\{ \frac{e^{-(R_a+\lambda)t}}{\sqrt{\pi t}} + \sqrt{(R_a+\lambda)} \operatorname{erf}(\sqrt{(R_a+\lambda)t}) \right\} \quad (13)$$

$$Nu = - \left[ \frac{\partial \theta(y,t)}{\partial y} \right]_{y=0} = \sqrt{Pr} \left\{ \frac{e^{-R_a t}}{\sqrt{\pi t}} + \sqrt{R_a} \operatorname{erf}(\sqrt{R_a t}) \right\}. \quad (14)$$

### RESULTS AND DISCUSSION

The problem of thermal radiation effect on a porous media transport under optically thick approximation formulated, analyzed and solved analytically. In order to point out the effects of physical parameters namely; magnetohydrodynamic force (M), radiation parameter ( $R_a$ ), Porosity parameter (K) on the flow patterns, the computation of the flow fields are carried out. The values of velocity, temperature, shear stress and rate of heat transfer are obtained for the physical parameters as mention. The velocity profiles has been studied and presented in Figures 2 to 4. Figure 2 shows the effect of the Hartmann number M on the fluid velocity and the results show that the presence of the magnetic force causes retardation of the fluid motion represented by general decreases in the fluid velocity. It is due the fact that magnetic force which is applied in the normal direction to the flow produces a drag force which is known as Lorentz force.

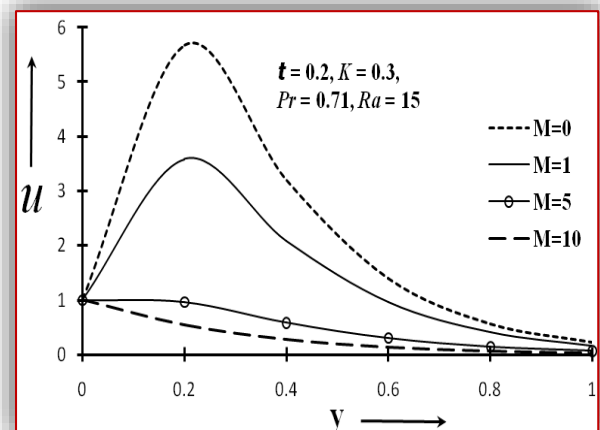


Figure 2: Flow velocity distribution for Hartmann number M

The opposite trend is observed in Figure 3 for the case when the value of the porous permeability ( $K = 0.2, 0.5, 1.0, 1.5$ ) is increased. As depicted in this figure, the effect of increasing the value of porous permeability is to increase the value of the velocity component in the boundary layer due to the fact that drag is reduced by increasing the value of the porous permeability on the fluid flow which results in increased velocity. The trend shows that the velocity is accelerated with increasing porosity parameter. The effect of velocity for different values of radiation ( $R_a = 0, 15, 16, 18$ ) is also presented in Figure 4. It is then observed that the flow velocity is accelerated with increasing values of radiation. Also it is seen that without radiation ( $R_a = 0$ , Figure 4) or for the small value  $K = 0.2$  (Figure 3), the values of flow velocity reduces exponentially from the plate, while for the higher values of K or  $R_a$  the flow velocity has a bigger pick in the neighbourhood of  $y = 0.2$ , but the opposite behaviour has been observed for the



effects of higher magnetohydrodynamic force ( $M=10$ , Figure 2).

temperature is observed to decrease with an increase in  $Pr$ . For lower  $Pr$  fluids, heat diffuses faster than momentum and vice versa for higher  $Pr$  fluids. Larger  $Pr$  values correspond to a thinner thermal boundary layer thickness and more uniform temperature distributions across the boundary layer. Smaller  $Pr$  fluids possess higher thermal conductivities so that heat can diffuse away from the vertical surface faster than for higher  $Pr$  fluids (low  $Pr$  fluids correspond to thicker boundary layers). For working oils ( $Pr = 11.4$ ), convection is very effective in transferring energy from an area, compared to pure conduction and momentum diffusivity is dominant. It is also observed that the temperature is maximum near the plate and decreases away from the plate and finally takes asymptotic value for all values of  $Pr$ .

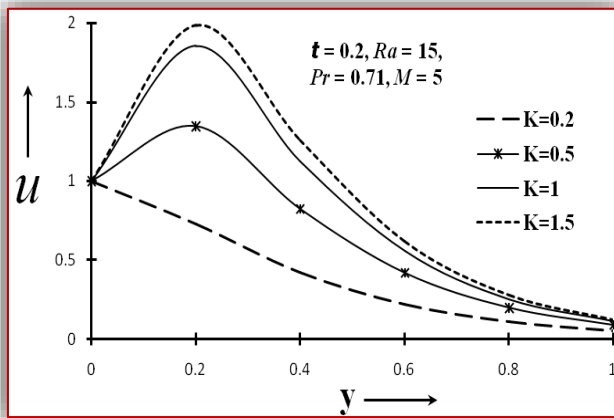


Figure 3: Flow velocity distribution for porosity  $K$

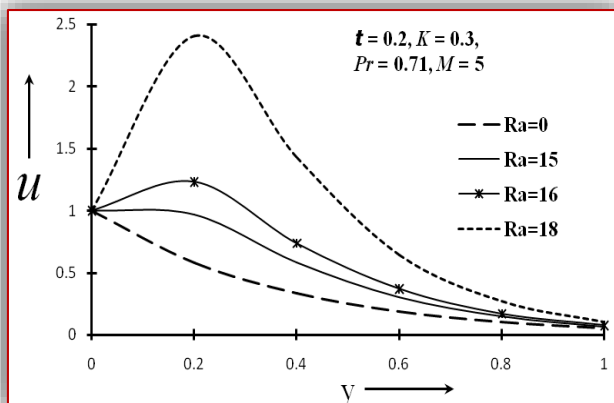


Figure 4: Flow velocity distribution for radiation  $R_a$

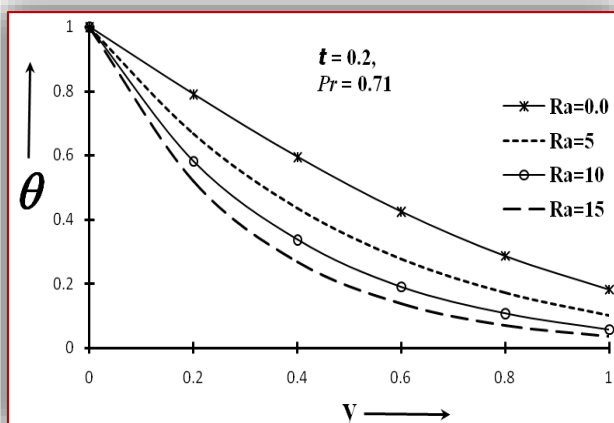


Figure 5: Temperature distribution for radiation  $R_a$

The temperature profiles are calculated for different values of thermal radiation parameter ( $R_a=0, 5, 10, 15$ ) at time  $t = 0.2$  and these are shown in Figure 5. The effect of thermal radiation parameter is important in temperature profiles. It is observed that the temperature increases with decreasing radiation parameter. Figure 6 reveals temperature variations with  $Pr$  (Prandtl number) which signifies the ratio of momentum to thermal diffusivity at  $t = 0.2$ . The

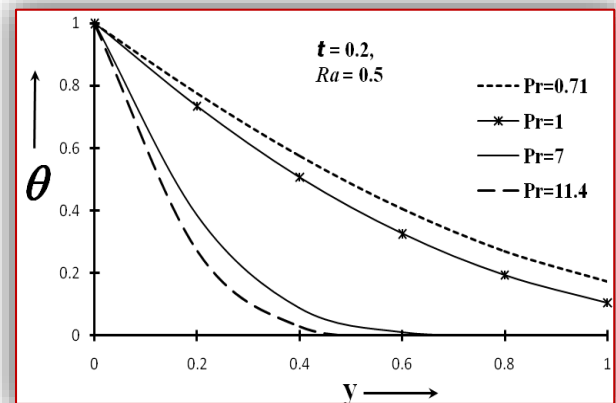


Figure 6: Temperature distribution for  $Pr$

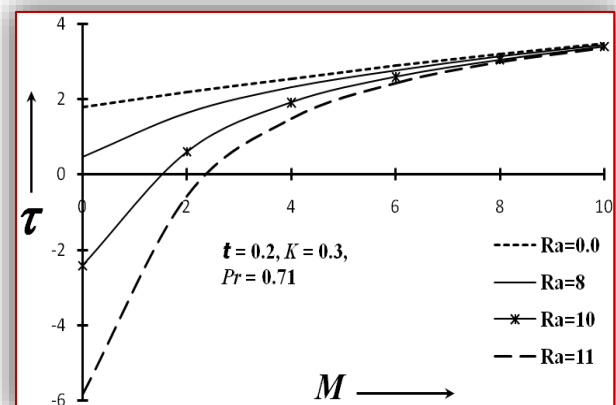
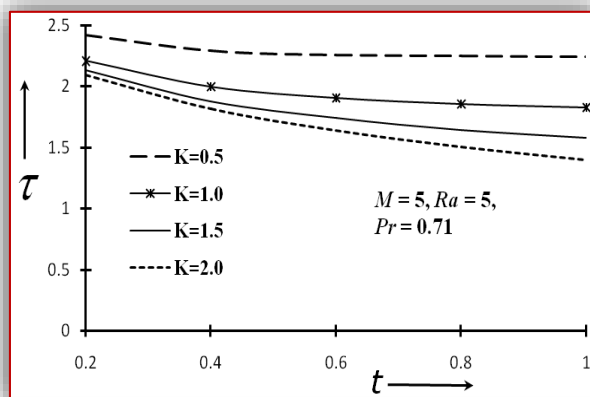


Figure 7: Skin friction distribution for radiation  $R_a$

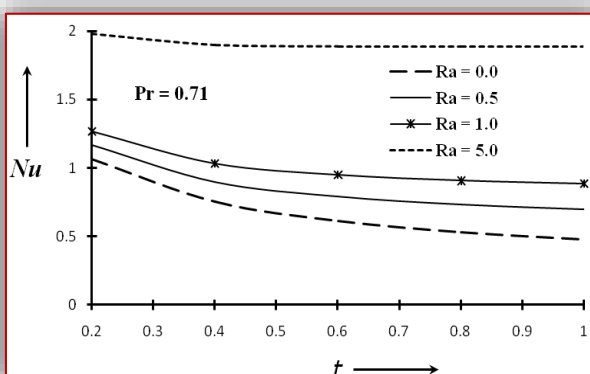
Figure 7 illustrates the transient shear stress variation with Hartmann number and radiation parameter. The shear stresses at the wall are seemed to be enhanced with a rise in Hartmann number, which is proportional to the square of the magnetic field,  $B_0$ . A reversed trend has been observed for conduction-radiation on shear stress ( $\tau$ ) i.e.  $\tau$  decreases substantially at the wall for  $R_a = 0, 8, 10, 11$ . For the non-radiating flow case,  $R_a = 0$ , a significant linear flow of shear stress is sustained

against hydromagnetic force. For the case,  $R_a = 10, 11$ , a significant flow reversal (backflow) is obtained within the region  $0 < M < 2.5$  i.e. shear stresses become negative. However for  $R_a = 0, 8$ , all backflow is eliminated entirely from the regime for all hydromagnetic forces and only positive shear stresses arise at the plate.



**Figure 8:** Skin friction distribution for Pr

Figure 8 shows the distribution of shear stress at the wall for various porosity parameters over time. With a rise in radiation parameter,  $K$ , from 0.5, 1.0 through 1.5 to 2.0 decreases the magnitude of the shear stress through the boundary layer. We observe that for all values of  $K$ , shear stress remains positive i.e. no flux reversal arises for all times into the boundary layer. With progression in time,  $t$ , the shear stress is however found to decrease continuously. Finally, in Figure 9 the distribution of rate of heat transfer with radiation parameter is shown against  $t$ . Inspection shows that, increasing radiation parameter,  $R_a$ , tends to boost the heat transfer rate at the wall i.e. elevate  $Nu$  magnitudes. A substantial decrease is observed in  $Nu$  for the time parameter.



**Figure 9:** Nusselt number distribution for radiation  $R_a$

## CONCLUSION

In the present work, we have analyzed flow, heat transfer on convection flow of a viscous incompressible, electrically conducting and radiating fluid over an infinite vertical plate

embedded in a Darcian porous regime in the presence of transverse magnetic field and thermal radiation using the classical model for the radiative heat flux. Final results are computed for variety of physical parameters which are presented by means of graphs. Laplace transforms solutions for the non-dimensional momentum and energy equations subject to transformed boundary conditions have been obtained and the results indicate that:

- ≡ The flow has been shown to be decelerated with increasing Hartmann number but accelerated with conduction-radiation and porosity parameters.
- ≡ Increasing Hartmann number also increases the shear stress and back flow has been observed for higher radiation near the wall.
- ≡ A positive decrease in  $R_a$  or  $K$  strongly enhanced the shear stress.
- ≡ Increasing thermal radiation contribution ( $R_a$ ) serves to enhance wall heat transfer gradient significantly in the porous regime.
- ≡ With an increase in time ( $t$ ), both the skin friction and wall heat transfer are decreased.
- ≡ Temperature is decreased with an increase in thermal radiation contribution ( $R_a$ ).

The study has important applications in materials processing and nuclear heat transfer control, as well as MHD energy generators. The current study has employed a Newtonian viscous model. Presently the authors are extending this work to consider viscoelastic fluids and also power-law rheological fluids. The results of these studies will be presented imminently.

## NOMENCLATURE

- $u$  non- dimensional velocity component in x direction [ $ms^{-1}$ ]
- $y$  normal direction of vertical plane surface [m]
- $C_p$  specific heat at constant pressure [ $J Kg^{-1}K^{-1}$ ]
- $D$  chemical molecular diffusivity [ $m^2s^{-1}$ ]
- $G$  acceleration due to gravity [ $ms^{-2}$ ]
- $G$  free convection parameter [-]
- $M$  Hartmann number (magnetic parameter) [-]
- $K$  permeability of the porous medium [ $m^2$ ]
- $Pr$  Prandlt number [-]
- $P$  pressure [mmHg]
- $\theta$  temperature [K]
- $\bar{T}$  dimensional temperature
- $\bar{T}_w$  dimensional temperature at the plate
- $\bar{T}_\infty$  dimensional temperature at the free stream
- $T$  non-dimensional time [S]
- $u_0$  plate velocity
- $B_0$  strength of the magnetic field
- $R_a$  Radiation parameter
- $q_r$  Radiative heat flux

$\bar{\sigma}$  Stefan-Boltzmann constant  
 $\bar{a}$  mean absorption co-efficient

**Greek symbols**

$\beta$  volumetric coefficient of thermal expansion [ $K^{-1}$ ]  
 $\kappa$  thermal conductivity, [ $J \cdot m^{-1} \cdot s^{-1} \cdot K^{-1}$ ]  
 $\mu$  kinematic viscosity [ $m^2 \cdot s^{-1}$ ]  
 $\rho$  density [ $Kg \cdot m^{-3}$ ]  
 $\sigma$  electrical conductivity  
 $\tau$  coefficient of viscosity

**Subscripts**

w conditions on the plane surface  
 $\infty$  conditions away from the plane surface

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## EFFECTS OF POLYETHYLENE GLYCOL ON THE MECHANICAL PROPERTIES OF MEDIUM CARBON LOW ALLOY STEEL

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**Abstract:** The effect of polyethylene glycol  $[H(OCH_2CH_2)_nOH]$  as quenchant was studied with a view to accessing the mechanical properties and microstructural evaluation of steel. The test samples were subjected to a conventional quenching treatment process using prepared polymer solution with a definite proportion as quenching medium. The samples were characterized using a microhardness tester, universal tensile tester for the mechanical properties and a metallurgical microscope used in analyzing its structural re-orientation. From the result, it was observed that the hardness increment of the quenched samples conform to literature review as there was also a rise in the tensile properties. This though, was at the expense of their ductility. The micrographs were found to have justified the reason for the increment recorded in some of the mechanical properties, as it displayed a high proportion of the martensitic phase.

**Keywords:** Quenching, Polyethylene Glycol, Impact Energy

### INTRODUCTION

Medium carbon steel (as-rolled) most often does not meet the requirements for some applications especially where high hardness and strength are required; this is due to their limitations in some mechanical properties. To meet these requirements, several methods of heat treatment techniques have been adopted with a view to manipulate its structure and thus widen its scope of application [6]. Among others, this technique includes the conventional normalizing process which requires the cooling of the materials in natural air to enhance the relief of stress that might have been induced during the manufacturing process; annealing, as it involves the cooling of the material in the furnace after heating to a predetermined austenitic temperature. Other conventional techniques are quenching and tempering operations [4].

Quenching is another heat treatment operation which has been adopted for decades now to introduce and improve high hardness and strength properties on steel [3]. In most cases however, it is observed to be at the expense of its ductility [5]. This operation involves the heating of the material to austenitic state and allowed to cool rapidly (Quenching) in a defined cooling medium such that the atoms will be forced to undergo a re-orientation and then results to the desired properties.

Several media are being used in the cooling of steel during quenching operations. The selection of

cooling medium depends, to a large extent, on the desired properties and application. Some of the media that have been conventionally used includes water, brine and oil. Recently however, the use of polymer has begun to gain relevance in the quenching operation.

Some researchers have been working tirelessly investigating the effect of polymer quenchants on the properties of steel [1,2]. All of these researchers have narrowed their study to low carbon steel with a view to improve the strength and justify it with the developed structures. Some of these researchers, who despite their intense efforts, have not studied and analyzed its effect on medium carbon steel when subjected to quenching operations in polymer, and the need to do that serves as a reason for this project.

### MATERIALS AND METHOD

#### Materials and Equipment

With the aim of determining the response of steel to polymer (Polyethylene glycol) quenching operation, a commercially available carbon steel of chemical composition shown in Table 1 was procured. Polyethylene glycol –  $H(OCH_2CH_2)_nOH$  [where n represent the average number of oxyethylene groups] – was also procured to serve as the quenchant. The equipment used to carry out the experiment includes: muffle furnace, hack saw, bench vice, spectrometer, instron universal tensile testing machine, microhardness testing machine, and metallurgical microscope.

**Table 1:** Chemical composition of the steel used in this experiment

Elements	C	Si	S	P
Composition	0.3800	0.1630	0.0399	0.0301
Elements	Mn	Ni	Mo	V
Composition	0.7425	0.0911	0.00180	0.0029
Elements	Cu	W	Cr	Co
Composition	0.3031	0.0003	0.0555	0.0094
Elements	Al	Ca	Zn	As
Composition	0.0019	0.0002	0.0037	0.0060
Elements	Sn	Fe		
Composition	0.0230	98.1858		

**Method**

The as-received 12mm diameter rod was firstly taken to U-Steel Ltd, Lagos for spectrometric analysis where it was confirmed to contain 0.38% carbon content. The bulk rod was machined to tensile and impact configurations using medium size lathe machine while pieces were also cut for microhardness evaluation. Four sample sets were machined each for the pre determined three different PEG mixture proportion and for the control. The samples were initially normalized so as to annul the mechanical history of the machined specimen and this serves as the initial microstructure for the experiment. Subsequently, all samples were heat treated to austenitic region in a muffle furnace and held for 60 minutes respectively prior to rapid cooling in prepared polymer mixtures of 20, 40 and 60% of Polyethylene glycol (PEG). The treated samples were designated to avoid mix-up in the course of characterization (See Table 2). The resulting developed structure were characterized and analyzed.

**Table 2:** Sample's designation

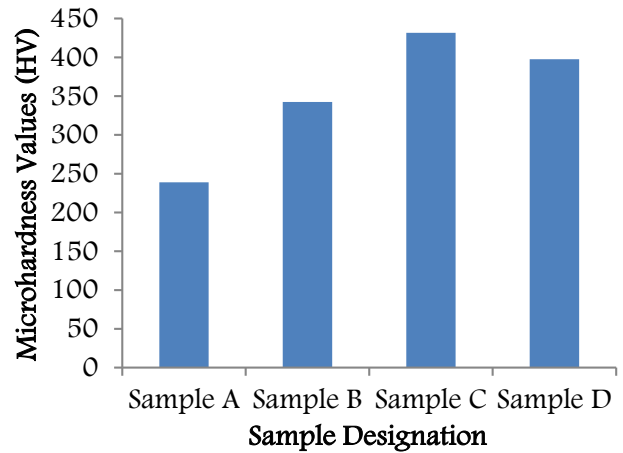
Label	Polymer : H <sub>2</sub> O
Sample A	Normalized
Sample B	3:7
Sample C	2:8
Sample D	1:9

**RESULTS AND DISCUSSION**

» **Effects of polymer quenching on the microhardness of medium carbon steel**

Figure 1 shows the hardness plots of the steel and its improvement after quenching operation was carried out. The untreated sample (Sample A) was observed to have the least hardness value thus indicating its unreliability in certain applications where high hardness is required. The effects of the quenching operation were explicit in other sample as they all exhibited higher hardness values. Sample C which was quenched in 2:8 polymer: water mixture respectively was observed to exhibit the highest hardness value of 431.7HV in comparison to the control sample that possess 238.9HV thus translating into 80.7% increment. The reason for this expected increment could be attributed to the very short time

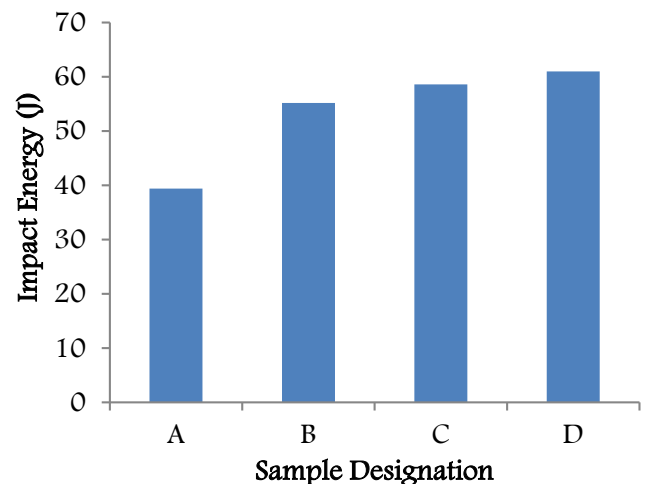
expended in bringing the temperature of the heated sample to a lower temperature such that no reaction would occur within the atoms of the material during the quenching process. This will be further discussed in the course of this section.



**Figure 1:** Variation of Hardness to Quenchant proportion

» **Effects of polymer quenching on the impact energy of medium carbon steel**

A progression in the impact strength with respect to the quenching media proportion was observed in the result (See Figure 2). The control sample as conventionally expected, displayed the least strength, while the quenched sample displayed interesting values that indicate that the proportion of the mixture for quenching is a factor in determining the impact strength of steel. Sample D quenched in 1:9 polymer:water exhibited the highest value indicating that it has the highest tendency to withstand sudden shock at a predefined condition prior to failure.



**Figure 2:** Variation of impact strength to quenching media ratio

» **Effects of polymer quenching on the tensile properties of medium carbon steel**

Figure 3 and 4 are the plots showing the tensile properties of the quenched and unquenched steel. The result of the ultimate tensile strength (UTS) for



the unquenched steel corresponds to findings in literature review [3,5].

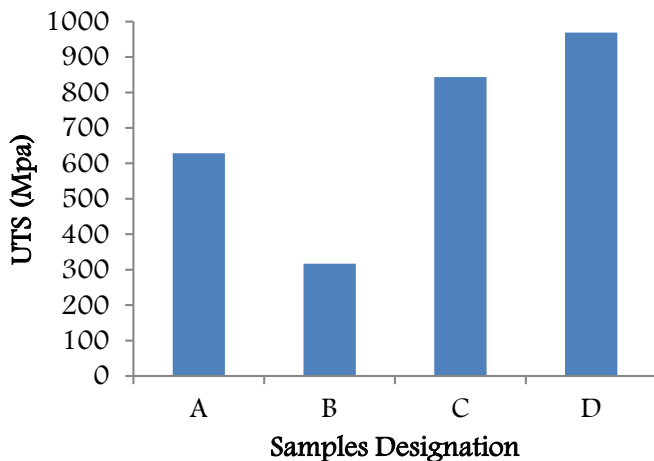


Figure 3: Plot of ultimate tensile strength versus the designation

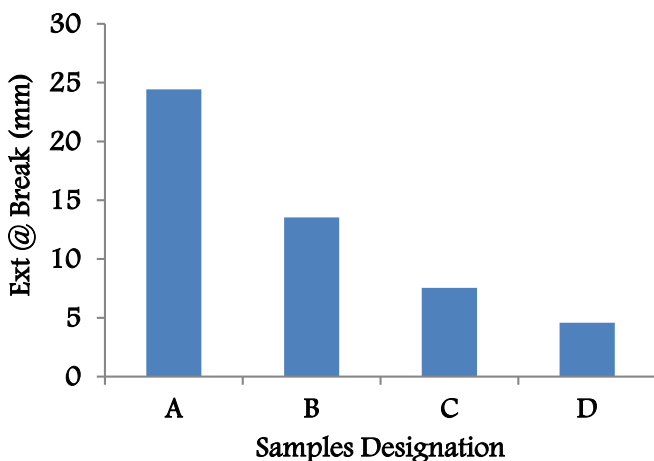


Figure 4: plot of extension of the steel at break versus the sample designation

While samples C and D were observed to display high UTS values (See Figure 4.3), Sample B however showed a reduction in comparison to the control sample. The reason for this could be attributed to an emergence of crack on the sample during quenching operation. Summarily, Sample D quenched in 1:9 mixture of Polymer and water respectively displayed the highest value for UTS indicating its ability to withstand higher load than others. This however, is a risk not worth taking as its ductility had drastically reduced as depicted by the results in Figure 4. Here, all quenched sample were observed to have sacrificed their ductility for strength and hardness as the unquenched possess the highest extension prior to failure thus indicating its high endurance limit at fixed load. The least 'extension at break' value displayed by Sample D showed that it is brittle and its failure will be catastrophic as there will be little or no notification prior to fracture.

» **Effects of polymer quenching on the microstructure of medium carbon steel**

The microstructures obtained are shown in the Plate 1 – 4.

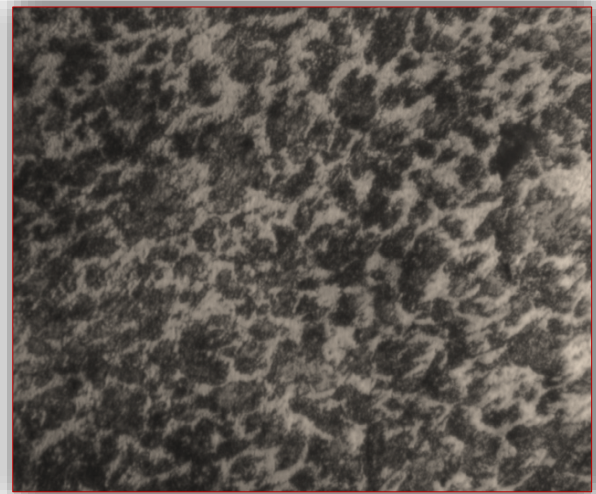


Plate 1: Microstructure of sample A (control – after normalizing operation) – 200X

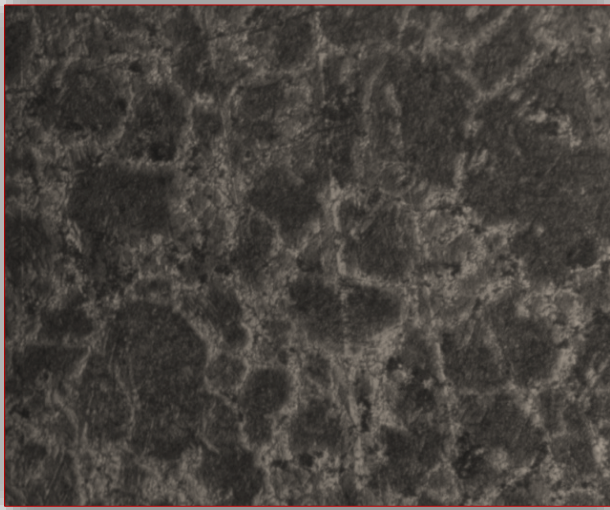


Plate 2: Microstructure of sample B 60 percent by volume of PEG (after quenching operation) – 200X



Plate 3: Microstructure of sample C 40 percent by volume of PEG (after quenching operation) – 200X





**Plate 4:** Microstructure of sample D 20 percent by volume of PEG (after quenching operation) - 200X

The microstructure produced by the control sample consists of pearlitic-ferritic structure while the microstructures produced by the processes consist of a finely distributed ferrite-martensite microstructure. The strong deformable second phase consists predominantly martensite with some retained austenite. Martensite provides the strength in the steel which justifies the improvement in some of the mechanical properties as earlier discussed; whereas the ferrite provides the ductility. The strong second phase is dispersed in a soft ductile ferrite matrix.

#### CONCLUSION

The effect of  $H(OCH_2CH_2)_nOH$  (polyethylene glycol) as quenchant was studied with a view to access the mechanical properties and microstructural evaluation of medium carbon steel. The test samples were subjected to a conventional quenching treatment process, and quenched in a prepared polymer solution with a definite proportion. The samples were characterized using a microhardness tester and universal tensile tester for the mechanical properties and metallurgical microscope used in analyzing its structural re-orientation. From the results, it was observed that the hardness increment of the quenched samples conform to literature review as there was also a rise in the tensile properties. This though, was at the expense of their ductility. The micrographs was found to have justified the reason for the increment recorded in some of the mechanical properties as it displayed high proportion of martensitic phase.

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## DEVELOPMENT OF COST EFFICIENT, OPEN SOURCE BASED BUILDING MECHATRONICS SYSTEMS

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**Abstract:** The European Union is constantly striving to reduce energy use of buildings, therefore constant regulations put into force in the energy sector. In response to these changes the population has to adapt, which means renovating or automating the heating system of the building sites. Industrial control systems required for the automation are inaccessible to the public considering their high price, in contrast, open and closed source field controllers offer a good and cheap, but limited capability alternative. This article presents a new method to achieve cost effective building automation alternative for small and medium sized buildings. Comparison of closed source and open source based building automation system is introduced.

**Keywords:** Energy consumption, Open source, Closed source, Building automation

### INTRODUCTION

In the European Union the annual energy consumption divided into three main sectors: buildings, industrial and services. The buildings' energy consumption accounts for the nearly 40 per cent of total energy usage. According to the EPBD directives, the energy usage have to reduce continuously, and by the mid-range term after 2020 only zero energy buildings can be build.

The building energy usage's main part the heating, ventilating and air conditioning system (later HVAC), and the sector holds the largest untapped potential to save energy. To optimize energy usage, there are two opportunities:

1. Modifying the building's physical parameters by renewing heat transfer surfaces

2. HVAC system optimization by field controllers

Modifying any building site's physical parameters are costly compared to HVAC system optimization. However, some robust HVAC controllers (e.g. PLC-s) on the market can nearly cost the same as a full building renewal with the disadvantage of their inflexibility. This means that each product can only use its own manufacturer's accessories and software that is required for programming and to achieve sufficient operating conditions.

In the following Open and Closed source system properties are presented, including its physical realization, and finally compare it.

### OPEN-SOURCE SOFTWARE AND HARDWARE

“Open-Source Software (OSS) refers to software systems which are free to use and whose source code

is fully accessible to anyone who is interested. Most OSS systems start out with a developer who wants to solve his or her own particular problem and makes the solution (system) available to others for free. Because it is free, it often attracts many users who have a similar problem, and because of the free access of source code, some interested users become co-developers by extending or improving the initial system. Together with the original developer, users and co-developers create a collaborative OSS community around the system. Without such OSS communities, OSS projects are not likely to be successful. Most OSS systems are not necessarily carefully designed in advance. They evolve in response to the needs of users in the OSS community, and the evolution is carried out by contributing (co-)developers of the same community. Although the evolution of an OSS system is not well planned, “giving users of a product access to its source code and the right to create derivative works allows them to help themselves, and encourages natural product evolution as well as preplanned product design.”[1]. Through the years, the open source projects became more effective, reliable and the community created standards like GNU GPL (GNU General Public License) that warrants the open source application rights. As the open source software begins to conquer the world, so does its own hardware such as the Arduino platforms. Numerous commercial hardware are already available.

These platforms are used mostly by hobby electronics and universities for education purposes, because



they are easy to use compared to others like ATMEL or Microchip. Furthermore, some companies saw a great opportunity and they are already using these products with their own hardware. This way they don't need highly trained developers and programmers.

**CLOSED-SOURCE SOFTWARE AND HARDWARE**

These systems are set up by companies specializing in closed-source software and hardware development. This process is difficult, time and money consuming, so the clients have to put their hands in their wallets for these products. In return, clients will possess a gadget worth to pay more than open-source systems. It is possible to choose from wide variety of additional accessories and modules, thereby avoiding to pay for unnecessary modules and accessories. The owner also receives customer support with the development team's professional experience; hence the customers never have to repair the system at their own risk. Not only the systems working exactly as they need to, but also more resistant to exterior attacks and unauthorized accesses. The only disadvantage is that the source code never gets to the customer, so they do not know how it works. Only the company's employees can modify it if so requested by the client.

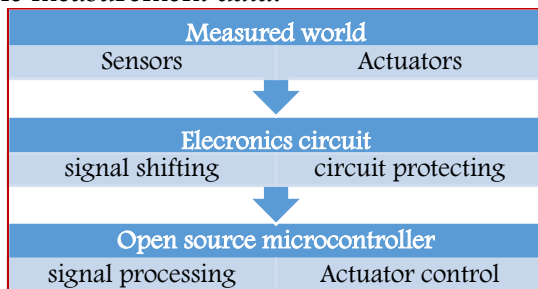
**ARDUINO BASED DESIGN CONCEPT**

The concept was to create a multi-functional device specially designed for non-industrial environment.

The main purposes are the following:

- 1) cheap energy control for buildings
- 2) measurement data acquisition
- 3) user friendly
- 4) plug & play
- 5) compatibility with data analyzing programs

The aim is data acquisition and control system development that is available for even an average household, and provide a user-friendly interface to handle measurement data.



**Figure 1.** System build-up layers

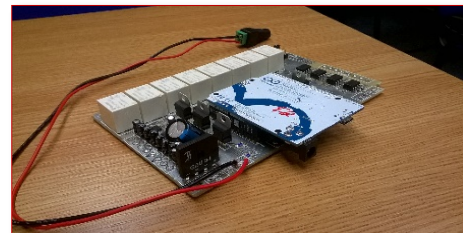
The first layer represents the connection to the outside world with precision sensors and actuators. Sensors convert the non-electric parameters – temperature, humidity, and global radiation etc. – of the environment to electric signals. These signals can be analog or digital, depending on the application. The sensor selection is prominently influences the system's behavior, because a needlessly accurate sensor increase the cost, or an inaccurate

measurement can cause unexpected events or failures.

The second level is the electronic shield that receives the signals from the sensors to shift signals for the operating slope, and amplifies the control signals for the actuators. The shield has another function to protect the control unit from harmful voltage spikes, electrostatic discharges (ESR) and also provides regulated voltage source, for all of the connected devices.

The third part is the open-source hardware platform, named Arduino that is a physical computing platform based on a simple AVR microcontroller board, and a development environment for writing software for the board. Using the platform makes the development easier and time effective, because its programming language named Wiring designed for rapid circuit prototyping. Arduino boards have a common connection pinout configuration that reached a wide range of the electrical community. So that pin configuration regards a standard, and usable of that makes the shield more flexible.

The development started as a fully custom-made PCB co-operating with Arduino compatible with any type of sensors. But this direction has soon turned out to be a dead-end, because designing and programming became too time-consuming and difficult.



**Figure 2.** UNI\_IO circuit, with Arduino Leonardo

The project's current aim is to apply a widely available development kit into an extension board compatible with the most commonly used sensors and actuators. The first version of the PCB (named as: UNI\_IO) is shown at Figure 2.

**Table 1.** UNI\_IO configuration

Name	Input	Output
Analog	8 ESD protected	8 PWM to Analog
Digital	8 isolated	8 relay
Serial	EIA 485, 1 Wire	
I/O	2 pull-up 5V I/O channel	

The PCB has 2 different connection ports, one for Arduino compatible, and the other to connect various controllers that meet the 3.3V-5V operating voltage requirement. Table 1 shows the specification of the PCB.

The digital inputs are isolated by an opto-coupler, so that protected from overvoltage. For the inputs, several digital signal sensors can connect, with 30V maximal input voltage. The digital outputs are relay output, which can switch power to drive devices.



The analog inputs are protected from ESD, and the voltage divided by 3 to avoid overvoltage failures. Analog inputs are an operational amplifier output with 2 times gain to create analog output from PWM (Pulse width modulated) signal for 0-10V transmitting.

The EIA485 converter placed on the PCB for the long distance communication (up to 1000-1200m), for example Modbus communication. Two pulled up input/output placed too, for mostly the 1-Wire communication.

And finally the PCB provide external and internal voltage levels: 12V, 5V, 3.3V to operate the board itself, and the sensors.

The Arduino Leonardo cooperating the UNI\_IO panel controller is ready to use, because in addition to the circuit, a control software is also made, which is built around the Modbus communication protocol. The idea was to develop a suitable program capable of handling household system signs such as water meters, gas meters and also HVAC consumption components like valves, motors and boilers. The success of the program shows that structure only has to be installed once on the controller, then any modifications are possible remotely via Modbus or even with a nearby laptop using a simple USB connection in real time.

The cycle period within full use is between 5-700 millisecond sparing additional resources if the aim is to measure once every second. In the previous sections only one half of the concept have been presented (field unit), but it requires an additional control unit which processes the data, stores and implements the control algorithms, such as PID control. For this purpose we can use Raspberry Pi, which is an open source-based AMR embedded system on which to run the control software.

Countless open-source controller and SCADA (supervisory control and data acquisition) software available on the market. For instance, the software named ScadaBR is capable of supervising an average household. The advantage of the SCADA based supervisor is the user friendly graphic interface helping to monitor and control the internal house environment easily and remotely.

**CLOSED SOURCE DESIGN CONCEPT**

The name of the product series is Energy Mentor that rests entirely on closed-source foundations in contrast to the Uni\_IO system and hardware. The main difference between the two embedded systems is that the EM has an integrated stand-alone central computing unit. The aim of its design was to create a device with the most versatile utility in the field of measurement and control purposes. As a result it can be applied to both home and industrial environments.



Figure 3. Energy Mentor series

Main advantages:

- » Additional expansion modules on demand
- » Low-power consumption, economic
- » DIN-rail mountable, robust
- » suitable to form network with multiple CPU-s and modules
- » Programmable in RTOS
- » Stand-alone system

The heart of the hardware is an AVR Xmega microcontroller with +3,3Vdc supply voltage according to industrial trends. The microcontroller has large amount of program-memory along with I/O ports compared to open source systems. This way it supports far more devices and suitable applications.

Currently the field controller has two support field IO modules, one with four and the other with eight channels. These two modules are rather useful in industrial and special environments.

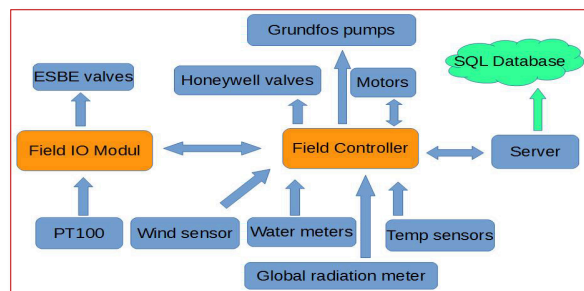


Figure 4. Test system construction

Such as testing of solar panels or engines, with long-life, high temperature range and accuracy demand fulfilled by PT100 heat sensors.

Table 2. Field Controller configuration

Name	Input	Output
Analog	4 ESD protected	2 PWM to Analog
Digital	8 isolated	2 TTL, 8 relay
Serial	EIA 485, EIA-RS232C, I2C, 1 Wire, Ethernet TCP/IP	
I/O	2 pull-up 5V I/O channel	

As shown in the configuration table (Table 2) a wide range of protocols and data transmission systems are available. This makes it easy to deploy an Ethernet TCP/IP or Ethernet / RS485 Modbus communication network. By using the Modbus protocol, the devices can be provided with a unique identifier, as well as Master or Slave functions. The Master device controls and manages the slaves together.

The development of the device is currently in the testing process of the second generation. The devices

withstood extended testing between both laboratory and production environment conditions. Within the stress-test a hybrid photovoltaic solar-thermal system consisting of pumps, linear motors and valves had been controlled and measured. Since 2014, the system is working properly.

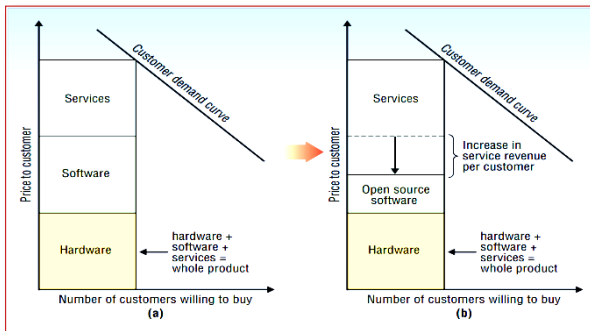
The firmware development started in Basic language, but is already in the process of rewriting into C language as well. In addition, a Real Time Operating System (RTOS) implementation is in the future plans to improve schedule processing flexibility.

**CONCLUSION**

As you can see in Table 3, the advantages of using Open Source systems cheapness, faster development production, products require less energy to invest in however, a less stable and efficient system is obtained. The closed source products in contrast provide more favorable physical designs, better communication capabilities and performance which is associated with robustness and reliability. Due to higher performance C.S. systems are able to accomplish the specific and unique tasks, such as: a central controlling unit for renewable energy systems, or HVAC systems.

**Table 3.** Comparison between systems

Name	Input	Output
Open-Source	Prototype, free source code, easy programming	unreliable, ineffective, non-unique solutions
Closed Source	robust, reliable, high performance, huge I/O, wide range of communication	complex programming knowledge, time and money consuming design



**Figure 5.** Price comparison, RIEHLE, Dirk. The economic motivation of open source software: Stakeholder perspectives, page 26.

But overall, we can say that open source systems can be a good alternatives for closed source systems till a certain level of need. For example if more I/O ports or faster operating speed is required closed source is a better choice. In turn open source devices are cheaper solutions that can be seen in Figure 5. This great advantage can be decisive for the appearance on the market.

**Acknowledgment**

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## DEVELOPMENT OF EARLY STRENGTH OF LIME STABILIZED EXPANSIVE SOIL: EFFECT OF RED MUD AND EGG SHELL ASH

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**Abstract:** The present study evaluated the effect of two solid wastes, Red Mud (RM) and Egg Shell Ash (ESA), in the enhancement of early strength of lime stabilized soil. Quick strength development is significant in highway projects longer wherein curing periods may lead to delay in completion of the work. In order to study the influence of the two waste materials, they were admixed with two lime contents chosen for stabilization of an expansive soil and their unconfined compressive strengths were evaluated over three curing periods of 0 (2 hours), 3 and 7 days of curing. The test samples were prepared in a split mould of 38 mm x 76 mm at a fixed density and moisture content. The results of the test revealed that ESA performed better than RM in enhancing the early strength of lime stabilized soil. ESA produced significant strength gain at low lime content and noteworthy gain at higher lime content whereas RM could produce only marginal strength gain at low lime content but noteworthy strength gain at higher lime content.

**Keywords:** Expansive Soil, Lime Stabilization, Red Mud, Egg Shell Ash, Early Strength

### INTRODUCTION

Lime stabilization has been one of the most common techniques adopted for stabilization of expansive soils. Expansive soils have been known for being disastrous on the structures constructed on them and their effects are only too well documented [1–5]. The primary reason for such problems is because of the volume change behavior of the soil [6] arising from the presence of montmorillonite group of minerals [7,8]. However, even such lime stabilized soil seems to be ineffective under certain conditions like sulphate rich soils resulting in the formation of minerals like ettringite [9,10] which render the soil even poorer than before. In order to reduce such damaging effects under adverse conditions, researchers have tried to use auxiliary additives to lime in soil stabilization to mitigate the damaging effects. A lot of industrial wastes have been adopted by researchers in finding a solution to such problems as well as augmenting the performance of lime. Wild et al. [11] studied the effect of GGBS in suppressing the swelling behavior of lime in sulphate rich environments. James et al. [12] studied the effect of lime and RHA on the index properties of stabilized soil. McCarthy et al. [13] investigated the effect of flyash on lime stabilized sulphate rich soils. Moayed et al. [14] studied the performance of micro silica addition to lime stabilization of saline silty soil. James and Pandian [15] studied the effect of

phosphogypsum on the development of early and late strength of lime stabilized soil. Sharma et al. [16] explored the behavior of remoulded clays blended with lime, calcium chloride and rice husk ash. Manikandan and Moganraj [17] evaluated the consolidation and rebound properties of lime stabilized soil admixed with bagasse ash. Shah et al. [18] examined the adverse effects of fuel oil contamination on the geotechnical properties of the soil and its stabilization with lime, cement, flyash and also their combinations. A lot of work on stabilization of soil with lime and industrial wastes mostly deal with the development of delayed strength of the stabilized soil. However, in certain cases the development of early strength assumes significance as in the case of subgrade stabilization of pavements and highway embankments wherein increased curing periods results in delayed projects. Okonwo et al. [19] state that during peak rainy seasons, construction work gets interrupted and hence it is desirable to reduce the setting time of the stabilized matrix. A few researchers have however, studied stabilization from the point of view of early strength development. James and Pandian [20] had earlier carried out a similar study on the early strength development of cement stabilized expansive soil admixed with ceramic dust and lime stabilized expansive soil admixed with press mud. Zhe et al. [21] studied the early strength and shrinkage of



cement and lime stabilized soil. The primary objective of this work is to study the effect of Egg Shell Ash (ESA) and Red Mud (RM) on the development of the early strength of lime stabilized soil.

### MATERIALS AND METHODS

The materials adopted in this study include the virgin expansive soil, lime, ESA and RM.

#### Virgin Soil

The virgin soil was obtained from Thiruvallur district of Tamil Nadu, India. It was tested in the laboratory and its geotechnical properties were determined and classified. Table 1 shows the geotechnical properties of the virgin soil. The geotechnical properties were all determined in accordance with Bureau of Indian Standards (BIS) codes.

**Table 1.** Properties of Virgin Soil

Property	Value
Liquid Limit [22]	68%
Plastic Limit [22]	27%
Plasticity Index	41%
Shrinkage Limit [23]	10%
Specific Gravity [24]	2.76
% Gravel [25]	0
% Sand [25]	2.5
% Silt [25]	60.5
% Clay [25]	37
Maximum Dry Density [26]	15.3 kN/m <sup>3</sup>
Optimum Moisture Content [26]	25%
UCC Strength [27]	115.8 kPa
pH [28]	6.53
Soil classification [29]	CH

#### Lime

Laboratory grade hydrated lime was adopted in this study. The lime adopted in the study was sourced from Nice Chemicals India Pvt. Ltd. The composition of lime used in the study as given by the manufacturer is tabulated in table 2.

**Table 2.** Composition of Lime

Component	Content (%)
Acidimetric	90
Chloride(Cl)	0.04
Sulphate(SO <sub>4</sub> )	0.4
Aluminium, Iron and insoluble matter	1
Arsenic(AS)	0.0004
Lead	0.04

#### RM

RM is generated as a by-product during the production of alumina. Depending on the raw material processed, 1–2.5 tons of RM is generated per ton of alumina produced. The worldwide production of RM is in the range of 70 -120 million tons per annum [30–32]. In India, about 4.71 million tons/annum of RM is produced which is 6.25% of world's total digestion with sodium hydroxide at elevated temperature and pressure [33]. It is a mixture of compounds originally present in the parent mineral bauxite and of compounds formed or

introduced during the Bayer cycle. It is disposed as slurry having a solid concentration in the range of 10-30%, pH in the range of 10-13 and high ionic strength. Less than 5% of RM is utilized worldwide [33]. RM has been investigated in earlier research works for various purposes. Kalkan [34] investigated the utilization of RM in stabilization of clay liners. Dass and Malhotra [35] had adopted lime for stabilization of RM bricks. Rai et al. [32] investigated the potential of sintered RM as an alternative clay as building material. The RM adopted in this study was obtained from MALCO aluminium industry, Salem district, Tamil Nadu, India. The RM was crushed and pulverized to a powder form and was sieved through 75 micron BIS sieve for use in the study. The typical composition of RM from MALCO is given in table 3.

**Table 3.** Typical composition of MALCO RM [33]

Component	Content (%)
Fe <sub>2</sub> O <sub>3</sub>	45.17
Al <sub>2</sub> O <sub>3</sub>	27
TiO <sub>2</sub>	5.12
SiO <sub>2</sub>	5.7
Na <sub>2</sub> O	3.64

#### ESA

ESA is the residue obtained on incineration of egg shells of poultry birds. The primary component of egg shell powder is calcium carbonate. A lot of work has been done on use of egg shell powder in construction industry including its use in concrete and in soil stabilization. Amu et al. [36] adopted egg shell powder as replacement for lime in soil stabilization and found that replacement of lime with egg shell powder produced marginally lesser strength than lime stabilized soil. James and Pandian [37] had earlier adopted egg shell powder in soil stabilization and found that it improved the soil properties albeit by physical interaction as calcium carbonate is a stable component and does not react in the presence of water. However, on incineration the calcium carbonate in egg shell powder decomposes to calcium oxide at high temperature [19]. Very few investigations have been carried out with ESA in soil stabilization. Okonkwo et al. [19] adopted ESA as additive to cement stabilization of lateritic soil. The ESA adopted in this study was prepared by controlled combustion of egg shell powder, obtained from a commercial manufacturer of egg products, in a muffle furnace at a temperature of 500°C and the resultant ash was allowed to cool down and then sieved through 75 micron BIS sieve.

#### METHODS

The soil sample was prepared for the investigation in accordance with BIS code [38]. The stabilization of expansive soil was done at two lime contents, one at Initial Consumption of Lime (ICL) and the other at Less than ICL (LICL). The basis for selection of lime contents for stabilization is founded on the work

done by Nazrizar et al. [39]. The determination of ICL is described in a similar earlier work by the authors [20]. The LICAL content was randomly assumed below the determined value of ICL. The auxiliary additive contents were randomly assumed on trial and error basis but limited to low doses. The determination of uniaxial strength of the stabilized samples were done by casting cylindrical specimens of dimensions 38mm x 76mm in a split mould, cast at a density of 14.3 kN/m<sup>3</sup> and 25% water content. The density and the water content of the specimens were fixed by performing compaction tests on lime stabilized soil using a Jodhpur mini compactor in accordance with BIS 4332 [40].

The results of the Jodhpur mini compaction test and standard proctor test are very close within the limits of experimental error [41]. To achieve the fixed density, carefully calculated weights of soil, lime and additive were weighed and packed in dry condition. At the time of preparing the specimen, the required quantity of water was added and statically compacted to the aforementioned dimensions. The prepared specimens were de-moulded immediately after casting and placed in sealable polythene covers to prevent loss of moisture and cured for periods of 2 hours, 3 days and 7 days for understanding the course of development of early strength of the stabilized soil. After the end of the curing periods, the samples were removed from the covers and strained axially until the failure of the specimen, at a strain rate of 0.625mm/min which is within the strain rate prescribed by BIS code [27].

## RESULTS AND DISCUSSION

The ICL was determined from the Eades and Grim pH test as 5.5%. The LICAL content was assumed to be 3%. Four trial values of auxiliary additives were assumed as 0.25%, 0.5%, 1% and 2%. The early strength development of ESA and RM admixed lime stabilized soils have been discussed in subsequent sections.

### Early Strength of RM Admixed Lime Stabilized Soil

The addition of RM to lime stabilized soil at LICAL content is shown in figure 1. It can be seen that the addition of RM to LICAL stabilized soil affects the strength of the soil. It can be noticed that the addition of RM results in an increase in the early strength of LICAL stabilized soil at 7 days of curing. The addition has no positive effect on the immediate and 3 day strength of the stabilized soil.

Looking at the effect of additive content, it can be seen that there is an initial dip in the performance of the stabilized soil at 0.25% RM content but performance increases on further addition of RM until 2% RM addition which is the limit of auxiliary content studied in this investigation. The trends of strength development are similar across curing periods. It can be seen that the maximum strength is achieved at 2% RM. The strength of the soil increases

from 517.69 kPa for pure lime stabilized soil to 563.73 kPa for 2% RM addition at 7 days of curing. In an earlier study, James and Pandian [15] found that phosphogypsum was capable of raising the strength of LICAL stabilized soil at a dosage of 0.25% addition.

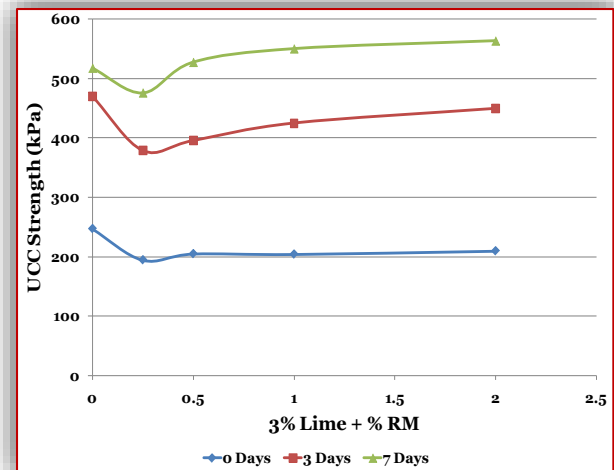


Figure 1. Early Strength of LICAL Stabilized Soil admixed with RM

Figure 2 shows the early strength development of ICL stabilized soil admixed with RM. The addition of RM to lime stabilized soil at ICL content shows a different result as addition of RM does not produce significant gains in early strength. There is a dip in performance on addition of RM at 0.25% addition. However, on increasing the content, there is an increase in the strength gain but at 2% addition, the gain is still marginal. As in the earlier case, the trends are similar across curing periods. The strength increases marginally from 981.32 kPa to 992.44 kPa at 7 days of curing. A similar outcome, at ICL admixed with 2% press mud resulting in strength gain at 7 days of curing has been recorded. [20].

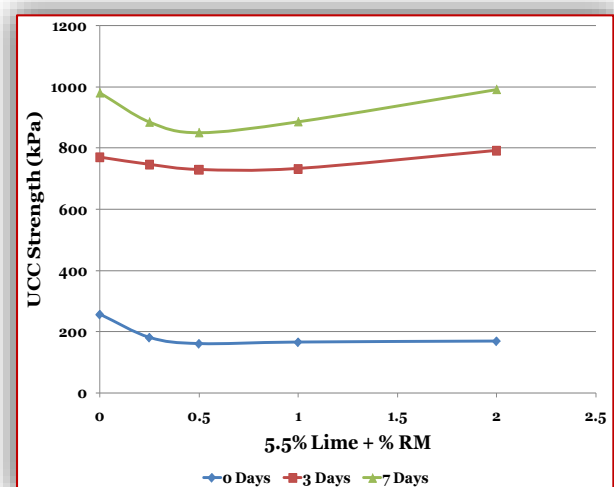


Figure 2. Early Strength of ICL Stabilized Soil admixed with RM

**Early Strength of Egg Shell Ash Admixed Lime Stabilized Soil**

The effect of the addition of ESA on the early strength of LICL stabilized soil is shown in figure 3. The addition of ESA results in the increase in the early strength of the stabilized soil. The general trends indicate that addition of increasing contents of ESA results in the increase in the early strength of the stabilized soil. The trends are more or less similar across various curing periods.

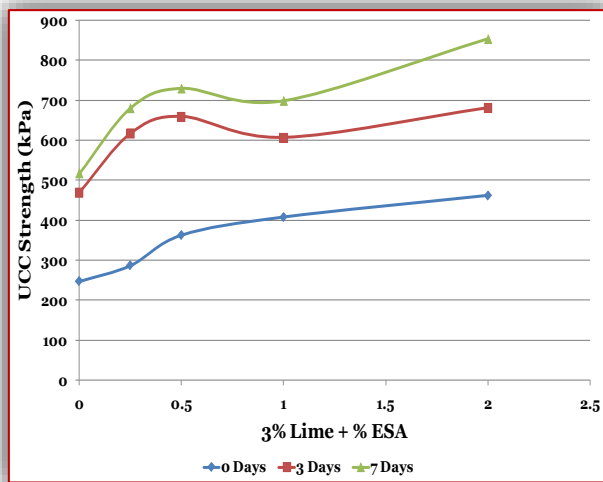


Figure 3. Early Strength of LICL Stabilized Soil admixed with ESA

Similar to RM admixed lime stabilized soil, the addition of ESA also produces maximum strength at 2% addition of ESA. The strength of the stabilized soil increases from 517.69 kPa to 853.66 kPa. Thus it can be seen that the strength gain achieved by ESA is tremendous when compared to RM. Okonkwo et al. [19] found that addition of 10% ESA to 6% cement stabilized lateritic soil raised the strength from 370 kPa to 614 kPa at 7 days of curing. In the present study, lime with ESA produced even higher strength. However, it should be noted that early strength gain is dependent on initial water content, stabilizer content and curing period [21].

Figure 4 represents the development of early strength of ICL stabilized expansive soil admixed with ESA. The immediate difference that is noticed is that the addition of ESA to ICL stabilized soil produced strength addition but peaks at a different ESA content when compared to LICL content. The addition of ESA to ICL stabilized soil results in peak strength at 0.5% addition of ESA. The strength of ICL stabilized soil increases from 981.31 kPa to 1081.65 kPa upon addition of 0.5% ESA.

In comparison, there was no change in the RM content that produced peak strengths in both LICL as well as ICL stabilized soil. This behavior, in the case of ESA, was unexpected and needs further investigation to determine the reason behind a shift in the optimal content of ESA for higher lime content.

However, both the cases reinforce the fact that addition of ESA can enhance the early strength of the stabilized soil. Okonkwo et al. [19] found that 8% cement stabilized lateritic soil admixed with 10% ESA raised the strength from 471 kPa to 687 kPa at 7 days of curing. As in LICL content, here as well ESA admixed ICL stabilized soil produced higher strength than cement with ESA.

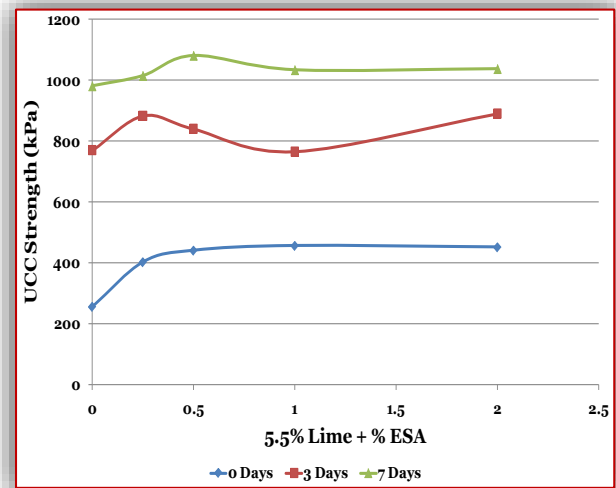


Figure 4. Early Strength of ICL Stabilized Soil admixed with ESA

**Percentage Early Strength Gain of Lime Stabilized Soil Admixed with RM and ESA**

The percentage early strength gain is calculated by comparing the strength of pure lime stabilized soil admixed with RM and ESA against the strength developed by pure lime stabilized soil at 7 days of curing, expressed in percentage. Bhuvaneshwari et al. [6] also performed a strength gain analysis for cured expansive soil-lime composites; however it was performed for subsequent curing periods.

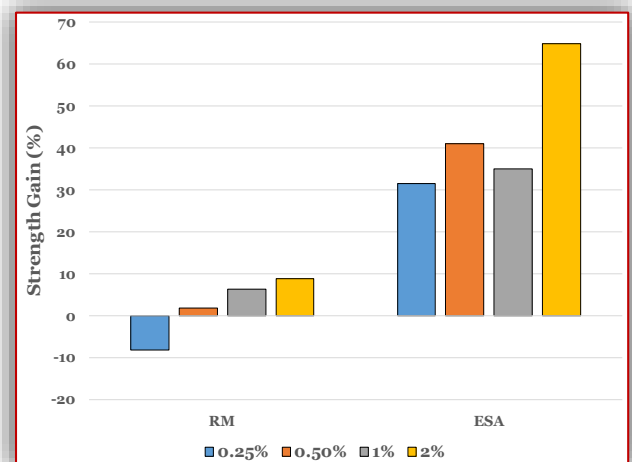


Figure 5. Percentage Early Strength Gain of LICL Stabilized Soil admixed with RM and ESA

Figure 5 displays the strength gain achieved due to the addition of RM and ESA to lime stabilization of expansive soil. It can be seen that the addition of ESA



to LICL stabilized soil produces better strength gain when compared to RM. Addition of red mud produces a steady increase in the early strength of the stabilized soil. Addition of 0.25% RM results in a loss in strength of lime stabilized soil, however, further increase in the RM content steadily results in strength gain. The gain in early strength increases from -8.12% to 8.89% for 0.25% to 2% increase in addition of RM.

In comparison, the addition of ESA results in a significant gain in early strength of the stabilized soil. For LICL stabilized soil, the addition of 2% ESA results in a tremendous strength gain of 64.9%. The addition of all combinations of ESA produces positive strength gain with a minimum percentage gain of 31.5% at 0.25% addition of ESA. James and Pandian [15] found that addition of phosphogypsum to LICL stabilized soil could not produce a significant strength gain. It can be seen that ESA produces a better performance when compared to phosphogypsum in enhancing the early strength at LICL stabilization.



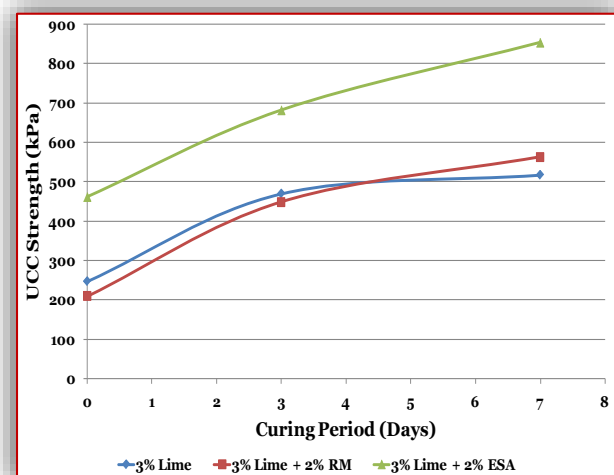
**Figure 6.** Percentage Early Strength Gain of ICL Stabilized Soil admixed with RM and ESA

Figure 6 reveals the percentage early strength gain of ICL stabilized expansive soil admixed with RM and ESA. A clear indication at the outset is that, in comparison with LICL stabilization, the effect of strength addition of both the additives is much lesser when stabilization takes place at ICL. In the case of RM, there is almost no gain in early strength with strength loss in all doses of RM addition, with the exception of 2% RM wherein the gain in strength is a meager 1.1%. In the case of ESA, despite no comparable strength gain as in the case of LICL stabilization, the percentage strength gain is a noteworthy 10.2% at 0.5% addition of ESA. The strength gain in all other doses is positive, but lies in the range of 3 to 6%. In an earlier study, at ICL, addition of phosphogypsum produced a comparable early strength gain of 14% [15]. At ICL stabilization, the performance of ESA drops below that of

phosphogypsum, despite the optimal content in both cases being 0.5%. But the difference in their strength gains is not huge and is still at comparable levels.

#### Early Strength Development with Curing

Curing period is an important parameter that influences strength development. In order to understand the strength development over curing period, a comparison of strength versus curing period has been done for the two additives. Figure 7 shows the development of early strength for LICL stabilized soil. However, the comparison has been made only for the optimal dosages of the additives to lime. The figure reveals that the strength development of RM admixed LICL stabilized soil is very much similar to pure lime stabilized soil. The addition of RM to LICL stabilized soil results in lesser strength at 2 hours of curing itself. With curing however, the strength develops, but at 3 days of curing it is still lesser than the strength of pure lime stabilized soil. The effect of addition of RM can be seen only at 7 days of curing wherein it produces higher strength than that of pure lime stabilization.

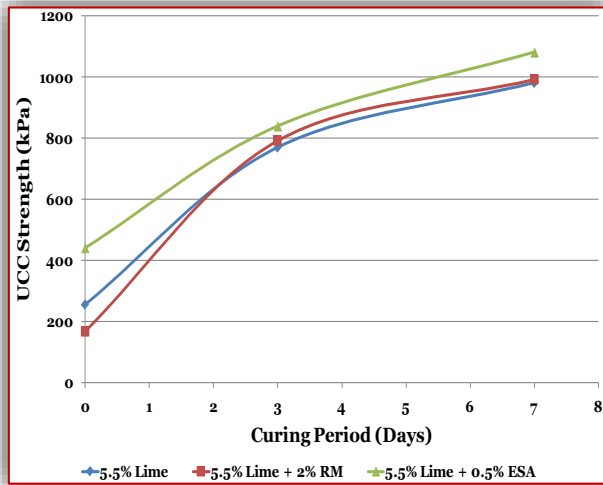


**Figure 7.** Development of Early Strength with Curing Period of LCL Stabilized Soil admixed with RM and ESA

In the case of ESA, the strength curve is significantly higher above both LICL strength curve as well the RM admixed LICL strength curve. This is due to the fact that, addition of ESA leads to a significantly higher strength at 2 hours of curing itself. With increasing curing period, the strength also develops proportionately and hence the curve stays significantly above the rest. Press mud when added to optimum lime content for soil stabilization produced a significant strength gain with curing in an earlier study [20]. However, in the present case, the effect of ESA was prominent at LICL that is at comparatively lower lime content.

Figure 8 represents the strength development of ICL stabilized soil admixed with RM and ESA. As in the case of LICL, the strength development curve of RM

admixed ICL stabilized soil is very similar to that of pure lime stabilized soil. The only difference being the effect of RM addition can be seen at 3 days of curing itself albeit very marginally.



**Figure 8.** Development of Early Strength with Curing Period of ICL Stabilized Soil admixed with RM and ESA. In the case of ESA, the strength development curve is significantly above the other strength curves but not as high as in the case of LICAL stabilized soil. One more point to be noted is that at higher lime content, the addition of ESA results in lesser strength development with curing as seen from the convergence of the curves at higher curing period. At a comparable lime content of ICL, press mud could not produce a significant strength gain [20] as produced by ESA with curing in the case of present study. However, in the case of RM, a similar status exists, wherein it was unable to produce notable strength gain with curing.

### CONCLUSIONS

Development of early strength of stabilized soil particularly assumes significance in the area of stabilization of subgrade for highway embankments and pavements wherein the constructed pavements need to be opened for traffic at the earliest. In such cases long curing periods may result in delay of projects and hence early strength development becomes a necessity for quick completion of projects in such cases. This study was performed with this in mind. Based on the experimental investigation, the following points can be concluded.

- (i) Addition of RM and ESA can enhance the early strength of lime stabilized soil. However, between the two, ESA produces better performance when compared to RM.
- (ii) At lower lime content of 3%, the effect of additives RM and ESA is more pronounced when compared to higher lime content of 5.5%.
- (iii) 2% RM was found to be the optimal dosage irrespective of lime content, whereas 2% ESA was found to be optimal at LICAL stabilization

whereas at higher lime content of ICL, 0.5% ESA was found to be the optimal dosage. However, this behavior needs to be investigated further through more detailed investigations.

- (iv) With increasing RM dosage, the strength of LICAL stabilized soil steadily increased, whereas only 2% RM dosage produced strength gain at ICL stabilization. Hence, further studies involving higher percentages of RM with lime need to be evaluated to clearly define the optimal dosage.
- (v) Results of strength development with curing indicate that ESA performs better than RM in both the lime contents and hence, ESA as an additive to lime stabilization can be provisionally recommended for enhancing the early strength of lime stabilized soil.
- (vi) This study limits itself with only lime contents below and at ICL. The effect of solid waste additives on stabilization with lime content above ICL and corresponding strength development can also be studied to identify efficient combinations for soil stabilization.
- (vii) This study limits itself to evaluating the unconfined compressive strength of the stabilized soil. The California Bearing Ratio of the said combinations should be evaluated to study their effectiveness for their application in subgrade stabilization for highway embankments and pavements.

### Recommendations for Future Work

- (i) Investigations performed at optimum lime content admixed with aforementioned solid wastes.
- (ii) Evaluation of CBR of the lime stabilized soil with solid waste additives for applications in pavement engineering.
- (iii) Investigations at longer curing periods to study the effect of the aforementioned solid waste additives in the long term stability and durability of lime stabilized soil.

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## THE EUROPEAN UNION AND THE UNITED STATES OF AMERICA FROM THE PERSPECTIVE OF DATA PRIVACY

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**Abstract:** While the data protection policies of the United States of America (USA) tend to differ state-by-state, the European Union is aiming to create and apply a unified legal system in all of its 28 member states, which during their accession process; all European Union candidate states must integrate into their legal system. In the USA, there is often a greater emphasis on the liberty of speech and the freedom of press, than the right to informational self-determination. This complicates those legal proceedings, which are commenced by a European state against contents, which are hosted on websites by an American hosting company. Furthermore, the USA, in the name of fight against terrorism, – often unwarrantedly and improperly by European Union legal standards – is collecting data during international trading and personal transportation, which violates the human rights accepted by the European Union. Due to the actuality of the topic, I shall compare the data privacy regulations of the European Union and the USA.

**Keywords:** data privacy, regulation, European Union, the USA, trans-Atlantic relationship

### HISTORICAL OVERVIEW

There is a perceptible difference between the evolution of the legal systems of the two powers: in Europe, the typical predominance of the continental legal system prevails, with its codification, and the preponderance of the written law against jurisprudence. Meanwhile in the USA the common law, known as the Anglo-Saxon law is dominant, which prefers jurisprudence-making precedents, which allow different interpretation of the law in different legal cases even in the same state. [1]

The professional literature classifies the European data privacy protection as a third generation system, which initial purpose was to lessen the dependency of the citizens towards the state in regards of obtaining public information. Second generational data privacy regulations have brought the emergence of the right of informational self-determination, while the third generational legislation was shaped by developments of the business world and the advancements in technology. As civilization progressed, the demand for a transparent state, the right to have access to and disseminate public information and for the freedom of information came to prominence, besides the protection of personal information. This has also brought about the need for transparency in the use of public funds at state- and other public bodies. The aforementioned factors have considerably supported the democratic operation of

the state. The appearance of the data of public interest helps it by way of the folk control democratic function, it encourages administrative organs' efficiency, the citizens to give birth the participation of truth, the corruption and state abuses in public affairs appearance, which one yielded the right of the expressions of an opinion. [2]

The protection of information in the European Union is determined by a data protection directive of the OECD (Organisation for Economic Co-operation and Development), based on international consensus, which came into force in 1980. An essential purpose of this directive is to enable the smooth operation of economic relations whilst protecting private information. The principles laid down by the OECD have influenced the creation of the Council of Europe's agreement, titled “Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data”, which was approved in 1981. [3]

In 2001, the office of the European Data Protection Supervisor's was created, in order to ensure that all the institutions and bodies of the European Union have the appropriate respect to the citizen's private life during the processing of personal data. [4]

In contrast, the citizens' right for the protection of their private information is significantly weaker than in Europe, despite Samuel Warren's and Louis Brandeis' study, published in 1890, which found that

the advancement of technology can be intrusive to one's privacy. This necessitated the creation of a new system for the protection of one's right to informational self-determination. This system has matured by the 1970s, when it was decided – citing fundamental rights –, that the citizens should be protected against large state records. Hereafter I shall present the most significant milestones of this process, based on a study, by András Molnár. [6] [7] In 1928 in the case of *Olmstead vs. the United States*, with a majority decision the Supreme Court held that telephone intercepts without a court order do not violate basic constitutional rights, because physically, the constitution regards the protection of privacy only within the house. It was because of this decision, that Louis Brandeis had formulated the “right to be let alone”. The “right of privacy”, only as an umbrella term was relatively lately introduced to the basic constitutional legal concepts in the 1960s, but still, it is not explicitly mentioned in the Constitution of the United States.

William Prosser, as a professor of law classifies the right to privacy into the legal system of compensation, where he views the public disclosure of private facts as a violation of the right to privacy, which results to a disadvantage for those affected, regardless of veracity. He defines the action of libel as a separate category, as well as the possession of image, name and other identifiers. Later, Gary Bostwick established the principle, that third parties should have access only to a certain protected zones to information about the individual.

In 1977, a judgment, made by the Supreme Court in regards to the *Whalen vs. Roe* case has established, that the interests, which are affected by issues related to the private sector are made up by several separate interests, which include information on the individual and its right to remain a secret. [8]

In a study by David Solove in 2006, he views the unauthorized collection of information, the abuse of information, which have been legally obtained and the publication of such information to the general public unconstitutional.

In summary, the U.S. does not apply a standard law for data privacy, because it is possible to interpret it differently from one Member State to another. In despite of some courts having declared the protection of data privacy as a basic right, there is no single official supervision. Another vulnerability presents itself as only American residents, and those with valid residence permit are subject to the Privacy Act (the federal data protection law).

#### **RELATIONSHIP BETWEEN THE EUROPEAN UNION AND THE UNITED STATES OF AMERICA**

As the development of the information society continues, privacy and the right to informational self-determination can succeed less and less. In

regards to data, lesser-developed countries are becoming increasingly vulnerable against more developed countries, which by the exploitation of the technological rift are carrying out unreported data mining. One way to reduce such dependency is to legitimize data collection between countries by mutual agreements and the establishment of proper safeguards. The legal harmonization of the OECD and EU satisfies this principle.

The “Safe Harbor” was created to facilitate the transmission of data to the United States. The assurance of the protection of private data during its processing is the most cardinal requirement of transmitting data to a third country. According to the Committee of the European Union, data transfer to the U.S. is considered to have an accepted level of safety, when the recipient U.S. Company is on the Safe Harbor list. The Safe Harbor list contains those Companies, which have agreed to meet the Safe Harbor data protection directives, set forth by the government of the United States.

The legal basis for all these are the 2000/520/EK (July 26<sup>th</sup> 2000) resolution of the European Committee based on the 95/46/EK directive of the European Parliament and the Safe Harbor act for providing adequate data protection, issued by the U.S. Department of Commerce, which contains all the data protection directives, that a U.S. based Company should meet. [9]

In the context of the Stockholm-program, the European Parliament has asked the European Commission to make a proposal for negotiations with the USA regarding data protection aimed at law enforcement and data exchange. The task force, based on the 29<sup>th</sup> article chaired by Jacob Kohnstamm has found that the passenger name records (PNR) of the U.S. collects such vast amounts of personal data of citizens travelling from the EU, which clearly is beyond the principles of necessity and proportionality. It states, that the fight against crime and terrorism does not justify the mass surveillance and tracking of passengers. Such police-like methods in EU member states are only feasible in special cases and within constitutional boundaries. The task force has also stated that it has not been presented with any statistics, which compares the number of criminals caught with the assistance of the PNR system with the number of surveyed passengers, which would justify the need for such surveillance. Thus, the task force recommends narrowing the range of personal data managed by the PNR system. In agreement with the European Data Protection Supervisor, the task force considers the recording of special data by the U.S. Department of Homeland Security unacceptable. Furthermore, it considers the 15-year long preservation of such data disproportionate, considering that according to the



EU Charter of Fundamental Rights such data needs to be anonymized or deleted six month after use.

The European Data Protection Supervisor supports the logging and documentation of each access to PNR data, so proper use by the U.S. Department of Homeland Security can be verified. [10] [11]

The trans-Atlantic partnership plays a significant role in the foreign politics of the EU, which aims to develop a trans-Atlantic market by 2015. In the framework of a trans-Atlantic partnership the European Union expects its partners to accept the values which it represents. Such values are democracy, human rights and the rule of law, sustainable economy and sustainable growth. The protection of these values must be assured even during the defense from global threats, such as terrorism. Despite the USA and EU being the world's largest bilateral trading partners, which causes economic dependence, nevertheless some acts of the U.S. – of which the European Parliament has on several occasion called on the U.S. Government to cease – often contradict the values represented by the European Union. Such acts are the penalties by death still accepted by a number of U.S. States, the maintenance of the Guantanamo Bay detention center and the unilateral visa requirement against some EU member states. The records of persons, suspected to be involved in terrorism and proven innocent are not being deleted from the database, furthermore the U.S. keeps records of their namesakes and last, but certainly not least – the controversial data mining done by the U.S. National Security Agency. For example: NSA confessed it, that Angela Merkel and the Greek government tapped his members' telephone, and more hundred users Google and Yahoo's drawer;<sup>1</sup> between 2004-2012 French economic leaders' interception<sup>2</sup>, CIA to which the door was showed because of spying chief from Germany.<sup>3</sup> The possibility that BND is German intelligence service arose on the other hand data it tracked recruited and European leaders for NSA.<sup>4</sup> The USA's senate accepted it meanwhile USA Freedom Act-of, which differs from European Union norms likewise. [12]

Concept definition differences may cause a problem the uniform data protection in questions. Since it is English language areas Data Protection, you are Data the personal data understand his protection by Security. The information security, you are INFOSEC expression generally the electronic information it is

used for protection. NATO in a standard Security of masks the administrative safety under Information. [13]

#### SUMMARY

The difference between the two powers goes beyond its historical roots. Despite that the United States itself is composed of numerous member states as well, its foreign policy does not view the European Union as a singular entity, and continues to show differences in treatment while dealing with EU member states.

The interpretation of data privacy and informational right to self-determination in the U.S. differs significantly from that of the EU. On the long term, the problems mentioned earlier can endanger the trans-Atlantic relationship. Related negotiations drag on exceptionally currently with the partnership, currently inside European Union debates it is accompanied by them.

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<sup>1</sup>referring to: <http://mno.hu/hirtvarchiv/beismerte-az-nsa-hogy-lehallgattak-merkelt-1192975>; (07.09. 2015.)

<sup>2</sup> referring to: <http://444.hu/2015/06/29/az-nsa-nem-csak-a-francia-elnokoket-de-a-francia-gazdasagi-vezetoket-is-lehallgatta/>, (07.09. 2015.)

<sup>3</sup> referring to:

<http://hu.euronews.com/2014/07/11/parbeszedet->

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## E-GOVERNMENT AS SOCIO-ECONOMIC TREND ~ KOSOVO CASE STUDY

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**Abstract:** The main mission of e-government in the first place is to provide a substantial increase of efficiency in the processing of massive requirements of citizens and providing administrative services within the state institutions, whether they are central or local institutions. There are increased amount of data for purchases, services and processing and is accelerated and the processing and storage of interactive databases and communication with customers. Likewise, e-governance contributes to long-term savings and significantly reduces the budget of the state apparatus. Substantial savings are possible, especially in the implementation of these governance models which interact in full horizontal communication among all relevant ministries, government institutions and public agencies or departments, and all state and local entities.

**Keywords:** e-governance, trends, service, administration, data, registers

### INTRODUCTION

That e-government be truly functional, for it to fulfill its mission satisfactorily, requires a precise and clear legal framework of the access availability level to personal data to protect in the first place all the citizens and their personal information.

It is necessary to develop an integrated national system of e-governance; should be included setting of all organs of state administration with the necessary information technology & programming packages. It is also necessary to train all those who work within the state and public administration, but also the citizens who use the system. In the initial stage, the cost of creating a service that functions as part of e-governance are very large, but the experiences of countries that consume these services for some years show that the subsequent savings in work of public administration have fully justified its initial investment. After all, the state and public administration with electronic governance have become much cheaper and more importantly, more transparent and more efficient.

However, a prerequisite for moving rapidly and functionally on e-governance is of course the fact that a large part of the country's population uses the Internet. In countries where the Internet has become an integral part of everyday life of the vast majority of citizens, this transformation of the service has its full meaning. In countries where the number of computers is still too small to invest in an integrated

system of e-governance would be premature and wasteful.

If we, for example, must be endowed with a certificate or declaration, it is sufficient that it be once in the system, and all those who have permission to access this system will be able to use the same virtual document. It is this unique administration which aims at strengthening the confidence of citizens in government and public administration.

All this of course allows considerable cost savings which until recently were considerable expenses for the public administration, but also provides a much better service for all users. To get a certificate or the required information is needed only a few minutes to work on your home computer, without the need of physical fatigue on many institutions counters. But perhaps the main social benefits of e-government are to ensure openness and transparency in all systems of governance and public administration. This is of course, the best way to fight corruption and abuse of power and position by any government official.

### USE OF THE INTERNET AND ELECTRONIC SERVICES TODAY

According to the latest figures of the UN today the internet is used more than 3 billion people, but there are significant differences not only between developed countries and countries that are developing, but also within the European continent.



The main primacy in this field have the Nordic countries, where over 85 percent of their population uses the Internet, with an impressive coverage of Iceland and Norway with over 90 per cent.

An extremely example guide and effective e-government offers small Estonia, which in the last decade has developed all of the e-government system. So today, almost all Estonian citizens have ID card with a special chip that through a special reader can access from their computers in an integrated computer system that allows them that almost all of their transactions government and public administration realize from the house. So for example via the internet to get any certificate or document is required to pay the tax and only some minutes to get the confirmation of payment and tax refund. Also, by means of electronic equipment can vote in local or general elections. If a citizen or potential investor in the Estonian economy will create an online company, for which would be needed just 18 minutes - that is probably a world record, but it gets even more useful information to enhance the professional image of Estonia as a place that really allows freedom of business and investment.

Estonia is also one of the first countries that immediately understand the dark side of e-government. Five years ago, after the relocation of a monument from the center of Tallinn, which is a symbol of the former occupation of Estonia by foreigners, was launched a virus around the world to seek specific information from the servers of the main institutions of Estonia, key at the same time, which cause a collapse in functional electronic services. For some days, Estonia was not able to use her official website. Their response, however, it was much pragmatic. With an intense lobbying, Estonia today has achieved to be the most positive image for e-governance becoming a center of excellence for the fight against cyber-terrorism, as well as the new EU Agency for the Information Technology.

#### **OECD AND RECOMMENDATIONS FOR ESTABLISHING e-GOVERNMENT**

All the benefits of the transition to e-government that more than a decade ago are recognized by an international organization, whose responsibility is to encourage the development and the global economy. OECD in 2003 published the first comprehensive analysis of the benefits of switching to e-governance. This review shows that it is important when deciding to transition e-government, both nationally and at the level of the main organs of the state administration. Computerization and networking systems between state administrations have made it possible for citizens to communicate directly and perform the necessary actions with government and public institutions. This communication has

increased government efficiency, transparency and confidence in the work of the state administration, and also reduced the total cost of administration by promoting socio-economic development.

In its thematic report from 2012, the United Nations notes that e-government is an important mechanism or tool that has initiated positive social change and the fulfillment of the Millennium Development Goals. In particular, the report shows an increase in the efficiency and transparency of e-governance.

International Telecommunication Union, as part of the global initiative "Connect with the world by 2015", calls for the harmonization of e-governance at the regional level so that all the citizens to participate actively in the management system. Then the whole system becomes an agent of change and social and economic reforms.

E-Governance today is based on a complex reform and reorganization of the classic work of the state and public administration, and its whole foundation is laid on the development of socio-economic policies for long-term strategies.

Today, only less than two percent of the world's governments do not have their own website and in less than forty countries, the relevant departments or ministries does' not yet have access through the Internet. Of course, this figure shows how e-government is still far from a global dimension. In more than 70 countries, all Internet users can communicate directly with the country's president.

#### **USE OF THE INTERNET AND e-SERVICES IN KOSOVO**

E-Kosovo began in 2008 with the designing and then the adoption of e-government strategy for 2009-2015 + with ambitious claims. E-government portal really provides an excellent overview of very useful informations. Most people today have the necessary need and knowledge for electronic interactive communication with the leadership of the state, the government and its ministries. This two-way communication is becoming the new standard of confidence in the work of these institutions and the basis of their reliability. Finally, it is certainly better that through criticism, comments, opinions to be channeled the demands of citizens and business community. It's hard to say exactly to what extent e-government strengthens tolerance in society, but the widespread use of the Internet certainly offers new insights about the world where there are different cultures, different ideas and values systems, also different and that no one has a monopoly on the truth. Therefore, e-government, but also the use of the internet today is based on the development of any modern country.

Association for Information and Communication Technology Kosovo (SHTIKK), in its annual report for 2013, estimates that the Internet in Kosovo, is in the

global standards. Internet penetration based on users is 76.6 % and 84.8% for households. This report provides updates of SHTIKK Regulation of 2012 by giving a brief overview of Internet usage in Kosovo in 2013.

Internet penetration in Kosovo based on users is 76.6%, this percentage was almost the same as those in developed countries. In a 2013 report published by the International Telecommunication Union, it is estimated that Internet penetration in developed countries is 77%. If figures are issued per household, then Internet penetration in Kosovo is even higher, reaching 84.4%. An estimation for the geographic penetration of the Internet has an average of nine wireless networks per kilometer everywhere in regional roads of Kosovo.

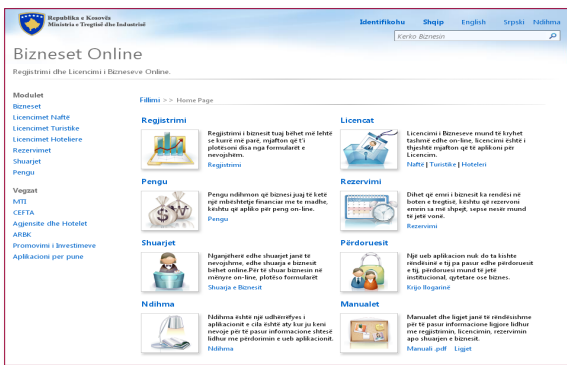


Figure 1. Online licensing system of the businesses in Kosovo

Regarding the situation of electronic services for businesses should be increased the efforts in awareness and training campaign for plurality of services offered but not yet satisfactorily used by business community itself. In the economic sphere, the availability of a variety of modern telecommunication services, helps businesses increase productivity and efficiency by creating more efficient manufacturing techniques and reducing the costs of coordinating of economic activity within and among businesses. Unfortunately, without a top-level domain of Kosovo, businesses cannot place the websites of their firms here and this way, various purchases and transactions remain extremely difficult to meet.

Kosovo should promote the information technology sector in particular to attract the foreign investment. Monitoring and support for public services is also important.

Over a million and one hundred thousand of Kosovo people use the Internet, with a nearly identical percentage of developed countries including the results for urban or rural areas which have almost equal usability. The percentage of rural population that uses the Internet is 77.7 percent, two points of index higher than urban population using the Internet with 75 percent. According to the results

show that 76.62 percent of the population are Internet users, while 23.38 percent stated they did not use it. Of these users, Internet access has 87 percent of urban households and 83 percent of rural households.

Kosovo is a society of widespread Internet, where the rate of Internet usage by the citizens is comparable to global rates.

Safety is the primary issue for the operation of IT systems in general and in particular for electronic governance. Physical protection of the equipments is essential to reduce the risk of unauthorized access to data and to protect against loss or damage.

Information System of the Government of Kosovo is largely conducted according to the standards and recommendations of Cisco and Microsoft. During this period, has been respected the standard of confidentiality, integrity and availability of information.

People's access to online public services has taken a great spreading, and it gives the possibility to people and civil society to monitor easier the institutions work.

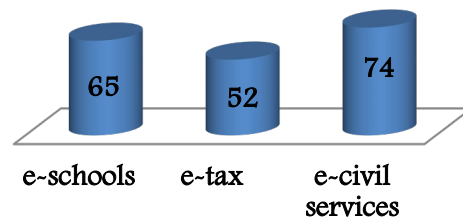


Figure 2. Differences in the use of e-services  
Asked which of the internet services is mostly used, in the first place is Facebook, followed by Skype, personal email and Twitter. Forms of social communication like Skype and Facebook have a greater use because of the Diasporas, which uses these forms of communication with family members. Given that remittances to seven consecutive years tend to rise in Kosovo (which is the only event in the region, given the global economic crisis of the recent years) it can be seen as a way to attract investments from abroad (Diasporas).

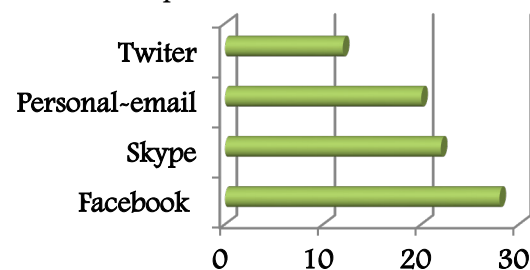
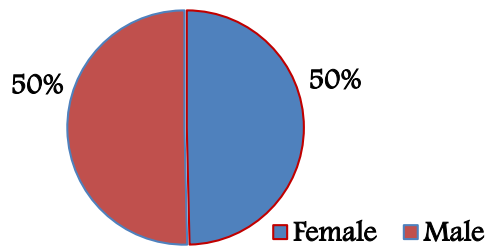


Figure 3. Web services that are used mostly  
According to the results, employees use the Internet at the rate of 51.75 percent, while 48.25 percent unemployed. Also in this study is showed that 86.76 percent of respondents use the Internet every day, while 9.57 percent just three times a week.

It also showed that the percentage of women who use the Internet is lower than men. 49.62 percent of women use the Internet, while 50.38 percent use men.



**Figure 4.** Users of electronic services according to gender structure

And in accordance with global trends, the number of Internet users via mobile phones is in the amount of 65.37 percent.

Kosovo is already a very dynamic online environment, with potential for further development of business, government and investors.

### CONCLUSIONS

The fundamental function and mission of e-government is the modernization of the administration or efficient and accountable management in all its levels.

For a faster economic and more substantive development in the Republic of Kosovo, without any doubt, enter the part of the creation and realization of more and qualitative electronic services for the citizens and businesses in Kosovo.

The creation of this environment of electronic services will enable citizens, businesses, as well as the Government, an increase in the living standards and a rapid progress in all areas.

E-governance will upgrade the administration and will create an efficient and responsible management in all levels of administration, and will reflect in the actual implementation of the Strategy for the Public Administration Reform.

With the implementation of e-government strategy, Kosovo society will have great benefits. The benefits will be economic and social, including the modernization of the administration, education, health, justice, security, business development, trade development, agricultural development, budget increase, the growth of democracy, the development of culture, scientific researches, various statistics, etc. Some of the benefits of e-government application would be:

- » Reduction of administrative loads and expenses;
- » It will increase the transparency and efficiency in public administration;
- » Develops effective relationships (student-teacher-parent) in education;
- » It increases significantly the safety and reliability in the justice;
- » Fights and reduces the organized crime;

- » Digitalizes the data and automates the processing of information;
- » Reduces the necessary time in decision-making;
- » Reduces the level of corruption;
- » Creates spaces for increasing the investments;
- » Citizens and businesses realize their obligations through the Internet;
- » Revenues realization electronically is monitored better
- » Facilitates the communication with the community, especially in rural areas;
- » The information published and online training that are undertaken, it influences on the increase of knowledge and makes the improvement of technology in all areas of life.

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## EXPERIMENTAL INVESTIGATION OF HEAT FLUX AT THE PANEL HEATING SYSTEMS

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**Abstract:** This paper aims to conduct the experimental research of heat flux of panel heating systems. Also, the aim of paper is to examine the performance of the newly developed concept „floor-ceiling“ heating. The study was conducted in the laboratory condition in the cooling test chamber that has the ability to work at temperatures lower than 0°C. As output parameters were used: electricity consumption for operating the heating panel and the indoor temperature of test model. Test model was investigated at the Faculty of Engineering at Kragujevac. Also, this research is part of the project „Development of net-zero energy houses.

**Keywords:** panel heating; floor-ceiling heating; heat flux; experimental

### INTRODUCTION

In Serbia, the panel heating systems are relatively well-known concept. However, as a result of lack of information as well as engineering prejudice to their right application is still waiting. It is known that panel heating systems due to its mechanism of heat transfer, provide the best thermal comfort. However, in scientific circles, there are many controversies that the panel system has the best characteristics.

This research is a continuation of previous numerical investigations of panel system. In addition to the standard types of panel heating (floor, wall and ceiling heating) in previous research to come to a new concept of "floor-ceiling" which proved to be more energy efficient compared to other panel heating systems [1].

This paper aims to conduct the experimental research of heat flux of panel heating systems. Experimental procedure was conducted on the test model consisted of two rooms (storey). The heating panels are made of the electric heating cables. External conditions are kept constant in the cooling chamber at the temperatures of 4.5°C. The measurement was conducted for wall heating panels, ceiling heating panels, and floor-ceiling heating panels.

### EXPERIMENTAL PROCEDURE

Experimental study of the characteristics of panel heating systems was performed at the Faculty of Engineering Sciences in Kragujevac, partly in the Laboratory of Thermodynamics and Thermal Engineering, and partly in the Laboratory of Motor Vehicles.

The experimental installation includes a test chamber, the test model of the house, measuring and control equipment for data collection.

The dimensions of the test chamber were 1500x1500x1800 mm and it placed inside the room dimensions 3500x5500x3800 mm (Figure 1).



**Figure 1.** The test chamber

Test chamber works on the cooling chamber principle which contains two evaporators associated with air chiller. Chiller on the condenser side uses air from the room located within the test chambers. The test chamber has the ability to cool until -15°C however, due to the work of the chiller inside the building in which the chamber was located and due to the low rate of air change in the room leads to overheating of the air and it is not advisable go to temperatures below -5°C. The temperature of the test chamber was controlled by PID controller type

XMTF-308 product Yuyao Gongyi Meter Co. Ltd. [2], which is connected to the PT100 probe. The humidity and temperature inside the test chamber was measured by the sensor of temperature and humidity type TSN-TH70E product "AREXX Engineering" Netherlands [3]. This sensor used "wireless" connection to communicate with the computer. The test model was consisted of two stairs that are placed one above the other so that each represents one room which was heated. Dimensions of the test model were 1000x800x650 mm where the room height was 650 mm. In addition, each stair has one opening on the side which glazed with Plexiglas dimensions 300x250 mm. This opening has the function of the window and also has the function of an inspection opening. In this experiment investigated four types of panel heating systems was used: floor heating, wall heating, ceiling heating and floor-ceiling heating. So the test model has the ability of the simulation any of the mentioned systems, and in each of the room the wall panel and floor panel was built and by rotation of the rooms for 180 °C floor panel become to the ceiling and vice versa (Figure 2).

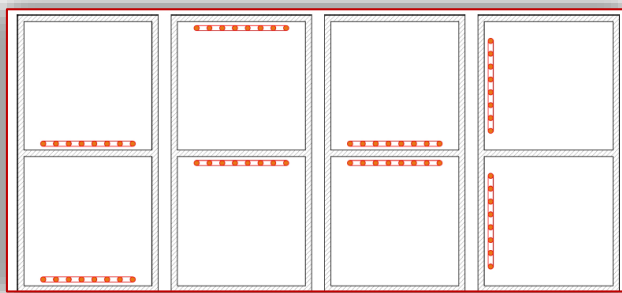


Figure 2. Analyzed panel heating systems

### MEASURING PROCEDURE

Figure 3 shows the installation for measuring of the heat flux that consisted of auto-transformers, regulators associated with the PT100 temperature probes, computers for data collection and flux meter type "Hukseflux TRSYS01-F".



Figure 3. The installation for measuring heat flux

Figure 4 shows the test model that was connected with the sensors of the temperature and heat flux. At the same time was measured heat flux on both sides of the structure. This was possible because the used flux meter has the two pairs of sensors for determining the heat flux. Figure 5 show software used for data collection from the measuring sensor. In each time it was written the data of the contact temperature and heat flux that was passed through the measuring element.

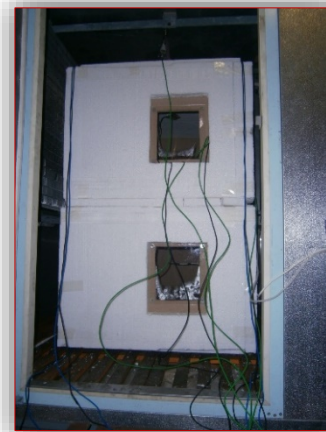


Figure 4. The test model connected to the measuring installation

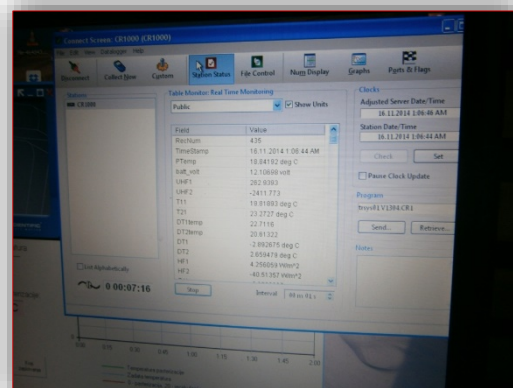


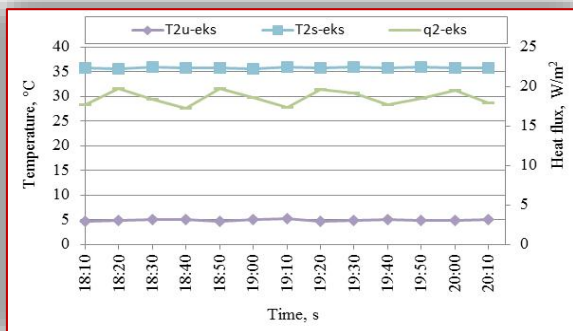
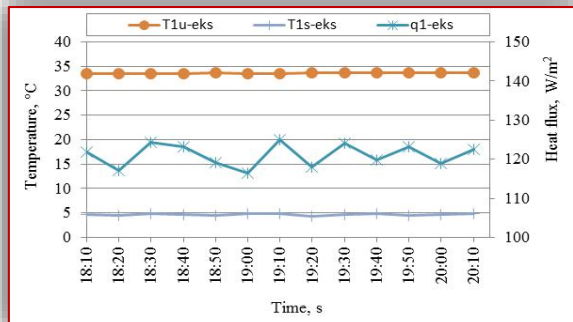
Figure 5. Software workspace for data collection

Figures 6 - 8 shows the measured values of surface temperatures and heat flows for wall, ceiling and floor-ceiling heating.

- » Wall heating (Figure 6). The internal temperature of the surface of the wall panels when the heating was in excess of 34°C, while the surface temperature on the outer side was about 5°C which was the ambient temperature. The value of the heat flux from the inner side of the panel (Figure 6 a) was in the range of 117 to 125 W/m<sup>2</sup>, while the outer side (Figure 6 b) ranged from 17.3 to 19.7 W/m<sup>2</sup>.
- » Ceiling heating (Figure 14). The internal temperature of the surface of the panels when the ceiling heating was at approximately 34°C, while



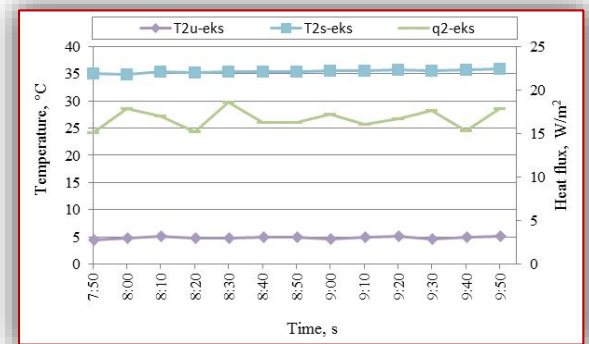
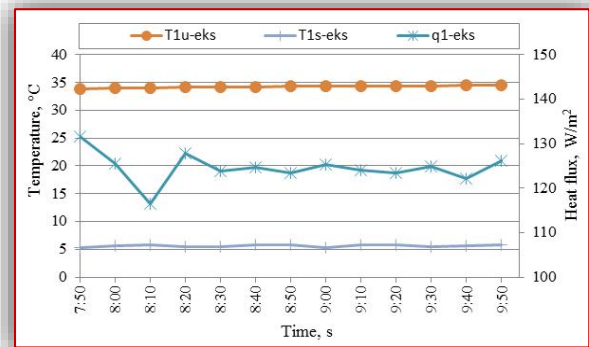
the surface temperature on the outer side was about 5°C which was the ambient temperature. The value of the heat flux from the inner side of the panel (Figure 7 a) was in the range of 116.6 to 126.1 W/m<sup>2</sup>, while the outer side (Figure 7 b) ranged from 15.1 to 18.5 W/m<sup>2</sup>.



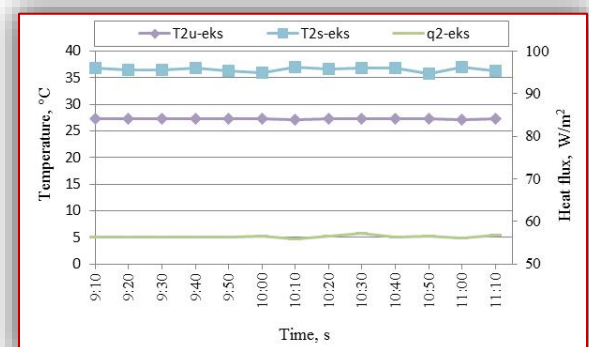
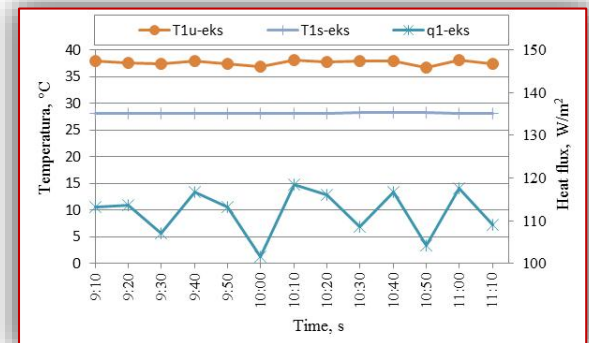
**Figure 6.** The contact temperatures and heat flux at wall panel on the inner side (left) and the outside (right).

» Floor-ceiling heating (Figure 8). The internal temperature of the surface of the panels when the floor-ceiling heating (temperature of the underside of the panels) was in excess of 36°C, while the surface temperature on the outer side was about 27°C. The value of the heat flux from the bottom of the panel (Figure 8 a) was in the range of 109 to 113.6 W/m<sup>2</sup>, while the upper side (Figure 8 b) ranged from 55.8 to 56.7 W/m<sup>2</sup>.

Figure 9 shows the energy consumption of analyzed heating panels. Consumption are shown at a constant outdoor temperature of -5°C, 0°C and 4.5°C. The ceiling heating has the highest energy consumption: 183.98Wh, 150.64Wh and 122.88Wh at the constant outdoor temperatures of 5°C, 0°C and 4.5°C, respectively. The lowest energy consumption has the floor-ceiling heating about 163.23 Wh, 131.71 Wh and 97.28 Wh at constant outdoor temperatures of -5°C, 0°C and 4.5°C, respectively. Wall heating has the energy consumption of 180.10 Wh, 145.87 Wh and 114.89 Wh and the floor heating has the energy consumption about 175.04 Wh, 141.25 Wh and 111.58 Wh at constant outdoor temperatures of -5°C, 0°C and 4.5°C, respectively.

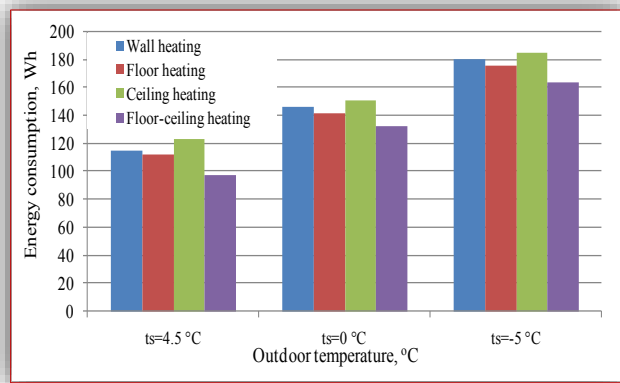


**Figure 7.** The contact temperatures and heat flux at ceiling panel on the inner side (left) and the outside (right).



**Figure 8.** The contact temperatures and heat flux at floor-ceiling panel on the inner side (left) and the outside (right).





**Figure 9.** The comparison of energy consumption of panel heating systems (floor, wall, ceiling and floor-ceiling heating)

### CONCLUSIONS

In the experimental procedure has been conducted up to identical conclusions as in the previous studies based on numerical investigation. So, floor-ceiling heating panels consume the least energy and ceiling heating panels has the highest consumption.

Within experimental research is also carried out and the measurement of heat flux. So that the value of the heat flux to the indoor environment was approximately 125 W/m<sup>2</sup> for wall and ceiling heating. For floor-ceiling heating value of the heat flux from the bottom side were about 110 W/m<sup>2</sup>, and the upper side of about 56 W/m<sup>2</sup>. Temperatures on the surface of the panel for the wall and ceiling heating were about 35°C, in a floor-ceiling panel temperatures were about 37°C at the bottom and about 27°C from the upper side of the panel.

### Acknowledgment

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## ENTERING AIR STATE INFLUENCE ON THERMAL PERFORMANCE OF HYPERBOLIC COOLING TOWER

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**Abstract:** Cooling towers overcome the problem of water supply for thermal power stations in the regions without enough cooling water from natural sources. The thermal capability of cooling tower is conditioned by three parameters: cooling tower range (the temperature difference between the water entering and leaving the cooling tower), entering air state and water flow rate. One of these parameters, the entering air state, can't be exactly estimated, it can only be predicted. The basic available solution is to follow the behavior of atmospheric air with the use of climatic curves. Seeking assurance that a cooling tower correctly performs the specified thermal performance, a three step methodology was used for evaluation of cooling tower performance: evaluation of thermal performance at design conditions, evaluation of tolerance between the design thermal performance and the thermal performance at acceptance test and evaluation of thermal performance at changeable climatic conditions. Its realization is followed through the example of the cooling tower located at the thermal power station in Bitola. Air wet-bulb temperature influence on thermal cooling performance is emphasized. The use of climatic curves is proposed for air state predicting.

**Keywords:** cooling tower, climatic curves, wet-bulb temperature

### INTRODUCTION

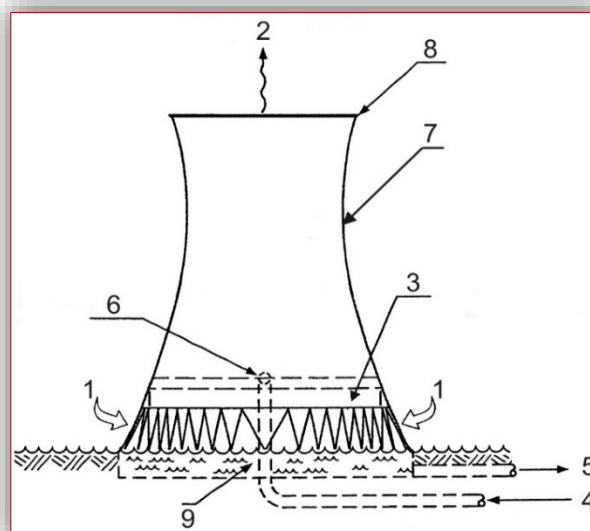
Thermal processes often generate heat that ought to be removed and dissipated in the environment. The main heat transfer medium used for this purpose is water. In cooling tower system, water is conducted in recirculating way.

Cooling towers overcome the problem of water supply for thermal power stations in the regions without enough cooling water from natural sources. Cooling tower system which is once completely filled needs only 2 to 3% of total water quantity, as additional water supply.

Today, cooling towers are exploited even in areas with enough cooling water drawn from natural sources, because of the increased temperature of discharge water, unacceptable from ecological standpoint.

Cooling towers for large power installations are chimney type steel-reinforced concrete buildings, Figure 1. They are high first-cost products that haven't energy requirements in exploitation.

Air density differentials that exist between the lighter, heat-humidified chimney air and outdoor atmospheric air cause air movement through the cooling tower. In this circulation, the air has direct contact with a very large water surface area. Water is cooled in simultaneous heat and mass transfer.



1-entering air, 2-leaving air, 3-heat exchanger, 4-hot water, 5-cold water, 6-distribution system, 7-concrete shell, 8-top platform, 9-cold water basin

**Figure 1.** Hyperbolic direct-contact cooling tower, [1]

The thermal capability of cooling tower is conditioned by three parameters: 1. cooling tower range (the temperature difference between the water entering and leaving the cooling tower), 2. entering air state and 3. water flow rate.

One of these parameters, the entering air state, can't be exactly estimated, it can be only predicted.

Because the cooling water flows in closed circulation system in which the heat source is some heat exchanger located in the thermal power station, for the steady-state functioning, the temperature difference in that heat exchanger is equal with the range, provided the flow rates through the cooling tower and heat exchanger are the same. Therefore, the range is determined by the heat load and water flow rate, not by size or thermal capability of the cooling tower.

The temperature difference between the water leaving the cooling tower and the entering wet-bulb temperature is the approach of the cooling tower. A larger cooling tower produces a colder leaving water or smaller approach to the entering air wet-bulb temperature.

The heat transferred between the air and water is proportional to the enthalpy difference of the entering and leaving air.

Generally, the specific enthalpy is a most important property in psychrometric calculations of thermal processes. Accurate enthalpy values are important because the total heat content of the air determines the total energy needed to change the conditions of the air from its current condition to the desired condition.

Enthalpy cannot be directly measured. In psychrometric practice, the graphical calculation of the enthalpy value is very common. The chart "specific enthalpy-humidity rate" displays the key thermodynamic characteristics of the air, and lets thermal engineers to quickly estimate the energy required to change the air temperature or air humidity. Because lines of constant enthalpy correspond almost exactly to lines of constant wet-bulb temperature, the change in enthalpy of the air may be determined by the change in wet-bulb temperature of the air.

For designer, purchaser and user of cooling tower, it is clear that the local climatic conditions dominate over the thermal performance of a cooling tower. They all need correct climatic information's. The basic available solution is to follow the behavior of the atmospheric air with the use of climatic curves. A climatic curve graphically represents the behavior of the atmospheric air.

From the observation of the weather conditions in the past, the possible future state of the local atmospheric air can be expected. In general, the period of records used in the calculations is 25 continuous years. Hourly records of air dry-bulb temperature and relative humidity or 438000 input values are included in the statistical data processing. Their examination and interpretation was conducted in order to draw the annual climatic curve. A climatic

curve for shorter period also exists, usually as summer climatic curve.

Climatic curve provides the possibility to capture the local climatic trends from the past one or two decades.

In Macedonia, climatic curves are published for Skopje and prepared for Bitola.

### **EVALUATION OF COOLING TOWER THERMAL PERFORMANCE**

The thermal performance of the cooling tower is usually expressed as a range that the cooling tower must accommodate under available air state.

Seeking assurance that a cooling tower correctly performs the specified thermal performance, a three step methodology was used for evaluation of cooling tower performance:

1. evaluation of thermal performance at design conditions,
2. evaluation of tolerance between the design thermal performance and the thermal performance at acceptance test, and
3. evaluation of thermal performance at changeable climatic conditions.

In the first step the designer makes a study of available combinations of heat load and flow rate for selected constructions of cooling towers. The result of this analysis is a series of cooling towers offered on the market by the producer. For each of them the performance curves are presented. Those performance curves are only predicted performance curves supplied by the manufacturer of cooling towers, because the location of a cooling tower is not known yet, that means the local air state is unknown, too, [2]. Computerized selection and rating programs are available from many manufacturers in order to generate performance ratings and curves for their equipment.

In the second step, after the cooling tower is built, an acceptance test is performed. The field acceptance test is conducted in accordance with the available test standard. During the acceptance test, the cooling tower operates under steady heat load and water flow, both near design values. Evaluation of tolerance between the design thermal performance and the thermal performance at acceptance test is realized in accordance with maximum recommended deviations, for range, flow, air state and heat load, in the used standard, [3].

In the third step, two elements were dominant: 1. experience of the cooling tower in operation condensed in updated performance curves and 2. climatic curves. The performance curves and the climatic curves may be used to evaluate a tower for year-round or seasonal use. For the periods with critical range needs, climatic curve was estimated as seasonal climatic curve. Because the critical performance level of an operating cooling tower can



be accurately determined only by thermally testing the tower under worst weather conditions, the help of climatic curves is needed, [4]. In psychrometrics long term meteorologically observed air states are statistically treated and then the pairs of air temperature and air relative humidity with maximum frequency of occurrence are inserted into psychrometric chart to obtain climatic curve, [5], [6]. The estimation of weather conditions for the warmest season of the year which is critical for cooling tower performance was realized with the use of summer climatic curve. The entering air wet-bulb temperature cycle through critical months is predicted using climatic curve for the site of cooling tower. Performance analysis have shown that cooling tower systems based upon wet-bulb temperatures which are exceeded in no more than 5% of the total hours during the summer period, have given satisfactory results. The capacity of the total water system is usually sufficient to neutralize the effect of peak wet-bulb temperatures, without detrimental consequences.

How strong the influence of entering air state on thermal performance is, can be observed from the comparison of the results for different climatic conditions (Table 1).

**Table 1.** Cold water temperature for different air states

Location	Air state from climatic curve		Cold water temperature °C	Difference %
	Temperature °C	Relative humidity %		
Skopje	35	28	32	+10
Bitola	27	45	27	-7
Ljubljana	30	40	22	-24

The three step evaluation was realized on hyperbolic cooling tower, at the thermal power station Bitola, which was selected as representative for the actual investigation. The cooling tower is designed by L. T. Mart Company Ltd, London, a subsidiary of Marley International Inc, and built by Vatrostalna, Zenica, [7], [8]. The dimensions of the cooling tower are: height 108 m, top diameter 55.5 m, neck height 81 m, air entrance height 6.5 m and heat exchanger height 2.5 m.

The values of the parameters involved in the evaluation process from the design, acceptance and operating period are summarized in Table 2.

In the Marley project documentation the designed thermal performance capability of this cooling tower is expressed as water flow rate at two specific operating conditions, range and entering air wet-bulb temperature. Nominal design parameters used in the natural drift hyperbolic cooling tower performance diagram, Marley No D 1005-77, are: hot water temperature 38.2°C, cold water

temperature 29°C, wet-bulb temperature 20°C, dry-bulb temperature 25°C, water flow rate 30000 m<sup>3</sup>/h and range 9,2°C. From the same performance curves, at extreme weather conditions in the acceptance test period, wet-bulb temperature 19°C, dry-bulb temperature 27°C and 14% lower used water flow, the nominal range is reached. The enthalpy of atmospheric air is 7.5% lower in regard to nominal enthalpy, but the smaller water flow rate contributes to the realization of the nominal range.

**Table 2.** Relevant parameters from cooling tower performance evaluation

Parameter	Designer offer	Acceptance test	Operating mode
Hot water temperature, °C	38.2	34.3 – 37.6	35 - 47
Cold water temperature, °C	29	23.2 – 27.7	26 - 34
Wet-bulb temperature, °C	20	14.3 – 19.1	14 - 18
Dry-bulb temperature, °C	25	19 - 27	20 - 38
Flow rate, t/s	8.3	7.3 – 7.4	5,8 - 7,7
Approach, °C	9	8.9 – 12.6	12 - 16
Range, °C	9.2	8.9 – 11.1	9 - 13

The period of record, used in the analysis procedure for the operating of the selected cooling tower, spanned 25 years, from 1984 to 2009. The thermal performance of the cooling tower in the operating period was evaluated on the basis of daily reports. Data for the long term operation of the cooling tower shows that the cooling system occasionally is carried through above-average periods for some of the parameters.

To continue performing as designed the cooling tower is continuously inspected and maintained, [9], [10].

## CONCLUSION

Three step methodology is proposed for evaluation of cooling tower performance. Its realization is followed through the example of the cooling tower located at the thermal power station Bitola. Air wet-bulb temperature influence on thermal cooling performance is emphasized. The use of climatic curves is proposed for air state predicting.

## Note

This paper is based on the paper presented at The 12th International Conference on Accomplishments in Electrical and Mechanical Engineering and Information Technology – DEMI 2015, organized by the University of Banja Luka, Faculty of Mechanical Engineering and Faculty of Electrical Engineering, in Banja Luka, BOSNIA & HERZEGOVINA (29th – 30th of May, 2015), referred here as [11].

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## EXPERIMENTAL INVESTIGATION OF THERMAL AND FLUID FLOW PROCESSES IN A PERFORATED PLATE HEAT EXCHANGER

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**Abstract:** The goal of this paper is to investigate thermal and fluid flow processes in an air/water perforated plate heat exchanger. The experimental investigation was carried out over a single perforated plate which was installed in an experimental chamber and heated by hot water. A fan with the variable flow was connected to the experimental chamber, and the flow rates were varied from 100 up to 360 m<sup>3</sup>/h. The thermocouples were attached to the surface of the perforated plate along upwind and downwind side, as well as at the inlet and outlet of the chamber. During each experiment, the readings of thermocouples were recorded alongside with air and water volume flow and temperatures of water at the inlet and outlet of the chamber. On the basis of the experimental results equations for heat transfer and pressure, drops were established. On the end, a comparison was done with other authors.

**Keywords:** perforated plate, pressure drop, heat transfer

### INTRODUCTION

One of the most important properties of heat exchangers, apart of having a high effectiveness is the need to be very compact i.e. they must accommodate a large surface to volume ratio. This helps in controlling the heat exchanger exposure to the surroundings by reducing the exposed surface area. A small mass means also a smaller heat inertia. This requirement is particularly important for small refrigerators operating at liquid helium temperature. The need of attaining high effectiveness and a high level of compactness together in one unit led to the invention of matrix heat exchangers (MHE) by McMation et al. [1]. Matrix heat exchanger consists of a package of perforated plates with a multitude of flow passages aligned in the direction of flow allowing high heat transfer in a proper design unit. This exchanger can have up to 6000 m<sup>2</sup>/m<sup>3</sup> surface to volume ratio [2,3].

The convective heat transfer characteristics of any heat exchanger surface can be determined using steady state, periodic test and transient test techniques [2]. For a steady-state method, the temperatures of hot and cold fluids entering and leaving the heat exchanger, as well as flow rates are

measured, and when steady state is achieved it is possible to determine heat flux, thus overall heat transfer coefficient. In the transient technique method, after the steady state is achieved the temperature of the fluid entering the heat exchanger is suddenly changed. The heat transfer coefficient can be determined from temperature-time history data. The periodic test techniques represent a variation of the transient method in which the temperature of the fluid entering the heat exchanger is continuously varied.

In 1966, an extensive experimental study of convective heat transfer and flow friction based on transient technique was published for eight different perforated surfaces [4].

G. Venkatarathnam and Ragab M. Moheisen give good literature review of MHE, their constructions and Nusselt criteria [3,5]. The goal of this paper is to investigate thermal and fluid flow processes on the air side of an air/water perforated plate heat exchanger. The research was conducted over a single 25,6% porous perforated plate.

### EXPERIMENTAL SETUP

Plate sized 740x145 mm, 2 mm thick, with square arranged, 2 mm in diameter, perforations was tested



in the experiment. The plate was divided in two sections: central section through which water flows and peripheral section, through which the air flows. Sections were separated by a gasket (Figure 1). The plate was placed in the channel of the experimental chamber, at which entrance was a thrust fan.

As a heating fluid, water was used. The heat source was the boiler with adjustable power. Water enters the collector and flows through the central part of the plate, and along the water flow, heat is transferred from the water to the plate. Exchanged heat is further transferred by conduction through the plate towards the edge of the plate, where it comes into the contact with the air stream. The heat is then transferred by means of convection from the plate to the cooler air stream.



Figure 1. A perforated plate with a gasket

For the needs of the experiment on the perforated plate, the thermocouples were set. In total 11 thermocouples were placed, 5 on each side of the plate (Figure 3,4) and one as control thermocouple for error estimation. Heads of thermocouples were covered with thermal conductive paste in order to ensure thermal contact between thermocouples and plate. Thermocouples were calibrated before the experiment. Also, the temperatures of air at the inlet and outlet of the chamber were measured by thermocouples.

The cold end of thermocouples was obtained as a mixture of water and ice. During each experiment, the air flow, water flow, temperatures at the inlet and outlet of the chamber and the plate temperature were measured. Measurements were conducted when the thermal equilibrium was achieved.

The convective heat transfer rate  $\dot{Q}_w$  from the water side is equal to

$$\dot{Q}_w = \rho_w \dot{V}_w c_w \Delta T_w \quad (1)$$

Similarly the heat transfer rate to air side is equal to

$$\dot{Q}_L = \rho_L \dot{V}_L c_p \Delta T_L \quad (2)$$

The heat transfer rate for the perforated plate was calculated as the average value of water and air side as

$$\dot{Q}_{av} = \frac{\dot{Q}_L + \dot{Q}_w}{2} \quad (3)$$

and the error of measurement is calculated as

$$\varepsilon = \sqrt{\frac{(\dot{Q}_{av} - \dot{Q}_L)^2 + (\dot{Q}_{av} - \dot{Q}_w)^2}{\dot{Q}_{av}^2}} \quad (4)$$

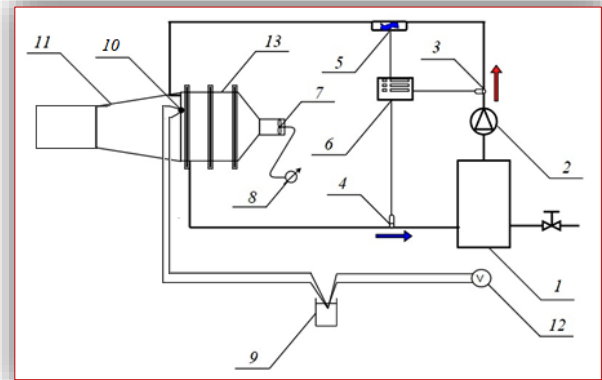


Figure 2. Experimental setup: 1 – boiler, 2 – pump, 3,4 – pt probes, 5 – ultra sonic water flow meter, 6 – aquisition unit, 7 – fan unit, 8 – fan speed control, 9 – cold end of thermocouples, 10 – thermocouples, 11 – Alonre balometer, 12 – milivoltmeter, 13 - chamber



Figure 4. Thermocouples positions on the perforated plate

In the analysis, only measurements with error less than 10% were used. For the measurement of air flow pressure drop through the perforated plate, the measuring system TESTO 454 with 0638 1447 probe was used. For the pressure drop range of 80 hPa.

The accuracy of measuring the pressure drop is  $\pm 0,3\text{Pa}$  or  $\pm 0.5\%$  of measured value. Measurement accuracy is therefore for a minimal and maximal pressure drop

$$\varepsilon_{pmin} = \frac{\delta p}{\Delta p} = \frac{0,3}{2,3} = 13,04\% \quad (5)$$

$$\varepsilon_{pmin} = \frac{\delta p}{\Delta p} = \frac{0,3}{13,43} = 2,23\% \quad (6)$$

## RESULTS AND DISCUSSION

The heat transfer coefficient  $\alpha$  is defined as

$$\alpha = \frac{\dot{Q}_{av}}{A\Delta T}, \quad (7)$$

where  $\Delta T$  is the difference between the average air temperature on the inlet and outlet of the chamber and the average value of perforated plate temperature and  $A$  is the overall heat exchanger surface on the air side. The Nusselt number is defined as

$$Nu = \frac{\alpha p}{\lambda}, \quad (8)$$

where  $p$  is the pitch between perforations and  $\lambda$  is the thermal conductivity. On the Figure 5 are presented results of obtained heat transfer coefficient Nusselt number. If the Reynolds number is determined as

$$Re = \frac{\rho w_0 p}{\mu}, \quad (8)$$

where  $w_0$  represents free stream velocity, and  $\mu$  and  $\rho$  are fluid density and dynamic viscosity. If the Nusselt number dependence is written as

$$Nu = CRE^n Pr^{1/3}, \quad (9)$$

(where Prandtl number for air is  $Pr = 0,7$ ), the Nusselt number is then

$$Nu = 1,188Re^{0,524} Pr^{1/3}. \quad (10)$$

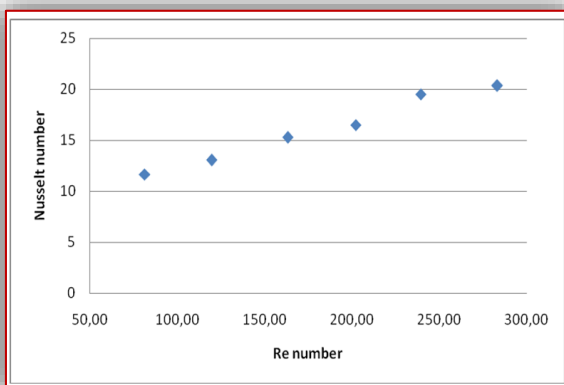
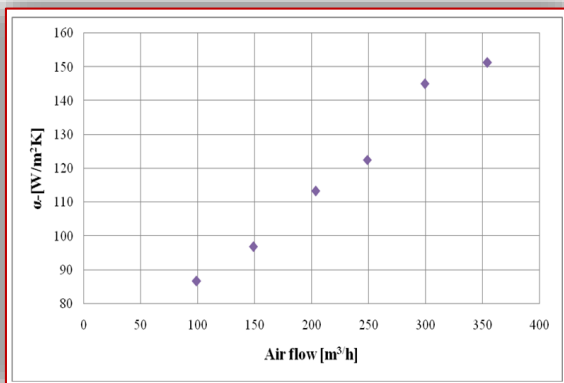


Figure 5. Heat transfer coefficient in the function of air flow and Nusselt number in the function of Reynolds number

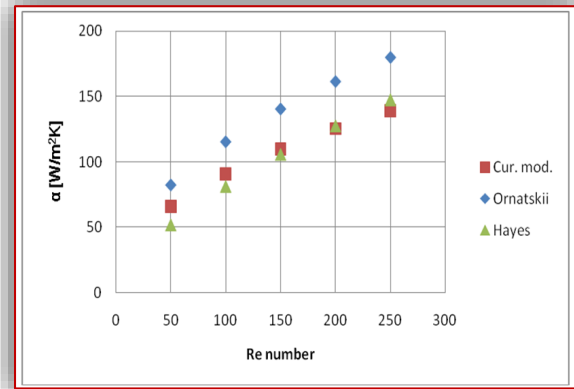


Figure 6. Comparison of results for heat transfer coefficient

The results for pressure drop through the plate with and without water collector are presented on the Figure 7. The general relation for the pressure drop was found in the form

$$\Delta p = \xi \rho \frac{w_0^2}{2} \quad (11)$$

where the  $\xi$  represents fluid friction and for observed plate it is equal to 43,7. The results are in good correspondence with results of Idel'chik presented on the Figure 8 [8].

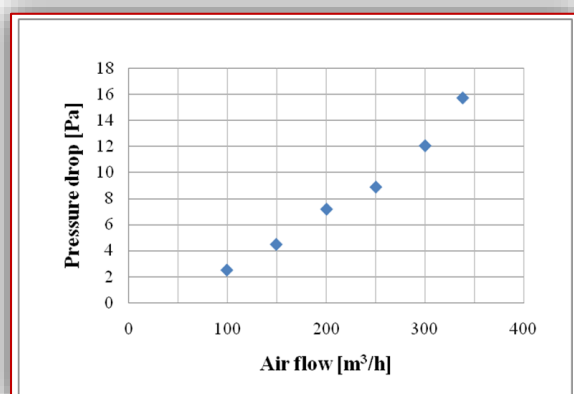
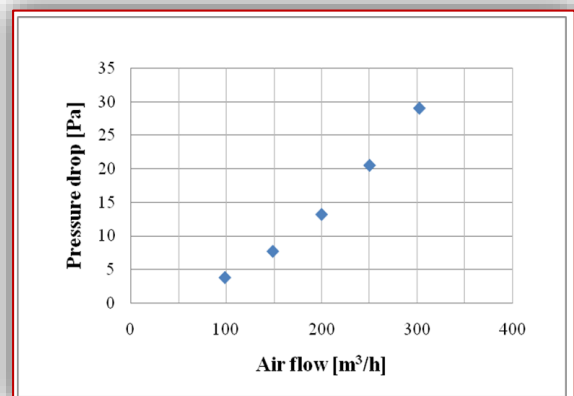


Figure 7. Pressure drop for the plate with water collector (left) and without it (right)

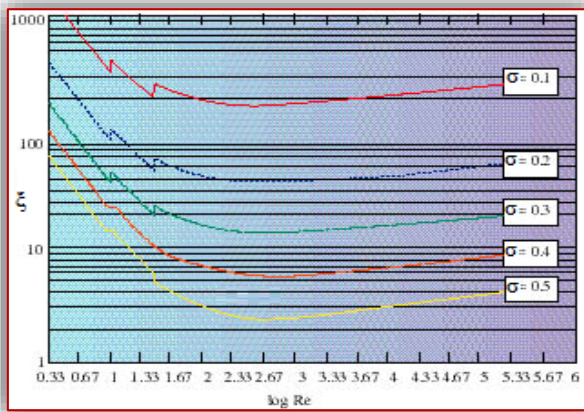


Figure 8. Pressure drop for a perforated plate by Idel'chik

## CONCLUSIONS

In this paper an experimental setup and its results for the research of perforated plate heat exchanger have been presented. A perforated plate which was installed in an experimental chamber and heated by hot water. A fan with the variable flow was connected to the experimental chamber, and the flow rates were varied from 100 up to 360 m<sup>3</sup>/h. For the needs of the experiment, thermocouples were attached to the perforated plate, as well as at the inlet and the outlet of the chamber to determine air temperatures. On the basis of the measurements, a criteria equation for Nusselt number was derived. Also, the air pressure drop was measured during the experiments. The results for Nusselt number and air pressure drop shows favorable agreement between existing Nusselt correlations for heat transfer for the perforated plate.

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## HARVESTING ENERGY-ULTRA LOW POWER DEVICE

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**Abstract:** Energy harvesting is rapidly expanding into new applications. The idea of micro-scale energy harvesting, and collecting miniscule amounts of ambient energy to power electronic systems, was still visionary and limited to research proposals and laboratory experiments. Ultra-low-power technology is enabling a wide range of new applications that harvest ambient energy in very small amounts and need little or no maintenance-self-sustaining devices that are capable of perpetual or nearly perpetual operation. An increasing number of systems are appearing that take advantage of light, vibrations and other forms of previously wasted environmental energy for applications where providing line power or maintaining batteries is inconvenient. The following article will discuss several technical challenges and show how ultra-low power technology is playing a key role in overcoming them.

**Keywords:** energy harvesting, ultra-low, power, ultra-low power, technology, ultra-low power technology

### INTRODUCTION - What is Energy Harvesting?

Energy harvesting is a process by which ambient energy is captured and converted into electricity for small autonomous devices making them self-sufficient or process where energy is derived from external sources, captured and stored for use in electronic systems.

Sources as lighting, temperature differentials, vibrations, and radio waves (RF energy) can be re-used to operate low-power electronic devices.

Energy harvesting has gained a lot of interest within the electronics design community over recent years. It is through this process that small quantities of energy can be captured, collected and then utilized by items of electronic equipment, allowing simple tasks to be accomplished without the need for incorporating a conventional power source in the system design. In order to do this effectively, however, the system needs to operate with the highest possible levels of efficiency, both in terms of the constituent parts that are specified and the way the system is laid out. New systems, which are now appearing in industrial and consumer electronics, also promise great changes.

Applications that are now utilizing energy harvesting (or scavenging) include building automation systems, remote monitor/data acquisition devices and wireless sensor networks. As harvesting does not rely on conventional forms of power source it has two key ecological benefits. Firstly it does not result

in any depletion of fossil fuel reserves and secondly it does not add to pollution levels (as there are no resultant carbon emissions, nor disposable batteries).

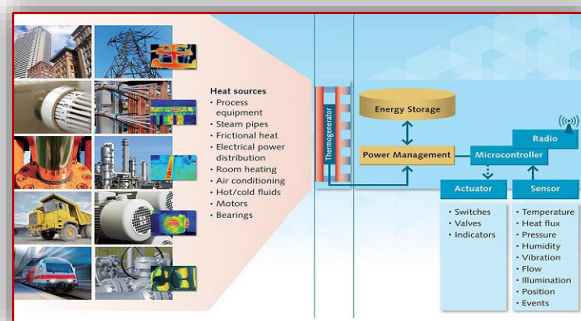


Figure 1. Energy harvesting ways

In addition to dispensing with the need for wiring or cabling and the convenience thereby derived, the real advantage of this sort of implementation for

OEMs and system integrators is that, once it is in place, it effectively has no day-to-day running costs, as there aren't utility bills or costly call out trips to replace batteries, etc.

Where is it useful?

- = Where line power is unavailable or costly;
- = Where batteries are costly or difficult to replace;
- = Where energy is needed only when ambient energy is present.

#### HOW EXTRACT THE REQUIRED ENERGY?

The harvesting of energy from the environment can be done in a variety of ways (depending on which proves most suitable for the specific application setting), with power levels normally in the region of 10 $\mu$ W to 400 $\mu$ W being generated. Among the mechanisms used are temperature difference, kinetics (normally through vibrational movement), solar power, the piezo-electric effect, the pyro-electric effect, and electro-magnetic. However, with the possible exception of solar energy, the perception that energy harvesting is 'free' energy is not totally accurate. Sources based on vibration or thermal gradients make use of considerable energy waste from the system. As a result repair and maintenance costs do need to be factored in.

#### Collecting Energy examples:

Music Club

- = A dance club in Rotterdam creates energy to power the LED lighting each visitor creates 20W of power by dancing on the flexible floor

Pedestrian Walk

- = Use of piezoelectric materials to harvest electrical energy from pedestrians walking over it

Footbridge

- = Piezoelectric materials can harvest energy from vibrations, such as the slight movement of a footbridge as pedestrians walk across it.

#### WHERE TO FIND "FREE ENERGY"?

Typical energy harvester output power

- = RF: 0.1 $\mu$ W/cm<sup>2</sup>
- = Vibration: 1mW/cm<sup>2</sup>
- = Thermal: 10mW/cm<sup>2</sup>
- = Photovoltaic: 100mW/cm<sup>2</sup>

Typical energy harvester voltages

- = RF: 0.01mV
- = Vibration: 0.1-0.4 V
- = Thermal: 0.02 - 1.0 V
- = Photovoltaic: 0.5 / 0.7 V<sub>typ</sub>/per<sub>cell</sub>

Power consumption

Battery powered Applications in:

- = Body Area Networks : 3 $\mu$ W = 1.8V \* 1.7 $\mu$ A

#### TYPICAL APPLICATIONS

Energy Harvesting applications are potentially everywhere .Applications that are now utilizing energy harvesting (or scavenging) include building

automation systems, remote monitor/data acquisition devices and wireless sensor networks.

As harvesting does not rely on conventional forms of power source it has two key ecological benefits. Firstly it does not result in any depletion of fossil fuel reserves and secondly it does not add to pollution levels (as there are no resultant carbon emissions, nor disposable batteries).

In addition to dispensing with the need for wiring or cabling and the convenience thereby derived, the real advantage of this sort of implementation for OEMs and system integrators is that, once it is in place, it effectively has no day-to-day running costs, as there aren't utility bills or costly call out trips to replace batteries, etc.

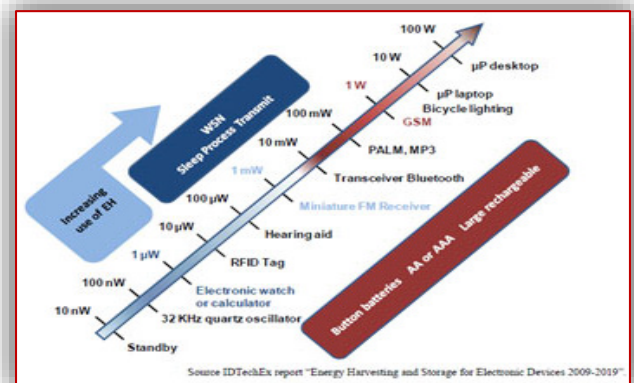


Figure 2. The power Range scale of real world applications

The power that is generated through the harvesting process can be used in many ways, for example:

- = Switches (building automation) - Here the mechanical force applied to move the switch ON or OFF is enough to generate a few milli Joules (mJ) worth of energy to run a wireless transmitter. This sends an RF signal that actuates a door latch or a light. As no wiring is needed there are both logistical and aesthetical upshots to this approach.
- = Temperature sensors (building automation) - The temperature difference between the ambient air and a heater can provide the power needed to send temperature data back to regulation system wirelessly.
- = Air conditioning (building automation) - The vibration of the air-conditioning duct can be employed to create an electrical signal via electromagnetic induction. The air conditioning can be controlled through this signal.
- = Remote monitoring (industrial/environmental) - This could be in the form of an unmanned weather station, a gas sensing system in a chemical plant, a Tsunami warning system. A solar cell or a small wind turbine can provide the energy required.



- = Medical implants (healthcare) - Such as blood glucose monitors, where heat or body movement allow a low power wireless transceiver placed on the patient's skin to feedback data to a hub without the need for inclusion of a battery (thereby improving the patient's comfort and reducing the inconvenience experienced)
- = Watches (consumer) - Where the use of either solar or kinetic energy can be used to run a battery-less timepiece.
- = Tyre pressure monitoring, using surface acoustic wave (SAW) sensing technology, it is possible to circumvent the issues arising from mounting the battery and complicated electronics needed to support temperature/pressure sensors on each of the vehicle's wheels, thereby reducing bill-of-materials costs and the engineering resource needed.
- = Portable consumer electronics Calculators, toys, piezo gas lighters, electronic car keys, electronic apparel etc
- = Industrial Mainly buildings, machinery, engines, non-meshed wireless sensors and actuators
- = Wristwatches, laptops, e-books,
- = Military and aerospace excluding WSN

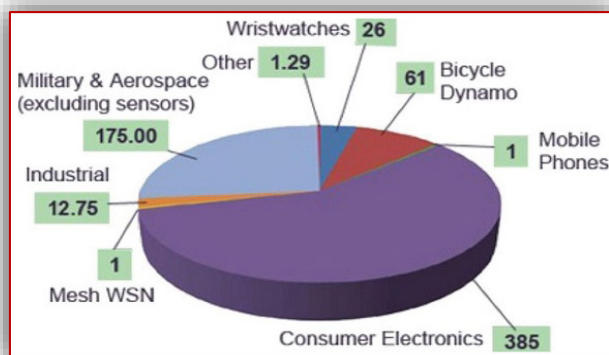


Figure 3. Applications that are now utilizing energy harvesting

### MARKET ACCEPTANCE OF ENERGY HARVESTING DEVICES

Market acceptance of energy harvesting devices is very application-dependant

This is based on several parameters:

- = Size & weight,
- = Amount of power generated versus amount of power needed by the system,
- = Cost: Ease of access to grid & ease of access to the module or system to power,
- = Number of devices to power,
- = Critical mission of the module or system to power,
- = Required device lifetime: Projected lifetime for the energy harvesting device compared to the system parts lifetime,

- = A major factor to be taken into account is if there is enough power harvested for a particular application from a particular environment, and if the scavenged power needs to be stored.

### MARKET DEMAND

Growth in the 2-digit range will increase the market volume by 4 within the next 5 years after 2015.

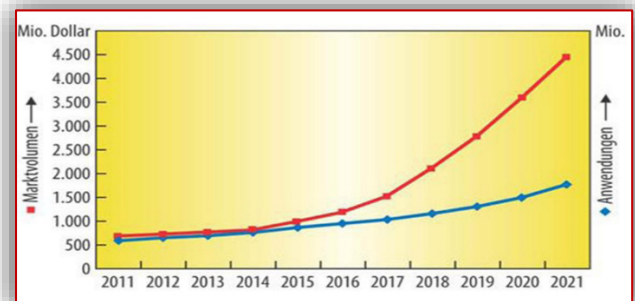


Figure 4. Market acceptance of energy harvesting devices

### CONSIDERATIONS ABOUT ENERGY STORAGE METHOD

With only  $\mu$ Ws of power to play with, it is clearly vital that everything possible is done to utilize it to the fullest. Engineers need to work hard so they can avoid wastage. This involves both hardware and software considerations and can be done through implementation of highly efficient component parts, as well as ensuring full design optimization.

It is imperative that the electronic system consists of low voltage circuitry made with smart power management. Energy storage may also need to be considered, as the sporadic nature of these systems' operation means that in many cases there is no direct relationship between the time when energy is harvested and the time when it is subsequently utilized.

The storage method used must be low voltage, with a high charge current capability, moderate discharge capability and possibly no self-discharge capability at all. The digital IC at the heart of the system must be able to offer more than adequate processor performance to carry out the system's tasks while simultaneously being able to support low voltage operation, so that the power budget is not exceeded. Furthermore this IC must be cost-effective enough that its implementation does not impact too greatly on the overall expense associated with the system - otherwise the system will have too high a price tag to justify deployment in many of the energy harvesting applications already discussed.

### RECENT APPLICATION

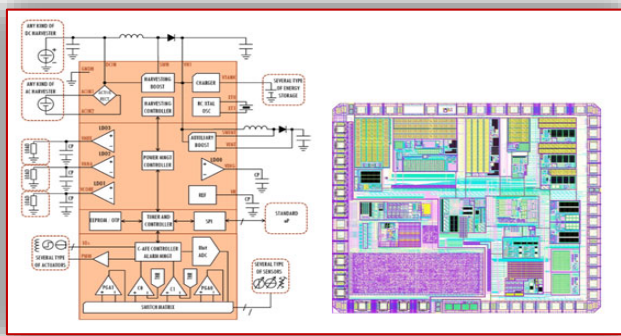
Together Canova Tech and ON Semiconductor have developed a fully flexible design platform that enables original equipment manufacturers (OEMs) to test and validate their Energy Harvesting Cell concepts or applications utilizing Canova Tech's ETA



Platform harvester module which features ON Semiconductor's LC87F7932B ultra low power, fully programmable micro controller. This approach combines an ultra-low power microcontroller with an efficient, ready to customize and predefined IC integrating critical and must-have blocks like the harvesting interface and power management functions, sensor and actuator interface.

Based on the LC87F7932 ultra-low power microcontroller unit (MCU) from ON Semiconductor, and Canova Tech ETA Platform, this new development kit gives engineers an industry-proven development kit that can be customized (hardware and Software) in order to suit specific application requirements and thus augment the system's power/performance characteristics.

The ETA platform is fully configurable and it can be interfaced and matched with most of the common energy harvesters in the market, handling DC and AC inputs larger than 0.9V or, with the use of an external transformer, larger than tens of a millivolt. The collected energy can be transferred / stored in various storage elements such as chemical batteries, capacitors and super capacitors. Through it the system can manage the accumulated energy efficiently, regardless of erratic delivery patterns, so that it can implement power saving strategies, like the use of the embedded ultra-low power configurable analog front end, in which the acquisition and conditioning of signals from the system's sensors can be carried out without the supervision of the external MCU.



**Figure 5.** Block Diagram and layout of the Eta Platform  
The LC87F7932B MCU is an 8-bit device based on CMOS technology. It has a central processing unit (CPU) running at a 250ns (minimum) bus cycle time. The IC integrates 32 kBytes of on-board programmable Flash memory, 2048 Bytes RAM, an on-chip debugger, an LCD controller/driver, a 16-bit timer/counter and a real time clock. Its 12-bit, 7-channel low power analog-to-digital (ADC) converter transforms the acquired signal after conditioning has been completed by the front end. This digital signal can then be transferred wirelessly

or stored for extraction at a later stage depending on the application.

## CONCLUSION

There are a number of major obstacles and challenges involved in the design of energy harvesting systems. Engineers need to boost processing performance as much as possible, while keeping overall power budget to a minimum and not accruing heavy expenditure in what can prove to extremely cost-sensitive applications. Every effort must be made to employ the best optimized components and to ensure that the development process is totally streamlined. By employing the development platform detailed in this article, based on an ultra-low power MCU architecture and a configurable and customizable device, engineers can overcome these obstacles and thus realize more effective implementations. This study provides an overview of ultra-low power energy harvesting application, especially recent technology developments and existing barriers.

## Note

This paper is based on the paper presented at The International Conference on Social and Technological Development – STED 2015, organized by the University for Business Engineering and Management, in Banja Luka, BOSNIA & HERZEGOVINA (1st and 2nd of October, 2015), referred here as[8].

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## LEED TECHNOLOGY IN URBAN PLANNING

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**Abstract:** Urban planning is a set of measures, guidelines and suggestions for improvement and unification of economic, social and sustainable development of certain areas. Planning in the modern era, accompanied by a number of bad consequences, has led to a steady rise in consumption of natural resources used to build traffic and utility infrastructure and expansion of settlements. Insufficient care of human race for environment and ecosystems caused the emergence of large-scale climate change and global warming. LEED (Leadership in Energy and Environmental Design) in urban planning represents a new approach to planning, which enables the use of renewable energy sources. The main goal of LEED technology is the protection and improvement of the environment, through the creation of modern and energy-independent urban space. In this paper, using the methods of description and comparison, as well as case studies of some examples, the possibilities offered by green building will be shown.

**Keywords:** Urban planning, LEED technology, environmental protection, renewable energy sources

### INTRODUCTION

Territorial grouping of people under the influence of different historical, sociological and economical factors forms an urban environment. The appearance of urban communities is directly linked to a steadily increasing population, resulting from social and technological revolution. Throughout history, there was an increasing need for better organization of living space in order to provide greater security, better work conditions and better living conditions. Thanks to the continuous development of industry, urban areas undergo great economic and architectural changes.<sup>1</sup>

Unfortunately, the impact of settlements on the environment and ecology has not been taken into account. Due to the global climate changes caused by man and his negligence, natural disasters take place: frequent occurrence of storm disasters, extreme heat, increase the risk of extinction of flora and fauna, increased risk of various infections and diseases in humans. Such changes have a lasting impact on the urban environment. Consideration of the environmental dimension and the impact of population on the environment is a very important part of planning, which gets special attention in recent years.

The concept of urban planning refers to the analysis of existing ways of using space, looking at the current problems, future needs and resources, as well as defining development goals. Through the planning process we can determine the further development and protection of the area.

People's awareness of science, technology and new developments are affecting the setting of new standards in construction. Watching from the physical point of view, the most important intervention which requires attention is green building. Green building is a concept that originated in 1990's in America, when planning had a special emphasis on respect for the natural environment. The introduction of a new planning approach provides a number of positive effects, which contribute to the integration of the urban environment and the natural environment, therefore the impact of climate change significantly eases. The area should be kept and used carefully, through the introduction of economic and environmental awareness within the behaviour of the space user. Lack of commitment to sustainable development is a major problem in many developing and developed countries. In recent years, awareness of quality mid planners and users of the area is increased, and the focus is solving economic and social problems

<sup>1</sup> Velimir IJ. Ćerimović, Sustainability, Developed Environment and Climate Change (The 1st National Conference With

Regional Participation Environmental Protection In Energy, Mining And Industry, 2010), p.300.



caused by the destruction of the natural environment and depletion of natural resources.

Proper use of land is fundamental to the preservation of environmental quality, the future of new generations and quality of life.

#### STRATEGY FOR URBAN PLANNING FOR SUSTAINABLE DEVELOPMENT OF URBAN SPACE

Programs for sustainable development and the appearance of green building is preceded by a long-standing analysis and identification of strengths and weaknesses of potential urban spaces. The aim of the strategy and plan is to promote new forms of technology and their appliance in urban areas. This way of development aims to solve global climate problem. With advancing and innovative ideas we can expect that sustainable urban development becomes a new vehicle of social and economic development of a region.

The concept of sustainable development is related to the conservation of natural resources through recycling, as well as their minimum use of energy. In addition to the recycling of materials and energy sources, the aim is to eliminate pollution and toxic waste that are an integral part of the urban environment.

The process of urban sustainable development is based on the areas that affect the space the most and it is essential to improve their use of natural materials in the construction purposes, the energy that needs to be directed towards renewable energy sources, water that can be used in various applications and troubleshooting harmful emissions coming from traffic.

Sustainable Development of Urban Environment is based on new technologies and developments concerning: solar energy, wind energy, bio-fuels and bio-materials and green architecture.<sup>2</sup>

#### GREEN BUILDING CONCEPT IN URBAN PLANNING

Cities play a dominant role in global economic development, due to the constant influx of population, urban areas exceed the planned capacity. The growth of cities and urban centres are faced with major problems that manifest themselves through improper use of natural resources. Urban growth is associated with the pollution of water, air and soil, which is the basis of every ecosystem.

Urban planning is a key role in improving the environmental conditions at the city level as well as on global level. Green building is intended to include all the elements of a space through environmentally sustainable system. Through urban planning we can

define the elements that directly impact on the environment, such as: the exterior of the building (facades, roofs), the yard around the buildings, open spaces, parks, streets and utility infrastructure. Studies dealing with problems of environmental planning and land use patterns show that urban areas have greater potential to create a sustainable system than rural areas. Sustainable Urbanization is a powerful tool for improving living conditions in cities and ecological capacity.

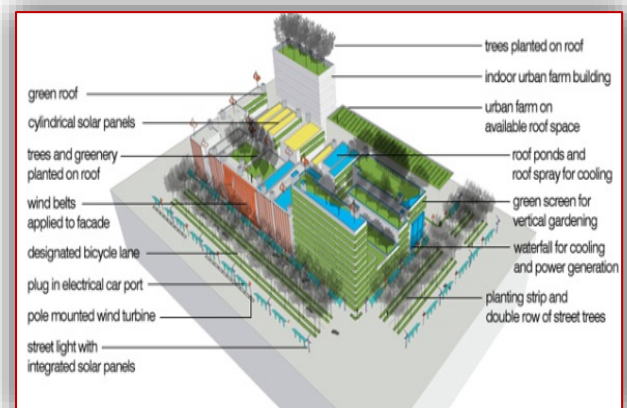


Figure 1. Energy Converting Desing [3]

Modern urban planning concept involves the creation of green spaces in cities to conserve power by promoting self-sustainable buildings and spaces, as well as the development of green building technologies. Using a modern approach to design green architecture we achieve first step in preserving the environment and energy, as if each object achieves economic, energy and social sustainability and creates the conditions for improving the quality of life of the users themselves, and therefore the environment. Conserving energy through the use of alternative energy sources (wind, solar) creates a new direction in design that tends to preserve micro vessels through the use of new technologies: solar panels, wind turbines for propulsion, savings and production of water, disposal and reuse of waste, then the use of new materials and structures that are self-sustaining. The facility aims to produce more energy than it consumes.<sup>3</sup>

Urban parameters of one location play an important role in creating a sustainable system. Therefore, special attention is paid to the orientation of the object in order to maximize the solar energy and provide natural ventilation. Savings of energy is achieved mainly due to the development of green

<sup>2</sup> Vera Backović, The Notion Of Sustainability In Contemporary City(Future Development Of Settlement In The Light Of Climate Change, 2011), P. 103.

<sup>3</sup> Ljiljana Blagojević, Dragana Ćorović, Environmental Aspects As A Basis Of Curriculum Innovation In Higher Education Of Architects: New Approaches To The Study Of History And

Theory Of Modern And Contemporary Architecture(Future Development Of Settlement In The Light Of Climate Change, 2011), P. 175.



spaces that have multiple roles: collecting water and use the same, creating a favourable microclimate and the creation of green oasis within the urban environment.

The current way of using transport infrastructure has led to an increase in greenhouse gas emissions, which is why cities are becoming unfavourable to the environment. Modern approaches to urbanism address the issue of reducing carbon dioxide emissions through a network of centres that operate independently and allowing space users to suit all daily needs within their centres. Street regulation is down to the formation of incoming and outgoing roads connecting different locations, while within a single urban centre is insisted on formation of pedestrian, bicycle and underground traffic flows. An important segment of transport infrastructure are planned green spaces along the roads that have a protective purpose of noise, noxious gases, oily storm water and separate spaces intended for people of transit routes. Special emphasis is placed on the use of permeable surface, which allows drainage of storm water from roads and thanks to the new technologies, reuse of processed water.

The concept of protection and improvement of the environment is based on the establishment of sustainable management of natural values, prevention, reduction and control of all forms of pollution through greening and landscaping large green space. The new model of planning involves reserving a large percentage of space for parks and green spaces in urban areas within themselves and around them.

Green infrastructure<sup>4</sup> is an important concept of protection of the natural environment. It covers all public spaces (parks, forests, open spaces, natural resources) and public roads, systems for wastewater drainage, objects and parts such as roofs and facades. The biggest problem is disposal the city water wastes from highways, parking lots, roofs and other surfaces into natural water areas. New technology allows collection and treatment of contaminated water, prevention of pollution and creating natural processes in urban areas. Modern technology promotes green roofs, protective vegetation along roads, rain gardens, permeable paving, the use of facade as vertical gardens and provides water treatment and its reuse.

#### **GREEN BUILDING SYSTEM – LEED**

LEED system (Leadership in Energy and Environmental Design) of urban areas combines the principles of sustainable development, urban planning and green building, which shows the level of responsibility of sustainable urban development.

The main criteria of evaluation areas are: energy efficiency, emissions, water consumption, the choice of building materials and construction and transport efficiency. LEED protocol has a major impact on the strategy of urban planning, dealing with the basic parameters of urban space. The first and most important parameter is the choice of the location intended for construction, taking into account the proximity of waterways and the impact of proposed development on the environment and land. Special attention is paid to the necessary consumption of water, energy and air pollution. Also, great importance is the choice of materials and raw materials. They choose materials that are sustainable and recyclable. Location must possess a quality physical environment in order to create the conditions with clean air, good isolation and low noise level. For the sustainability of an important area's closeness of transportation and utility infrastructure, which is based on good transportation connections, reducing vehicle use and connect; on with green infrastructure is essential.

LEED urban space is a system which is focused on sustainable construction and focuses on education and raising awareness of space users through its programs and categorization. Spaces that meet the requirements of sustainable, green building, could enter the classification system LEED-ND (Neighbourhood Development).

Urban development areas that have the economy, sustainability, functionality and comfort are representatives of modern urbanism and are part of the LEED green building standards. LEED standards are the beginning of a new era of building regulations, which aims at solving the problem of energy consumption and pollution emissions by promoting the principles of green building and energy efficiency.

#### **CONCLUSIONS**

Urban plans for sustainable development represent a set of measures, guidelines and recommendations for the protection, development and improvement of urban areas. Plans are national and local character regardless that government in their implementation has a large number of individuals involved - residents and organizations. Based on the evaluation of previously implemented plans, it is necessary to create strategies for new plans whose main goal is the revival and development of urban areas. Plans are comprehensive, they have a long-term character and through them it is necessary to consider all the potentials and limitations in terms of energy saving and urban ecology, as well as economic and

<sup>4</sup> Jasminka Cvejić, Aleksandar Bobić, Andreja Tutundžić, Stojanka Radulović, Cities Adaptation To Climate Changes – The Role Of

Green Insfrasturcture (Future Development Of Settlement In The Light Of Climate Change, 2011), P. 27.

sociological sense. According to the program, a key factor for urban development is sustainability in the construction and use of alternative forms of energy in order to prevent the devastation of land and impact on reducing consumption of natural resources.

Urban planning in developing countries and developed countries is represented by programs that are incurred as a result of long-term analysis of the situation in the country and the implementation of previous plans. Plans are given guidelines for troubleshooting energy conservation that are not based only on resources already taken into account but also the limit that needs to be considered in order to obtain high-quality solution.

Strategies and concepts of sustainable development incurred in developed countries with much lower natural potential in comparison with Serbia, can serve as a good example and it is possible to convey the positive experience with us. Serbia has a diverse structure of land from south to north, but it is possible to promote sustainable development and overcome the discrepancies. Applying experience in the way to treat the area with different positions and taking in account the manner of their connection, in Serbia, it is possible to achieve a more balanced and successful urban development. The analysis and comparison of urban planning in Serbia and planning in other countries would be possible to integrate into existing plans and implement innovations that are already having a positive impact on urban development around the world.

#### Note

This paper is based on the paper presented at The 12th International Conference on Accomplishments in Electrical and Mechanical Engineering and Information Technology – DEMI 2015, organized by the University of Banja Luka, Faculty of Mechanical Engineering and Faculty of Electrical Engineering, in Banja Luka, BOSNIA & HERZEGOVINA (29th – 30th of May, 2015), referred here as [7].

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## REMOTE CONTROL OF A ROBOTIC ARM USING THE OPERATOR PANEL

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**Abstract:** This paper presents the adopted solution for remote control via Ethernet of a robotic arm controlled by a Siemens PLC. PLC control interface is designed with a touch screen Weintek. This HMI control the local PLC, entering the coordinate on the axes X, Y and Z. The HMI command so the stepper motors which actions on the axis of the robotic arm. This presents the Ethernet interface to be controlled remotely. With authentication (user and password) you can interference on the displacement path of robotic arm. Subject allows the development in a virtual environment for e-learning and monitoring of actions (webcam).

**Keywords:** PLC, robotic control, HMI, remote control

### INTRODUCTION

Introducing the programmable automations on a larger and larger scale due to their quality and working precision, as well as due to a good price/quality report, imposes them for the substitution of the old command schemes of equipment. More and more equipment are modified on their command part, a numeric command or the display of the realized quantities or of those to be realized being required. The use of programmable automatons together with the frequency converters makes the equipment safer, with a higher precision and a shorter time for realizing the product.

Through its conception, a programmable controller is adaptable for functioning in the industrial environment, it can operate in a large variety of temperature and humidity. It is easily adaptable to interfacing with any process and does not raise any special problems regarding the training of service personnel, due to the programming facilities it offers. The industrial robots appeared as a response to the human's need to automate the manufacturing processes, especially the repetitive ones. The main activities that industrial robots can carry out are linked to the transporting and manipulating of objects and also to realizing some processes (painting, inspection, assembling, etc.). [4]

The utilization of PLCs presents a series of advantages, among which the reducing of

manufacturing time and the decrease of costs are the most important. Mainly, any application that requires electric control needs a PLC. [3, 6]

The interface is necessary in the commanding and monitoring of the process realized by the PLCs, because they do not have a screen. EMT3070a is a touchscreen produced by Weintek Company, which facilitates the creation of a graphic interface for a high number of PLCs found on the market. [5]

### THE SYSTEM STRUCTURE

#### Siemens PLC

The Programmable Logic Controllers are command and adjustment programmable automates that are used for industrial machines and processes. Their programming is done using dedicated software, developed by each PLC manufacturer, but having as common point the use of the Ladder Diagram (command electric schemes).

#### The Weintek interface

##### HMI – operator panel

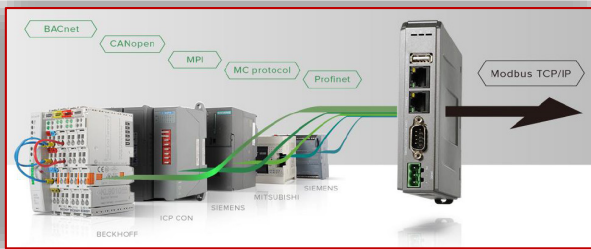
HMI eMT3070A (Figure 1) is a touch screen produced by Weintek which facilitates the creation of a graphic interface for a large number of PLCs found on the market. EMT3070A series is the new generation of HMI from Weintek. This is more than a simple touch screen; it is capable of programming the PLC and of transferring data and programs among several similar devices from this producer. [8, 9]





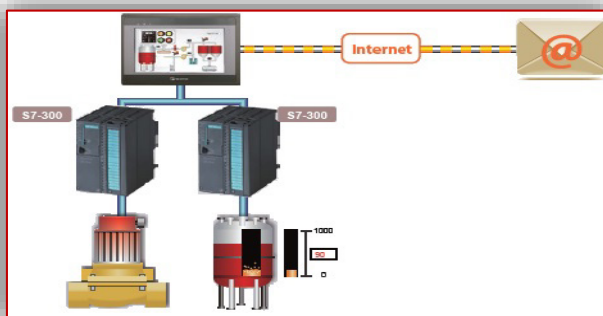
**Figure 1.** The panel eMT3070A

One of the great advantages of this equipment is able to be put into an Ethernet network because of the network card provided. Placing into a network one HMI can be done in different ways and can use existing network or it can be create a network in which to operate. (Figure 2)



**Figure 2.** Different types of network protocol

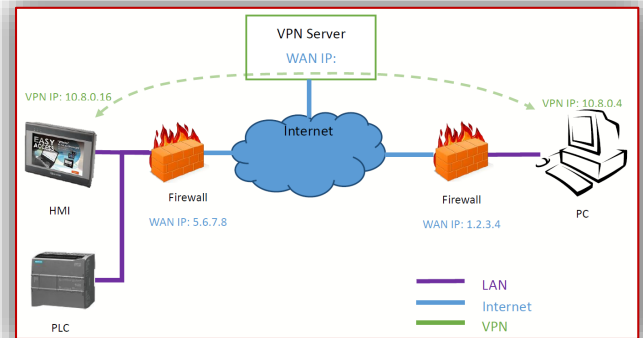
The way the system is built allows implementation in any type of network and access the machine remotely via LAN or even WAN (Internet). This allows by default to the multiple users to be connected for monitoring or edit the process values in real time. Another advantage is email notification if a fault occurs, is set regular reporting or in case of predefined reports. (Figure 3)



**Figure 3.** Email notification

**EASY ACCESS – control software** is the software which work with touch screens produced by Weintek and it becomes very easy to monitor and troubleshoot HMI and PLC that are at a remote location as long as Internet connection is available. As EasyAccess 2.0 already takes care of network settings and addresses security issues, the user can connect easily to the HMIs as if they were on the local network. (Figure 4)

EasyAccess 2.0 not only makes possible direct connection to a Weintek HMI, but also provides pass-through function that enables the user to connect to the PLC on the remote HMI's network. Consider an EasyAccess network as shown below where a PLC is within the same LAN network as the HMI. [7]



**Figure 4.** The EasyAccess network configuration

The HMI list (Figure 5) shows all HMIs registered in the current domain, and the HMI Group list shows all groups currently existing in this domain. The first column can sort the HMI by name, while the other columns can be set to show the following information: Private IP, Public IP, Activation Date, or Custom Field.

HMI Name & Type	Private IP
Demo-2 Type: eMT3070A	192.168.1.88
Default HMI Type: eMT3070A	192.168.1.33
Default HMI Type: MTB1000E	192.168.1.68
nicolas Type: eMT3070A	192.168.1.44
Default HMI Type: MTB0500E	192.168.5.23
Default HMI Type: eMT3070D	192.168.1.44

**Figure 5.** HMI Management



**Figure 6.** Different platform connections

In conventional HMI architecture, the operators must operate in front of the machine, and only one operator can access one HMI at one time. This way is very inefficient. Through remote control distributed architecture greatly improves the monitoring efficiency on the plant floor. The HMI can be flexibly

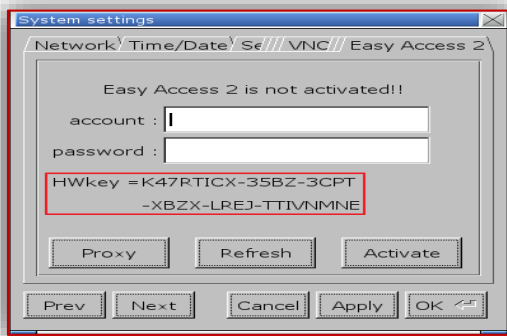
designed for multiple levels of operators (system engineer, plant manager remote technician, and etc.) to access the needed information anywhere in the plant floor at the same time and from different platforms. (Figure 6)

**Remote control**

**Configure remote control**

The HMI must have been activated in order to be connected using EasyAccess 2.0.

The activation status can be check it on HMI in the [EasyAccess2] tab of the System settings page (Figure 7). HMI's Hardware key will be required for insert in the web page of EasyAccess HMI Manager.

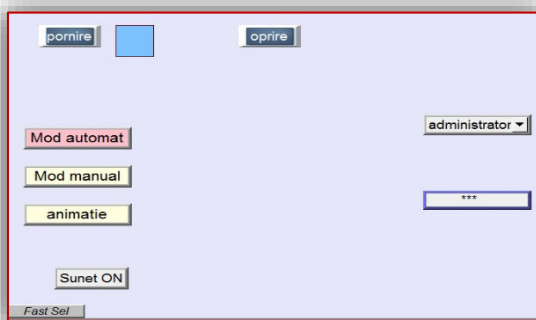


**Figure 7.** Activation status and Hardware key EasyAccess 2.0 service requires that each HMI belong to only one domain. If an activated HMI does not currently belong to any domain, once it goes online, it will obtain a set of Session ID/Password, which can be used to add the HMI to a domain. Therefore, once an HMI is added to one domain, it cannot be added to another one.

**Application interface**

**HMI – operator panel**

User interface that we have created for the simulation operation of robotic arm is made of five windows (main menu, X axis, Y axis, Z axis and animation (monitoring)). At the time of simulate, navigation between windows is performed using specific buttons (Function Keys).



**Figure 8.** Main menu panel

Main Menu panel (Figure 8) present major information to any user, while having windows (screens) for additional axes robotic arm that works.

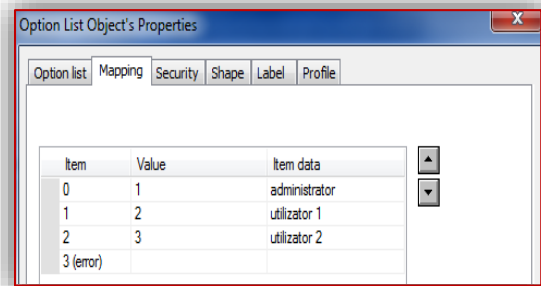
This panel consists of buttons with which we communicate with the other interface windows, buttons and switches automatic and manual start and stop the operation of the program. [1, 2]

Interfaces allows creating different security levels that can be divided into categories of users. Each user access can be set to different interfaces of the program, you can set up to 12 users whom have individual levels of security:

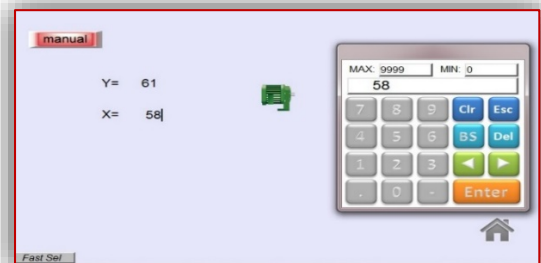
- » Administrator - has access to all buttons, windows and all functions available;
- » User - has access to all the windows but no to all buttons and available functions;
- » Guest - has access only to monitoring

To use the interface have to be logged with username and password preset.

Within the security level was used Option List Object button where have been defined usernames and passwords. (Figure 9)



**Figure 9.** Usernames and passwords



**Figure 10.** The animation windows



**Figure 11.** The user window

In animation windows (Figure 10) robotic arm moves in X and Y directions and it can be set the values for manual mode, but just if we are login in

like Administrator. Another else we can only monitoring the moves on axis. [1]. In figure 11 we observe disappears of the Manual Mod for User account.

Through EasyAccess 2.0, if the customers is reporting a problem, which may or may not require inspection by an engineer, he can remotely connect to the HMI to investigate the problem. The customer needs no extra network configuration, just Internet connection. In addition, he can also update the HMI project, monitor the PLC by Ethernet Pass-through, or even update the PLC program.

### CONCLUSIONS

The paper highlights the utility and importance of programmable automates in the control of the industrial processes, command the function over 3 axis of a robotic arm, in order not using CNC commands.

The interface has been designed so that the displacement moves on X, Y and Z of the robot arm to be controlled by using the eMT3070a interface. It allows to start and stop the application on the panel Weintek, as well as monitor the movement on the axes. With authentication (username and password) you can interference on the displacement path of robotic arm.

Implementation of multiple security levels provide a better organization in use by the program operators. Subject allows the development in a virtual environment for e-learning and monitoring of actions (webcam).

### Note

This paper is based on the paper presented at The International Conference on Social and Technological Development – STED 2015, organized by the University for Business Engineering and Management, in Banja Luka, BOSNIA & HERZEGOVINA (1st and 2nd of October, 2015), referred here as[10].

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## RECURRENT NEURAL NETWORK SHORT-TERM PREDICTION OF DISTRICT HEATING SYSTEM IN TRANSIENT REGIMES

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**Abstract:** District heating companies have growing and significant need for improving economic and energy efficiency. Also, they have a challenge to keep the cost of produced and delivered heating energy as lower as possible. That is why it is very important to optimize production of heating energy using better prediction and control of customer needs. In this paper, the focus is on short-term prediction. Real historical data are used from city of Nis, south-eastern Serbia, heating plant Krivi vir, 128 MW installed power. This prediction is particularly important for heating in transient regimes which unlike the standard heating regime does not have continuous supply of heating energy throughout the specified heating time period. An application of neural networks is realized based on original historical data of heating source by using recurrent neural network to fulfill demands on variation in ambient temperature during a heating day and satisfied results are obtained.

**Keywords:** district heating system, recurrent neural network, short-term prediction, energy efficiency

### INTRODUCTION

District heating companies are responsible for the delivery of heating energy produced in the central plant to the consumer through a hot water system. At the same time, they are expected to keep the cost of produced and delivered heat as low as possible. That is why we have a growing need for optimizing the production of heating energy through better prediction and management needs of consumers. Many consumers choose to be excluded from the district heating system and change it with decentralized individual heating system.

District heating systems can be characterized by a reduction in energy consumption, increasing energy efficiency and reducing the generation of pollution. This means that the optimal operation of the district heating system has significant economic potential, as discussed in [1].

Accurate prediction give possibility for increasing efficiency of heat production, decreasing fuel consumption and connected with it emission decreasing from combustion products to the atmosphere. Heat production efficiency can be optimized through the use of appropriate procedures for running heat sources alongside short-term heat demand prediction combined with preparation for adjusting heat source work parameters to the predicted heat load for a few hours hence. The artificial neural networks model delivers good forecasting results. The accuracy of the results

depends on the kind of network, its architecture, the size and type of input data as well as the prediction period.

Prediction accuracy within a 3-5% margin of error is sufficient to steer heat source operations.

Prediction of heat consumption can be broadly classified as evaluation and time-dependent prediction. There is long-term, mid-term and short-term prediction. In this paper, we are dealing with short-term prediction.

Short-term prediction shows a period of several days or hours in advance to on a daily basis and manages the planned district heating system.

This prediction is particularly important for transient heating in which unlike the standard heating regime does not take place continuously throughout the time period specified heating. So it is very important to achieve quality prediction for a short period in order to reduce the consumption of thermal energy production and increased coefficient of exploitation of equipment. This gains more importance due to the fact that district heating systems in Serbia, by definition, are interrupting. Heating is not being continuously but starts in the morning and turns off in the evening.

There is various statistical prediction techniques explained in [2] that can be applied to short-term prediction. That is why there are widely used methods with supervisory learning such as support vector machine (SVM), support vector regression

(SVR), artificial neural network (ANN) and partial least squares (PLS). In [3] the method of SVR, PLS and ANN used for short-term forecasting of heat consumption of district heating Korean city Suseo. In [4] artificial neural network (ANN) used to predict one hour in advance of the thermal load, including different types of days such as public holidays, Saturdays and Sundays as input variables.

In this paper we used a modelling techniques such as "black box" based on artificial neural networks (ANN) to predict the thermal energy power on the heating source Krivi vir, in the city of Nis, Serbia Southeast region. As input variables we take time, previous consumption data over power on the heat source and the outside temperature with the aim of forecasting for one week in advance.

### ARTIFICIAL NEURAL NETWORKS

Neural networks, or artificial neural networks (ANN) as they are often called, refer to a class of models inspired by biological nervous systems. The models are composed of many computing elements, usually denoted neurons, working in parallel. The elements are connected by synaptic weights, which are allowed to adapt through a

learning process. Neural networks can be interpreted as adaptive machines, which can store knowledge through the learning process. Artificial neural networks are a collection of mathematical models that simulate some of the observed properties of biological nervous system and withdrawing similarities with biological adaptive learning. They made up of a large number of interconnected neurons which, like biological neurons, are associated with their relationships, which include bandwidth (weight) coefficients, which are similar to the role of synapses.

Most neural networks have some kind of rules for "training", which are the coefficients of connections between neurons are adjusted based on the input data. In other words, neural networks "learn" over the case (such as children learn to recognize a specific subject, object, process or development through appropriate examples) and have the ability for generalization of training data.

Great potential of neural network is ability to do parallel data processing, during the calculation components that are independent of each other. Neural networks are systems composed of a number of simple elements (neurons) that process information in parallel. Functions that are neural networks able to handle the specific structure of the network, the strength of connection and data processing are performed in neurons.

The application of artificial neural networks to short-term prediction yields encouraging results; a discussion can be found in [5]. The ANN approach does not require explicit adoption of a functional

relationship between past load or weather variables and forecasted load. Instead, the functional relationship between system inputs and outputs is learned by the network through a training process. A minimum-distance based identification of the appropriate historical patterns of load and temperature used for the training of the ANN has been proposed in [6], while both linear and non-linear terms were adopted by the ANN structure.

### RECURRENT NEURAL NETWORKS

Recurrent ANNs, due to feed-back connections, have the ability to model time series in a very efficient way [7] and have shown more robustness with respect to variations in structure than feed-forward models.

Recurrent neural networks (RNNs) are dynamical systems that are specifically designed for temporal problems, as they have both feed-back and feed-forward connections. More specifically, a form of memory is incorporated in RNNs, with the states of the neurons from previous iteration steps being stored and used to influence the prediction of future iterations. RNNs have been shown to out perform feed-forward neural networks on timeseries tasks and have been empirically shown to be successful on time series data sets. The overall structure of a RNN consists of synaptic connections between the input, hidden and output layers of neurons. Knowledge is represented in a network by the values of these synaptic connections.

In this paper, Elman recurrent neural networks are used. Elman neural networks are also known as partial recurrent networks or simple recurrent networks. These are multilayer perceptrons augmented with one or more additional context layers which store output values of one of the layers delayed by one step. These layers are used to activate this or some other layer in the next time step. (Figure 1)

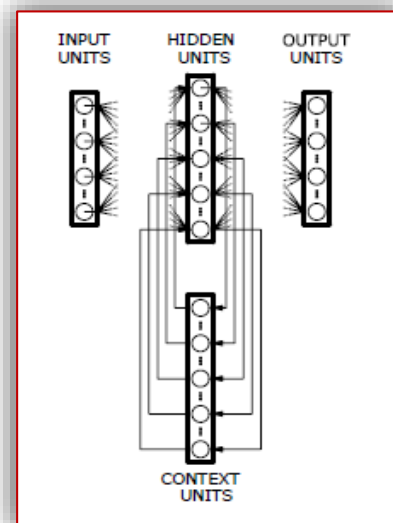


Figure 1. An Elman recurrent neural network

An Elman neural network has been implemented in order to forecast thermal power from heating source for short-term period of 1, 3 and 7 days.

The feedback from the hidden to the context layer allows Elman networks to learn, recognize and generate temporal patterns, as well as spatial patterns. Every hidden neuron is connected to only one neuron of the context layer through a constant weight equal to +1. Hence, the context layer constitutes a kind of copy of the state of the hidden layer, one instant before.

The number of context neurons is consequently the same as the number of hidden neurons. According to the method presented by Sarle [8], the whole data set was subdivided into a training set and a validation set. The whole training phase was stopped when the lowest error on the validation set was reached.

The proposed Elman recurrent neural network has one hidden layer, no bias and hyperbolic tangent sigmoid has been the first transfer function and as the second linear transfer function has been used. As the network training function the algorithm of gradient descent with momentum and adaptive learning rate backpropagation has been used.

Heating day started at 5 in the morning and finished at 9 every evening. Also, the most important parameter for heat load prediction, an ambient temperature is one of the inputs. Input vector for prediction consist of data for 5 previous days for power from heating source, an ambient temperature for previous 3 days and an ambient temperature for predicted day and time by hours. So, in total we have 10 input neurons.

Hidden layer after many iterations defined with 20 neurons and output layer has predicted power on the heating source as the output.

### NEURAL NETWORK APPLICATION

In the present paper, for the purpose of improving the accuracy of heat load prediction, we add a new input data for heat load prediction and adopt an Elman recurrent neural network as the prediction network to capture the dynamical variation of heat load by reconsidering characteristics of heat load data.

In order to realize neural network and perform certain conclusions to predict the power on the heat source in interrupt and transient regimes, it is first necessary to perform rearrangement of inputs or input vectors as it is defined in the previous section. A set of data for training is taken from heating source Krivi vir, Nis, Serbia installed power 128 MW for the period October 15.2012 ~ March 16. 2013 and prediction period is for the period 22 March – 28. March 2013.

The objective of optimization of heating is to manage to reach lower thermal power on the heating source with lower temperature of input water. On that way,

fuel consumption would be lower and most important objective would be fulfilled – satisfaction of consumers with appropriate temperature in their premises.

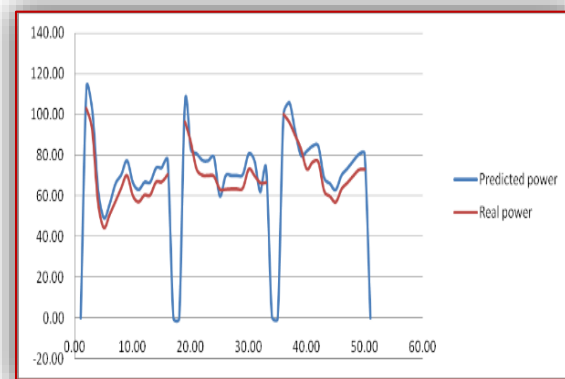
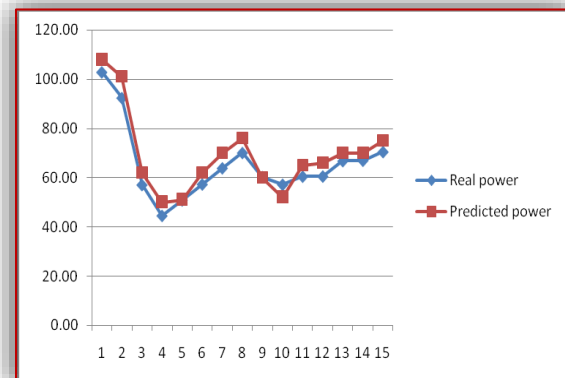


Figure 2. Real and predicted power for 24.March and 24-26. March 2013, respectively, using Elman recurrent neural network

The important fact is that just for period February – March 2013 during 12 days, there were 92 hours without heating energy delivering and where thermal power on the heating source was zero, because of high ambient temperature. These facts make worse preconditions for good optimization.

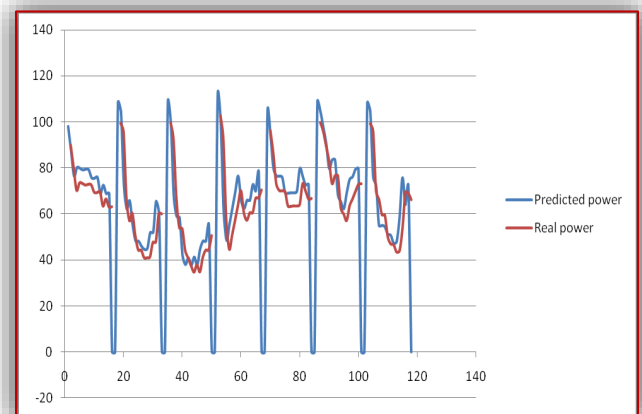


Figure 3. Real and predicted power for 7 day period 22. March-28.March 2013, using Elman recurrent neural network



Figures 2 and 3 respectively show the recurrent neural network that realizes the prediction of 1, 3 and 7 days in advance. The obtained results are satisfactory. The mean square error is obtained by minimization and a small learning rate is relatively high. By comparing the results obtained with real data shows that with great certainty can be used to correctly and accurately predict. Better results were obtained for shorter prediction, which can be corrected by modifying selected neural network or by selecting another type of neural network that will realize the simulation with a smaller percentage of average error, or a larger set of data.

It is important to point out that despite the fact that the average error is smallest for the shortest prediction, it can be concluded that the error is relatively uniform for all three periods of prediction. It was 3.5% for the prediction of 1 day in advance, 4.5% for the prediction of 3 days in advance and 5.2% for the prediction of 7 days in advance.

Chosen prediction period is a period where no stopping of delivery heating energy was and good results were obtained. But, for choosing other week for prediction where we have periods of days with zero power on the heating source than we will get higher average error. It shows that we need modifications of used recurrent neural network and introducing new inputs in network. This topic will be subject of further research.

#### CONCLUSION

Short-term prediction of power on the heat source is realized using real measured data for the period from 15 October 2012 until 31.03.2013, from the heat source Krivi vir, the city of Nis, Serbia South-East region, with installed power of 128 MW. Prediction is performed using an Elman recurrent neural network. The period of 22-28. March 2013 was taken as a period for prediction.

The results obtained by simulating neural network prediction are compared with real power on the heat source and satisfactory results were obtained with an acceptable average error. The obtained satisfactory results are especially important because it is an interrupt regime of operation of district heating system where the heating period is from 5 in the morning to 21 in the evening but also high ambient temperatures leads to the turning off heating in certain daily intervals. You must take into account the fact that as an external factor taken just outside temperature, and further research should be taken into account other conditions.

#### Note

This paper is based on the paper presented at The 12th International Conference on Accomplishments in Electrical and Mechanical Engineering and Information Technology – DEMI 2015, organized by the University of Banja Luka, Faculty of Mechanical Engineering and Faculty of Electrical Engineering, in Banja Luka, BOSNIA

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## THE Datafit ANALYSIS OF SMALL AND POWDERY FERROUS WASTES DESTINED FOR THE PRODUCTION OF BRIQUETTES IN SOME LABORATORY EXPERIMENTS

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**Abstract:** From steel industry activities derive a wide range of wastes, that can be categorized as recyclable wastes (ferrous and nonferrous wastes) and storable wastes, as well (slag, sludge, tar, oils). On the platform of a steel mill virtually all sectors contribute to the pollution of at least one environmental factor. Most frequent, ferrous scrap results from the steel industry while processing iron and steel. Reintroduction into the economic circulation of products of small and powdery ferrous wastes (fine and pulverous ferrous wastes) lead to reduction of water/air/soil pollution levels. Every tone of ferrous waste recovered and returned to steel production circuit leads to an economy of investments and operating costs. The paper approaches the problem of fine and pulverous wastes recovery from mining and steel industry. In fact, our research carried out shows that wastes can be used to produce briquettes.

**Keywords:** pollution, environment, steel industry, usage, wastes, briquetting, the Datafit analysis

### INTRODUCTION

Nowadays, among the main materials consumed worldwide (wood, steel, cement, and plastic), steel is in the first place and will still be there in the future. Steel and iron used as materials in many industrial fields, have the property to be recovered from manufactured products after their usage, regardless of period of time corresponding to those products' life. During ferrous metallurgy processes by which iron ore is converted to steel (iron and steel) and continuing with the manufacturing processes of these products, there are different forms of iron and steel scrap that results, having the generic name ferrous scrap. The steel industry uses large quantities of materials both in primary and secondary development process. The raw material used for primary development process in steel industry is iron ore [1,2,10,11,13]. Exploitation of iron ore deposits which are subjected to concentration operations, leads to obtaining fine grained iron concentrates which makes the process of agglomeration very difficult.

From steel industry activities derive a wide range of wastes, that can be categorized as recyclable wastes (ferrous and nonferrous wastes) and storable wastes, as well (slag, sludge, tar, oils). On the platform of a steel mill virtually all sectors contribute to the pollution of at least one environmental factor. Most

frequent, ferrous scrap results from the steel industry while processing iron and steel, from industries where steel products are processed or used as such, and from the ferrous part recovery process. Ferrous scrap in the steel industry may be pulverous, deriving from exhaust gas treatment plant, from steel processes, or may be pieces, deriving from steel and iron making processes. The flow of production in steel industry generates, on a continuous basis, wastes containing iron and carbon, in quantities directly proportional to the output. Within the manufacturing process, in addition to the main product there are sometimes secondary products, and there are always wastes: pulverous (powdery), small (fine) or large sizes, containing utile components like carbon, iron and alloying elements. Ferrous scrap can and should be reused, in their entirety, within steel industry. In fact, the pulverous ferrous wastes can be processed by pelletizing and the fine and pulverous ones by agglomerating and briquetting technologies. Every tone of ferrous scrap recovered and returned to steel production circuit leads to an economy of investments and operating costs. Romanian steel industry is currently experiencing technological gaps regarding the collection, transport, storage and, especially, the use of all categories of waste.

**LABORATORY EXPERIMENTS**

Briquetting is the method by which pieces of spherical, oval or rectangular forms are obtained from fine/small and pulverous waste during compressing operations on specialized equipment, followed by a drying–roasting process in order to increase their mechanical characteristics [5–13].

Briquetting applies to pulverous wastes (powder resulting from dedusting plants) and also to fine products obtained by precipitation. For waste briquetting (at 50–60°C) inorganic binders are used (limewash, Na<sub>2</sub>SiO<sub>3</sub>) and sometimes organic binders (sulphite liquor, heavy tars etc.) Briquetting operation consists of:

- ≡ preparation, mixing and homogenizing waste with binder to ensure optimum moisture and granulation;
- ≡ compression of the mixture;
- ≡ hardening;
- ≡ transport and storage of briquettes.

Mixing and homogenization of the mixture is performed in mixture drums, screw mixers, paddle mixers. Compression is performed on presses with rotating cylinders and piston presses. Hardening is performed by cooling and sintering.

Experiments on the production of briquettes were conducted within the laboratory of the Doctoral School of the Faculty of Engineering Hunedoara, University Politehnica Timișoara. Determination of waste chemical composition was carried out in the laboratories of ArcelorMittal Hunedoara Company.

To obtain briquettes, the raw material is subjected to fine grinding, which usually is performed in ball mills. Wastes which are substandard in terms of grain size are ground with these mills. Recipes with pulverous wastes are prepared. Homogenization of waste is done manually or in mixing plant with the addition of binders, and to obtain briquettes, the press is equipped with a mold chosen in accordance with the type of desired briquette. The proportions of wastes were determined in 13 recipes, compliance with these recipes is mandatory in order to obtain briquettes with appropriate quality standards [5–13].

Recipes composition and chemical composition of briquettes obtained were displayed in Table 1 and Table 2, respectively in Table 3 and Table 4, [10,11]. Once the briquettes are obtained, they are subjected to hardening processes after a diagram heating/holding/cooling, and then dried and tested to determine the qualitative characteristics (compression tests to determine resistance to cracking, crushing and grinding interval).

For recovery of small and pulverous wastes as briquettes from steel industry, energy and mining, we considered the following wastes: agglomeration–

furnaces dust, steel dust, galvanic sludges (two different types) and red mud from bauxite refining (bauxite residue). As binder for the manufactured briquettes we considered the following three types of powdery materials: limewash, bentonite and graphite [5,6,10–13].

**Table 1.** The used wastes and the composition of briquetting recipes (%) – Recipes R1 – R6

Wastes type	Composition of briquetting recipes, [%]					
	R1	R2	R3	R4	R5	R6
Steel dust (P.O.)	40	36	33	30	27	24
Agglomeration–furnaces dust (P.A.F.)	30	33	36	39	42	45
Galvanic sludge 1 (N.G.–O)	2	2	3	4	5	6
Galvanic sludge 2 (N.G.–B)	8	9	7	7	6	4
Red mud from bauxite refining (N.R.)	10	10	10	10	10	10
Graphite powder (G)	2	2	2	2.5	2.5	3
Bentonite powder (B)	4	4	3.5	3.5	3.5	3
Limewash powder (V)	4	4	4.5	4	4	4

**Table 2.** The used wastes and the composition of briquetting recipes (%) – Recipes R7 – R13

Wastes type	Composition of briquetting recipes, [%]						
	R7	R8	R9	R10	R11	R12	R13
Steel dust (P.O.)	20	17	15	13	8	5	2
Agglomeration–furnaces dust (P.A.F.)	48	51	54	57	60	63	66
Galvanic sludge 1 (N.G.–O)	7	5	6	6	5	7	8
Galvanic sludge 2 (N.G.–B)	5	6	5	4	7	5	4
Red mud from bauxite refining (N.R.)	10	10	10	10	10	10	10
Graphite powder (G)	3	3.5	3.5	4	4	4.5	4.5
Bentonite powder (B)	3	3	2.5	2.5	2.5	2	2
Limewash powder (V)	4	3.5	4	3.5	3.5	3.5	3.5



**Table 3.** Chemical composition of the recipes, (%) – Recipes R1 – R6

	R1	R2	R3	R4	R5	R6
Fe <sub>2</sub> O <sub>3</sub>	37.16	40.26	39.66	36.47	40.08	36.10
SiO <sub>2</sub>	16.95	17.52	15.70	19.30	18.29	18.01
ZnO	10.82	8.47	8.56	9.54	8.42	9.76
CaO	10.56	9.42	10.64	9.92	11.23	11.62
Al <sub>2</sub> O <sub>3</sub>	7.16	7.40	10.14	8.55	7.68	6.1
Na <sub>2</sub> O	4.10	4.80	3.75	4.66	3.80	5.16
MgO	2.47	2.13	2.04	2.19	2.27	1.41
MnO	1.63	1.28	1.37	1.44	1.41	1.13
P <sub>2</sub> O <sub>5</sub>	1.54	1.87	1.18	1.21	1.21	1.10
Other oxides	7.6	6.8	6.9	6.7	5.6	9.6

**Table 4.** Chemical composition of the recipes, (%)– Recipes R7 – R13

	R7	R8	R9	R10	R11	R12	R13
Fe <sub>2</sub> O <sub>3</sub>	39.20	43.15	33.57	38.42	40.02	34.73	36.02
SiO <sub>2</sub>	18.58	17.28	16.84	16.52	18.68	11.15	10.37
ZnO	8.40	9.13	9.47	8.76	5.81	16.99	16.73
CaO	10.32	11.56	11.08	10.96	9.56	7.57	7.44
Al <sub>2</sub> O <sub>3</sub>	9.14	8.14	8.33	7.54	7.26	2.80	2.43
Na <sub>2</sub> O	7.23	4.13	4.20	5.32	6.12	7.33	7.67
MgO	1.57	1.15	2.08	1.89	2.37	2.60	2.56
MnO	1.08	1.04	1.33	1.62	1.13	2.20	2.14
P <sub>2</sub> O <sub>5</sub>	1.93	1.34	1.45	1.28	3.11	2.41	2.53
Other oxides	2.55	3.08	11.65	7.69	5.9	12.0	12.0

The quality characteristics the resistance to crushing and the resistance to cracking of obtained briquettes, are calculated. With the data obtained, we conducted several dependencies that demonstrates the influence of the composition of briquetting load on these indicators, using Datafit and Matlab programs.

Firstly, in our mathematical analysis, we plotted in Datafit program the variation in resistance to cracking and resistance to crushing of obtained briquettes, according to the proportion of the small and pulverous wastes used in the recipes (steel dust, agglomeration–furnaces dust, galvanic sludges). The obtained mathematical correlations, the regression equations (polynomial regression model type:

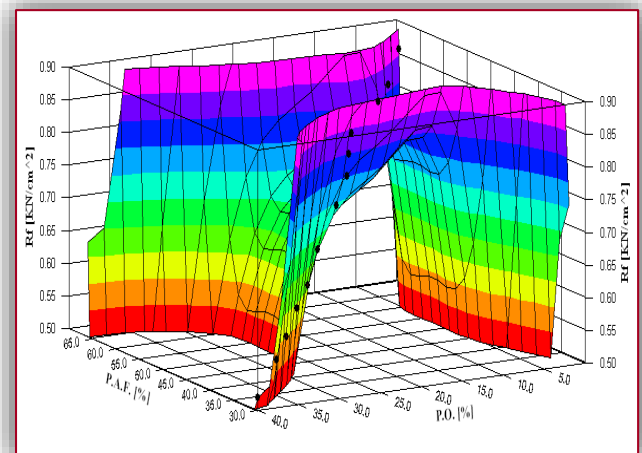
$$y = a + b \cdot x_1 + c \cdot x_1^2 + d \cdot x_1^3 + e \cdot x_1^4 + f \cdot x_1^5 + g \cdot x_2 + h \cdot x_2^2 + i \cdot x_2^3 + j \cdot x_2^4 + k \cdot x_2^5)$$

and the regression surfaces are shown in the Figures 1–6. Conveniently, these models are all linear from the point of view of estimation, since the regression function is linear in terms of the unknown parameters a, b, ....

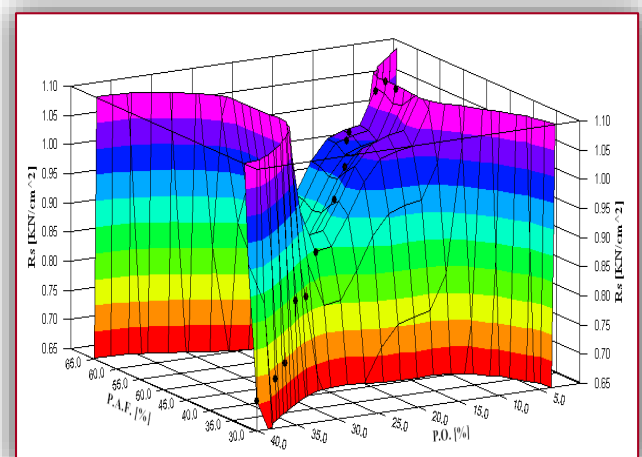
Therefore, for least squares analysis, the computational and inferential problems of polynomial regression can be completely addressed using the techniques of multiple regression, done by treating x, x<sub>2</sub>, ... as being distinct independent variables in a multiple regression model.

## RESULTS OF THE Datafit ANALYSIS

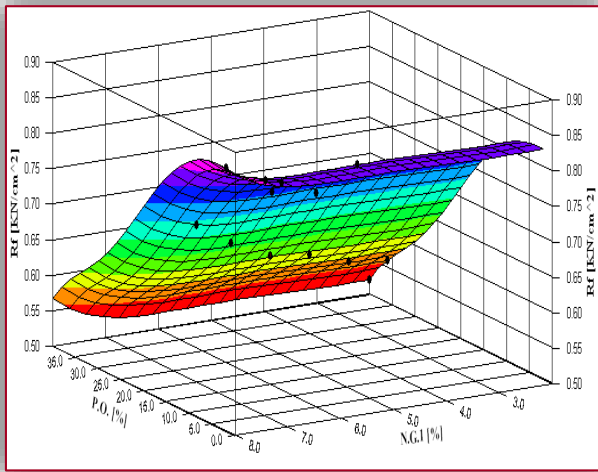
DataFit is a simple and efficient science and engineering tool that simplifies the tasks of data plotting, regression analysis (curve fitting) and statistical analysis. The data were processed in DataFit programs to obtain correlations between the main characteristic of the obtained briquettes – resistance to crushing and resistance to cracking – and the proportion of components in the recipe (small and pulverous wastes quantities).



**Figure 1.** The regression surface determined by the briquettes resistance to crushing depending on the proportion of steel dust and agglomeration–furnaces dust (the coefficient of multiple determination: R<sup>2</sup>=0.9996349716, the polynomial regression equation coefficients are: a=–205.6158; b=23.8851; c=–1.0830; d=0.02397; e=–0.0002; f=1.1140; g=0.7284; h=–0.0802; i=0.0041; j=–0.0001; k=9.2884)

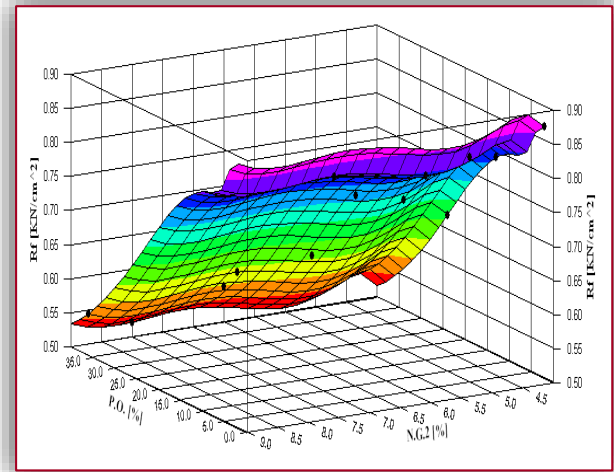


**Figure 2.** The regression surface determined by the briquettes resistance to cracking depending on the proportion of steel dust and agglomeration–furnaces dust (the coefficient of multiple determination: R<sup>2</sup>=0.9920884722, the polynomial regression equation coefficients are: a=440.0762; b=–51.3919; c=2.3642; d=–0.0530; e=0.0006; f=–2.5292; g=–1.9088; h=0.2059; i=–0.0105; j=0.0002; k=–2.2424)



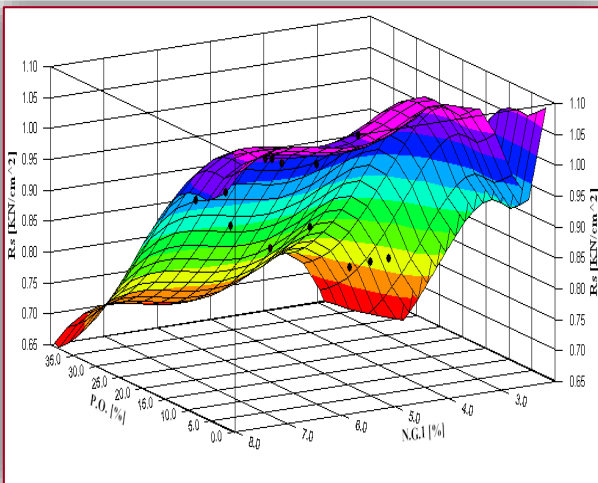
**Figure 3.** The regression surface determined by the briquettes resistance to crushing depending on the proportion of steel dust and galvanic sludge 1 (the coefficient of multiple determination:

$R^2=0.9996578109$ , the polynomial regression equation coefficients are:  $a=0.8178$ ;  $b=-0.0009$ ;  $c=0.0004$ ;  $d=-0.0001$ ;  $e=2.4959$ ;  $f=-2.6265$ ;  $g=0.0215$ ;  $h=-0.0186$ ;  $i=0.0065$ ;  $j=-0.0010$ ;  $k=0.0001$ )



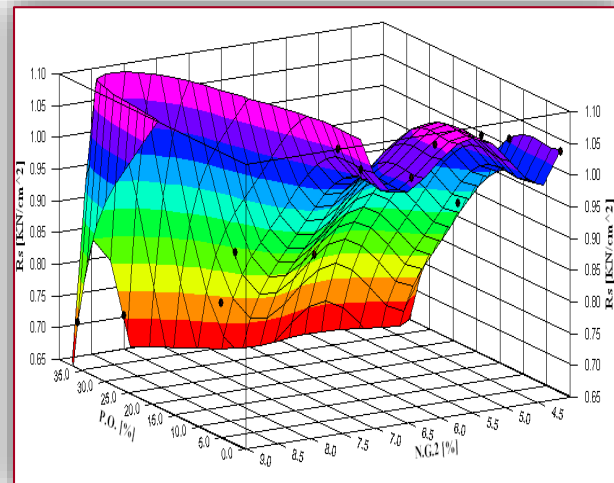
**Figure 5.** The regression surface determined by the briquettes resistance to crushing depending on the proportion of steel dust and galvanic sludge 2 (the coefficient of multiple determination:

$R^2=0.9999509001$ , the polynomial regression equation coefficients are:  $a=-244.5798$ ;  $b=2.6814$ ;  $c=-3.0316$ ;  $d=1.5452$ ;  $e=-0.3655$ ;  $f=0.0321$ ;  $g=693.4561$ ;  $h=-780.7115$ ;  $i=436.4224$ ;  $j=-121.1669$ ;  $k=13.3702$ )



**Figure 4.** The regression surface determined by the briquettes resistance to cracking depending on the proportion of steel dust and galvanic sludge 1 (the coefficient of multiple determination:

$R^2=0.9975716124$ , the polynomial regression equation coefficients are:  $a=18.0641$ ;  $b=2.3436$ ;  $c=-2.8285$ ;  $d=1.5497$ ;  $e=-0.3915$ ;  $f=0.0364$ ;  $g=-70.6418$ ;  $h=107.5958$ ;  $i=-78.7594$ ;  $j=27.8951$ ;  $k=-3.8446$ )



**Figure 6.** The regression surface determined by the briquettes resistance to cracking depending on the proportion of steel dust and galvanic sludge 2 (the coefficient of multiple determination:

$R^2=0.9968434407$ , the polynomial regression equation coefficients are:  $a=116.5405$ ;  $b=-0.0161$ ;  $c=0.0036$ ;  $d=-0.0003$ ;  $e=0.0001$ ;  $f=-1.2262$ ;  $g=-101.6929$ ;  $h=35.1393$ ;  $i=-5.9538$ ;  $j=0.4944$ ;  $k=-0.0161$ )

The accuracy of DataFit has been verified with the Statistical Reference Datasets Project of the National Institute of Standards and Technology (NIST). DataFit is a science and engineering tool that simplifies the tasks of data plotting, regression analysis (curve fitting) and statistical analysis. With the combination of the intuitive interface, online help and wide range of features, it is a tool that is used effectively by both engineers and scientists.

## CONCLUSIONS

Waste recycling represents one of the economic solutions of environment ecology. In this sense the group of authors has made a series of experimentations regarding their transformation in used products in the iron-and-steel industry.

To obtain the products in forms of briquettes many series of receipts have been tested and according to

qualitative characteristics of the obtained products the processing receipts have been chosen.

The data obtained has been processed in Datafit program, which that allowed the establishing of optimal domains of variations of the technological parameters in view of obtaining some products with superior technological characteristics.

The paper presents results of research on the strength of briquettes obtained from recycled ferrous wastes – through resistance to crushing and the resistance to cracking –, research conducted to acknowledge the following two technical problems:

- » the alteration of the experimental briquettes resistance, in accordance with the quantity of various ferrous wastes (steel dust, agglomeration–furnaces dust, galvanic sludges) used for the experimental recipes preparation;
- » the influence upon the resistances of some chemical compounds from materials recovered by briquetting.

As a result of analyses performed on products obtained by processing small and pulverous wastes from industrial steel and mining areas and the experiments conducted in the laboratory stage, we consider the following:

- » the studied small and pulverous wastes (steel dust, agglomeration–furnaces dust, galvanic sludges) can be processed by using the available technology like briquetting and can be reintroduced into the steel circuit with minimum investment costs;
- » reintroduction of small and pulverous wastes into economic circuit has both economic and ecological effects, by releasing the occupied terrains (ponds, landfills, disused buildings) in case of deposited wastes, vacancy of areas for waste resulting routinely on technology flows.

Taking into consideration the existing local conditions, as a result of the strong economic restructuring, a large amount of pulverous and small ferrous wastes remained, it is necessary to intensify the wastes recovery process, both because it represents a source of iron, poor raw material, and because of technological and ecological considerations. We consider that can be processed both the wastes resulted in technological flows and those deposited in ponds or landfills.

For Romania the recovery of ferrous wastes represents a priority for the durable development strategy because the natural resources of some raw materials categories are poor or insufficient and the resources can substitute part of the raw materials with significant low costs.

Comparatively with the practice and the world wide manifested tendencies, the Romanian industry registers gaps in the powder wastes collection, transportation and storage area, as well as in that of

the recovery technologies area by their recycling or reusing. Thereby, the approach of the superior recovery of small and powder ferrous wastes problem was considered necessary and convenient.

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## ANALYSIS AND REQUIREMENTS FOR FLEXIBLE MANUFACTURING ENTERPRISE

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**Abstract:** Currently, in terms of development of application software products and are quite clearly specified the key trends that need to be respected when computer support project activities. In particular, user interface with a high degree of comfort interactive graphics, two-dimensional and three-dimensional computer graphics significantly contribute to more effective project methodology and procedures. This stems mainly from the fact that in modern manufacturing systems design engineering high number of solving the problem is clearly graphic in nature. Automate tasks graphic character is therefore an important direction of development of the area concerned.

**Keywords:** CIM-OSA, JIT, CIB, CIM, HIM

### INTRODUCTION

Engineering production directed to meeting the social requirements for consumer products, production companies and requires the development and application of appropriate methods of design implementation, i.e., production systems. Piercingly increase productivity, improve quality, save raw materials, energy, environmentally sound manner and under. It is only possible in well-designed, it well-structured and optimized production systems. Required changes are mainly based on the use of new approaches in project activities. A systematic approach, good orientation in developing directions of science, considerable creative potential, as well as the right strategic decisions given the rapidly changing technical, technological, economic and social conditions are necessary in a practical project activity.

In actual practice, the identified shortcomings of the design process. These are generally analyzed in terms of cost, time of preparation, quality and other criteria designed production systems. A significant impact on the design of science in solving specific problems is relatively little pronounced. In this regard, the recently quite successful and they create the applied advanced design methods. These in some areas reached the level of world-class innovation trends [1, 2]. Onset type of production systems JIT (Just-In-Time), CAD (Computer Aided Design) / CAM (Computer Aided Manufacturing), CIM (Computer integrated Manufacturing), HIM (Human integrated

Manufacturing) and so on. He has created a new impetus for the integration of philosophical, technical, economic and social concepts design theories, methodologies and tools for market development stage company. New production technology based on currently CNC production machines, industrial robots, flexible transportation and storage equipment, computer control technology and other means bring problems integrating character. Their solution requires a new industrial structure. For its preparation is an important knowledge base and design theory, based on scientific knowledge, methods and tools to adequately develop analytical and synthetic culture engineering activities [3].

Notable innovation trends in this area is computer aided design. According to scientific forecasts, the use of computer support will be essential methods used in engineering activities of different nature. Trends computer support in full will affect the area of technical preparation machinery production and actual production. Concrete expression systems are applied to product development, manufacturing technologies and processes, manufacturing systems planning, organization and management of the production and operation. It is generally considered that computer support in the design of complex production systems becomes essential both in terms of general as well as specific characters of automation engineering and technical operations.

Computer aided design activities has also its specific problems that need to be addressed. The development process is not only experienced hardware and software, but significant progress has been identified in the implementation of computer and information technology.

#### **ANALYSIS OF TRENDS IN THE DEVELOPMENT OF MECHANICAL ENGINEERING**

For the current development strategy of mechanical engineering is critical orientation to customer requirements. These requirements relate to the new functional products, environment, education, humanizing the life, culture and the production. Satisfying them puts pressure on shortening innovation cycles in the development and manufacture of products. Mass-produced goods cease to be attractive relative to individualized and rapidly changing customer demands.

Competitiveness is associated with the use of new types of products and their functions, new materials, new technologies, including information and knowledge. According to [4,5,6] Mainstreaming engineering and manufacturing changes are:

- » customer orientation in production but also in business,
- » segmentation as well as opening new markets,
- » increasing uncertainty and risks.

An important factor in the current as well as future changes in engineering production is therefore its customer orientation. This philosophy is based on [7]:

- » selection of customer values,
- » the creation of values,
- » delivery of customer value.

The strategy to achieve competitiveness calls for a more flexible production. Required:

- » rapid adaptation of new products,
- » quick customer satisfaction.
- » high quality,
- » reasonable price.

#### **REQUIREMENTS FOR FLEXIBLE MANUFACTURING ENTERPRISE IN ENGINEERING PRODUCTION**

From the perspective of orienting the manufacturers to flexible production, to meet customer requirements, the following factors are important [8]:

- » Customer - Respecting client needs is a must have when developing a new product.
- » Automation - Product instability is now the main factor which should guide the automation of production. The production process is broken down into small units that can be built as the islands of automation, and then integrated.
- » Integration - It is seen as linking between the existing organizational units, respectively subsystems, which, depending on the degree of integration coalesce into a qualitatively new unit.

It builds primarily by means of information and material flows. The number of exchanged information continues to grow, their rate of exchange requirement increases, the time for decision-making is reduced.

- » Agility - Agile enterprise must reach to produce the right product at the right place at the right time for the right customer at the correct price.
- » Variability products - Building of variation based on the use of standardization of elements, resulting in the interchangeability and routing modules. When designing modular concept allows for added modules to create different variants. Approach allows for short time from standardized components to design a large number of final products.
- » Additional value - To ensure the competitiveness of the company it is necessary that this focus on those activities that will allow it to offer products with a sufficient proportion of added value.
- » Time - It allows to overtake a competitor in customer satisfaction. The new structure of the company must be flexible so that time losses were minimal.
- » Innovation - Large manufacturing strategies are built on a unique idea, abilities and not only on investments. In a rapidly changing environment, innovation is a must. Competition in innovation is reflected in shortening the development time of new products and their marketing.
- » Flexibility - It does not require achievement of a maximum of productivity, ie, to means of production than were used, but it requires the ability to be available to manufacture the product in the required time.
- » Manufacturing cells - Cell structure provides interconnection between machines, saving time and space. Operation of the means of production is synchronized material flow fast.
- » JIT - The essence of the elimination of those times that do not contribute to the formation of the new value of the product. The method was developed in response to the speed and flexibility in responding to market.
- » Group technology - Similar product groups are formed on the basis of material flow through the same means of production. On a group of technology is thus also possible for a small number of products in batches to achieve high production flexibility, ensuring the quality and aspect of the production process and show the economic effects of scale.
- » Quality - It is a necessity, it cannot now be separated from requirements to customer satisfaction, but not enough to gain the customer.



- » Decentralized management - With flexible production management is decentralized. Most decisions are implemented on the ground in the production system. Management is easier and faster.
- » Multi-professional activity of the workers - To meet customer requirements creates interdisciplinary problem-oriented and time-bound groups in which employees assume different roles, often pass from one to another working system and used very flexibly their working time.

The main changes in recent years, affecting the reorganization are [9]:

- » Increased use of modern means of computer equipment and software, computer networks and the like. Their innovation takes place at ever shorter intervals.
- » The explosion of new knowledge, disciplines and sources of information (eg. Internet). People are inundated with information, and it is still difficult to find accurate information required by decision.
- » Globalization and internationalization development, production, trade and business.
- » The amount of training programs, retraining people is taking place in ever shorter cycles.
- » Rapid changes in the product mix, diversification, changes in the portfolios of companies, mergers and bankruptcies.
- » New discoveries, inventions, technologies, business opportunities in new market segments.

#### THE FUNDS NECESSARY FOR THE DEVELOPMENT OF MANUFACTURING PLANT

It is especially needed to develop the means of production (machinery), human resources, engineering, planning and management methods for supporting decision-making. Overview of development needs is shown in Figure 1.

#### THE ANALYSIS OF GENERAL TRENDS IN THE DESIGN OF PRODUCTION SYSTEMS

Analysis and evaluation of new methods and approaches to designing of production systems (clusters) deal with a series of works [9, 10, 11]. A comprehensive look at the issue is presented especially the work of Jones' Designing methods "[1]. Classic design methods are classified in two main groups ie as an evolution of existing solutions and design based on drawings. New strategies are classified into six groups. As fundamental aspects for project evaluation strategies are used:

- » presentation of the breakdown of projects on subtasks,
- » strategy of partial sequence solutions and interrelationships,

- » techniques for generating project ideas, review solutions, process information processing and so on.

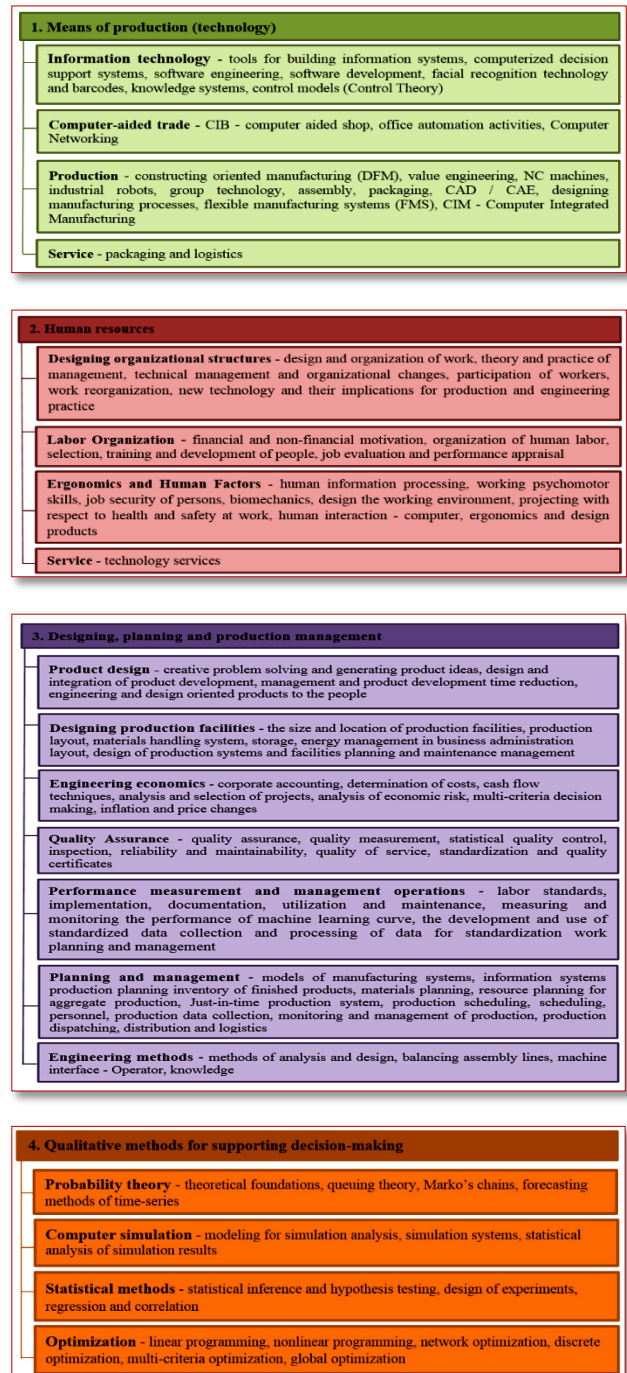
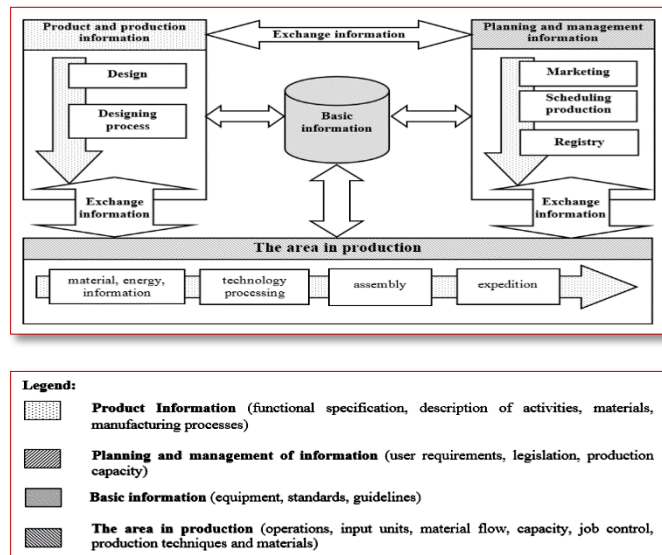


Figure 1. Overview of the envisaged areas of modern production

Strategy Selection of project solutions for the concrete realization of the conditions is complex and often ambiguous. Surveys show that in the design of complex production systems (complex) is most commonly used cyclic and branched-chain strategy. In addition to general project methodology is currently being developed special approaches to innovation-oriented systems such as CIM, flexible manufacturing, robotic manufacturing, customer-oriented production and so on. In terms of computer

support in these modern methodological aspects of the production it is recorded major progress. Reformation for access to scientific design methods of production clusters can be considered in the program ESPRIT procedure known as CIM-OSA. Its conceptual diagram is illustrated in Figure 2. The methodology of great importance modeling procedures integrated into one unit.



**Figure 2.** Developing Production grouping procedure CIM – OSA

The Esprit project includes also the methodology to design structural systems CIM distinctive analytical phase (what should be addressed) and implementation phase (as is to be addressed). In the analytical phase is generated model around the system (includes a context diagram) and model behavior of the system (data charts). The implementation phase will specify the structure of decision-making.

In terms of basic directions of development of engineering design is identified by the penetration of knowledge engineering in this field [12]. Particularly in the USA, these new technologies are beginning to use in commercial practice (Intel Corporation, Technowlledge, Inference Corp., etc.). Knowledge Engineering is represented by expert systems and differs from traditional software systems more characters. The design is applied in two different ways:

- » partial systems to the design defined technical units or industrial complexes (eg. A part robot, NC operation, etc.). Systems of this type are less difficult to prepare and are easy to acquire.
- » complex systems designed for large engineering units (DARS projects, etc.). Applications of this kind for Slovak conditions anticipated.

## CONCLUSION

The design technology and product innovation, a higher degree of satisfaction of social requirements (customer requirements) is essential in the

implementation of new project activity. It is particularly important to work towards the development of robotic manufacturing systems. Preferred are those engineering approach enables the use of the knowledge potential of multiple disciplines, allow the right strategic and tactical decisions in particular in relation to the rapidly changing technological, economic and social conditions.

Study and analysis of current approaches to modern designing of that, it has several shortcomings, especially in terms of examining the impact of science to solve specific problems. It can be concluded that the impact of science on designing solutions to existing problems has its specific provisions. As a result of such contexts they are therefore developed and applied advanced design methods. They are influenced most significantly to progress in information and computer technologies.

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<sup>1</sup>Sunday ARIBO

## PITTING TEMPERATURE OF DUPLEX STAINLESS STEELS IN OILFIELD ENVIRONMENTS

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**Abstract:** The critical pitting temperatures of some selected duplex stainless steels have been determined. Potentiostatic polarisation was conducted for all the alloys in aerated and CO<sub>2</sub>-saturated oilfield brine. A constant potential of 250 mV versus Ag/AgCl was applied and the temperature of the solution was ramped at 1°C/second. The critical pitting temperature was determined as the temperature at which the current densities of the alloys exceeded 100 µA/cm<sup>2</sup>. Results showed that the critical pitting temperature was lower for the alloys in the CO<sub>2</sub>-saturated oilfield brine compared with the aerated environment. Also, the pitting resistance equivalent number did not seem to determine the resistance of the lean duplex stainless steels as UNS S32101 and UNS S32304 with equivalent PREN exhibited different pitting temperatures.

**Keywords:** Pitting, oilfield brine, stainless steels, PREN

### INTRODUCTION

Duplex stainless steels are specifically designed to be used in aggressive environments where both corrosion resistance and mechanical properties of 300 series austenitic stainless steels are inadequate (Ezubar, 2010). The major limitation to the use of these alloys has been the high cost of the materials (Singh et al., 2007). The recent surge in the price of nickel and molybdenum has driven the cost of production of duplex stainless steels higher. However, the development of lean duplex stainless steels with much lower nickel and molybdenum content can offset some of the cost issues (Gudme and Nielsen; Rommerskirchen et al., 2009; Rao, saithala et al., 2011). The austenite phase in such alloys has been maintained by adding more manganese and nitrogen. With the development of lean duplex stainless steels, material cost is reduced, duplex microstructure is retained and the steel still retains reasonable quality (Berezovskaya et al., 2008). Lean duplex stainless steels are now candidates for many oil and gas applications such as flowlines, carcass of flexible pipes, umbilical tubing, heat exchangers, separation units, cable trays and transportation vehicles (Gudme and Nielsen; Rommerskirchen et al., 2009; Jordan, 2006). Lean duplex stainless steels are also structurally stable and the phases reform easily after welding as result of nitrogen addition. However, very limited corrosion data exists on the lean duplex stainless steels in both marine and CO<sub>2</sub>-saturated saline environments.

The pitting resistance equivalent number (PREN) is the factor on which the pitting behaviour of alloys are ranked. However, the pitting behaviour of passive alloys also depends on the passive film characteristics, the temperature and composition of bulk solution (Olefjord, 1980, Oldfield, 1987). Pitting resistance equivalent number is often represented by the amount of the corrosion resistant alloying elements in the substrate alloy (%Cr +3.3%Mo +16%N). Chromium, molybdenum and nitrogen are the major alloying elements that contribute to this number as shown in the formula (Bendall, 1996). However, the characteristics of the passive film on stainless steels is different from the substrate alloy. The passive film composition is however dependent on the substrate's composition and the corrosion medium (Olsson and Landolt, 2003). Alloying elements have been reported to be enriched in the passive film of passive alloys (Olsson and Landolt, 2003; Newman, 2001). Molybdenum and chromium are reported to be present in the passive film while nickel is said to be either absent or have very negligibly presence in the oxide film. However, it is said that the nickel is enriched just below the oxide film (Newman, 2001; Qiu, 2002). The pitting behaviour of stainless steels is also said (Newman, 2001; Qiu, 2002) to be dependent on the chloride ion concentration of the corrosion medium. However, despite the importance of the passive film chemistry to pitting corrosion, the pitting resistance



equivalent number has been developed based of the alloying elements in the substrate.

The present study looks at the critical pitting temperature of duplex stainless steels. These alloys have equal proportion of ferrite and austenite and so the pitting behaviour is more complex. This is so because the alloying elements are partitioned differently in the two phases. Also, the presence of high manganese and varying nickel additions in the lean duplex alloys make the pitting characteristics different from the fully austenitic and fully ferritic alloys.

**METHODOLOGY**

Potentiostatic polarization measurements were taken for the alloys in a three electrode electrochemical set up using an Ag/AgCl reference electrode and a platinum counter electrode. The oilfield brine was initially sparged with CO<sub>2</sub> for 8 hours and kept in the laboratory shelf. Before each experiment, the oilfield brine was also sparged for one hour resulting in a pH of approximately 5.0. Moreover, CO<sub>2</sub> was continuously fed into the solution throughout the duration of the experiment. A potential of 250 mVAg/AgCl was applied for all the experiments and the temperature ramped at 1°C/minute from ambient until the current density exceeded 100 µA/cm<sup>2</sup>. The same procedure was repeated for the alloys in the oilfield brine left in aerated conditions having a pH 6.5.

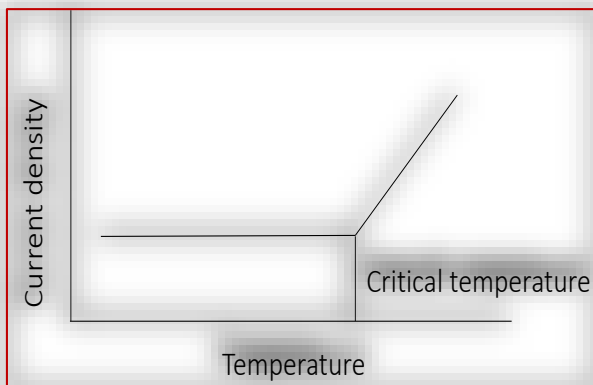


Figure 1: Schematics of how the critical pitting temperature is determined

Table 1: Properties of alloys (solution annealed conditions) used for the research

ASTM/UNS	Type	Cr	Ni	Mo	Cu	Mn	N	PREN <sub>16</sub>
S32101	Lean duplex	21.26	1.60	0.24	0.26	4.81	0.23	25.7
S32304	Lean duplex	23.00	4.80	0.30	0.25	1.00	0.10	25.5
S82441	Lean duplex	24.11	3.59	1.60	0.37	2.85	0.27	33.7
S32205	Duplex	22.43	5.73	3.15	0.24	1.40	0.18	35.7

Table 2: Oilfield brine adopted for the research

Salts	mg/L
NaCl (Sodium Chloride)	24090
KCl (Potassium Chloride)	706
CaCl <sub>2</sub> .2H <sub>2</sub> O (Calcium Chloride Di-hydrate)	1387
MgCl <sub>2</sub> (Magnesium Chloride)	4360
BaCl <sub>2</sub> .2H <sub>2</sub> O (Barium Chloride Di-hydrate)	16
SrCl <sub>2</sub> .6H <sub>2</sub> O (Strontium Chloride Hexa-hydrate)	33
Na <sub>2</sub> SO <sub>4</sub> (Sodium Sulphate)	3522
NaHCO <sub>3</sub> (Sodium Bicarbonate)	304

**RESULTS**

Figures 2, 3 and 4 show the critical pitting temperature of the alloys. The results obtained show that the critical pitting temperature is lower in CO<sub>2</sub> saturated oilfield brine than the aerated environment for all the alloys. Lean duplex UNS S32101 has pitting temperature of 23 °C and 25 °C in CO<sub>2</sub> saturated oilfield brine and aerated environments respectively. UNS S32304 has pitting temperature of 30°C and 33°C in CO<sub>2</sub> saturated oilfield brine and aerated environments respectively. UNS S28441 has very close values of 37 and 38°C in CO<sub>2</sub> and aerated environments respectively. UNS S32205 has critical pitting temperature of 50 and 58°C in CO<sub>2</sub> and aerated environments respectively.

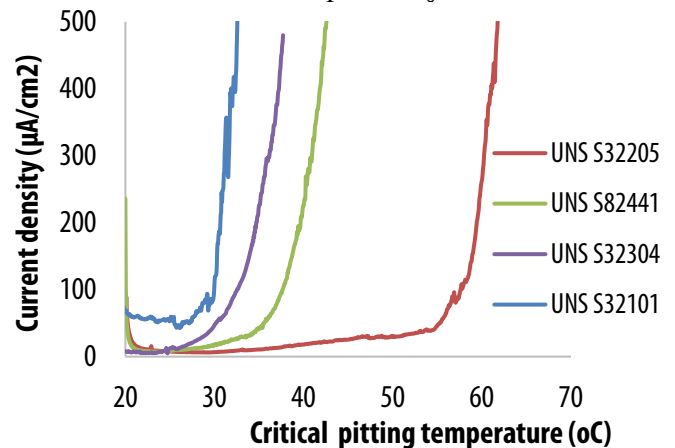


Figure 2: Critical pitting temperature in aerated oilfield environment

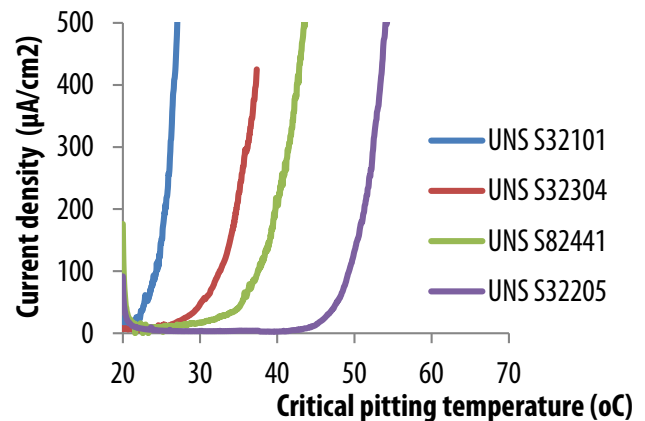
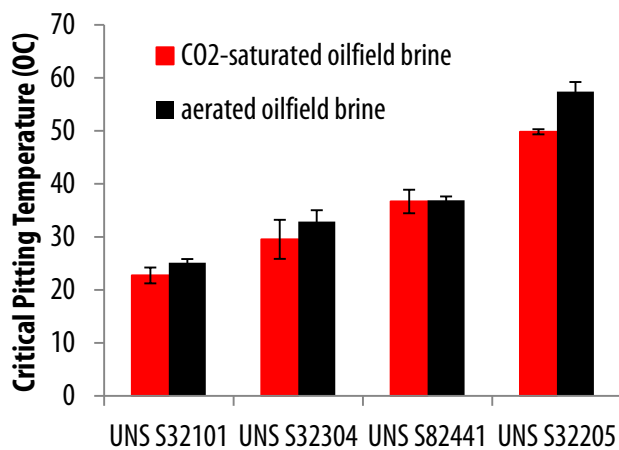


Figure 3. Critical pitting temperature in CO<sub>2</sub> saturated oilfield environment



**Figure 4.** Critical pitting temperatures of the alloys in both aerated and CO<sub>2</sub>-saturated oilfield environments

## DISCUSSION

The critical pitting temperature is lower in CO<sub>2</sub> saturated oilfield brine than aerated brine for all the alloys. Standard duplex UNS S32205 and UNS S82441 seem to exhibit differences in their pitting characteristics. Both alloys however, exhibit higher pitting temperature expected of highly alloy steels. However, UNS S32205 exhibited higher pitting temperature than UNS S82441. Another observation is that the lean duplex UNS S32304 has a higher pitting temperature compared to UNS S32101 in both environments.

Acidification resulting from the dissolution of CO<sub>2</sub> in water to form carbonic acid is thought to be a reason for the aggressiveness of the CO<sub>2</sub> saturated oilfield compared with the aerated environment. Also, lower oxygen content of CO<sub>2</sub> saturated environment would render the passive structurally defective and less dense (Anselmo *et al.*, 2006).

Possibility of chloride ion adsorption and incorporation in the passive film formed on passive alloys has also been reported (Olsson and Landolt, 2003; Hubschmid *et al.*, 1995; Landolt *et al.*, 1990; Virtanen *et al.*, 1994). According to Anselmo *et al.*, 2006, the behaviour of passive film in CO<sub>2</sub> saturated environment is dependent on the synergistic effects of both chloride ion concentration and CO<sub>2</sub>. According to these authors, at higher chloride ion concentration (40,000-80,000ppm) the pitting potentials of martensitic stainless steel is lower in CO<sub>2</sub> saturated environment as compared to aerated seawater environment. They also argued that the pitting behaviour changed at lower chloride concentration (20,000-30,000 ppm).

Both the chemistry of the near surface of the bulk alloy and that of the passive film are important to the resistance of alloys to pit formation (Elsener *et al.*, 2011a, Elsener *et al.*, 2011b). Elsener *et al.*, 2011a) reported nickel enrichment at the interface between the bulk and the passive film formed on UNS S30400 and UNS S31803 after exposure to an alkaline

medium for 24 hours. UNS S32304 and UNS S32101 have similar pitting resistance equivalent number (PREN) as shown in Table 1. However the two alloys exhibited differences in their pitting characteristics. This is thought to be as a result of the differences in the chromium and nickel additions as well as the higher manganese in UNS S32101.

Higher nickel content of the bulk UNS S32304 may result in a higher enrichment of nickel (Olefjord, 1980, Elsener *et al.*, 2011; Lorang *et al.*, 1994) at the interface between the bulk alloy and the passive film. This is in addition to the higher chromium expected in the passive film of UNS S32304. The lean duplex alloy UNS S32101 on the other hand has higher manganese and lower nickel addition in the bulk. This could make the layer below the passive film have less nickel enrichment and the passive film of high manganese addition. Manganese being an active (Elsener *et al.*, 2011a; Elsener *et al.*, 2011b) element is then dissolved into the solution leaving the passive film defective. There is therefore a need to incorporate the factors of nickel and manganese into the pitting resistance equivalent number for the lean duplex stainless steels.

Addition of 3.15 wt. % molybdenum in UNS S32205 seems to outweigh the higher chromium addition in UNS S82441. Hence, the higher pitting temperature attained by UNS S32205.

## CONCLUSIONS

The critical pitting temperatures of some selected duplex stainless steels have been determined. Potentiostatic polarisation was conducted for all the alloys in aerated and CO<sub>2</sub>-saturated oilfield brine. A constant potential of 250 mV versus Ag/AgCl was applied and the temperature of the solution was ramped at 1°C/second. The critical pitting temperature was determined as the temperature at which the current densities of the alloys exceeded 100 µA/cm<sup>2</sup>. Results showed that the critical pitting temperature was lower for the alloys in the CO<sub>2</sub>-saturated oilfield brine compared with the aerated environment. Also, the pitting resistance equivalent number did not seem to determine the resistance of the lean duplex stainless steels as UNS S32101 and UNS S32304 with equivalent PREN exhibited different pitting temperatures.

1. Critical pitting temperature is lower for the alloys in the CO<sub>2</sub>-saturated oilfield brine compared with the aerated environment.
2. The pitting resistance equivalent number does not seem to determine the resistance of the lean duplex stainless steels as UNS S32101 and UNS S32304 with equivalent PREN exhibit different pitting temperatures.
3. UNS S32205 has a higher pitting resistance compared with UNS S82441 in both environments

4. UNS S32304 has a higher pitting resistance compared with UNS S32101 in both environments
5. There seems to be a wide margin between the pitting temperature of UNS S82441 and UNS S32205

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## HIEMENZ MAGNETIC FLOW BY DIFFERENTIAL TRANSFORMATION METHOD AND PADE APPROXIMANT

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**Abstract:** The Magnetohydrodynamic (MHD) Hiemenz boundary layer flow over a flat plate embedded in a porous medium in the presence of transverse magnetic field has been studied. The governing equations are solved by differential transformation method with Pade approximant (DTM-Pade) and Runge-Kutta method along with shooting technique. The results of these two methods are compared with the results obtained by finite difference method in conjunction with quasilinearization technique reported earlier in case of the flow without porous medium. It is found that the results of DTM-Pade, Runge-Kutta and quasilinearization technique agree with each other within a certain degree of accuracy. The convergence of the method in attaining the ambient state is faster in case of Runge-Kutta method than the DTM-Pade which can be improved by employing higher dimension Pade approximant matrices. It is also remarked that both magnetic field and porous matrix enhance the velocity field as well as skin friction.

**Keywords:** Hiemenz magnetic flow; Porous medium; DTM; Finite difference; Quasilinearization

### INTRODUCTION

Flows in which the velocity of the incoming fluid is perpendicular to a plane surface is known as Hiemenz flow [1]. If in addition the fluid is electrically conducting, the flow is then called Hiemenz magnetic flow. The solution of this problem is of interest because it is one of the few exact solutions of Navier-Stokes equation in magnetohydrodynamics. Further, the governing equations of the Hiemenz magnetic flow are non-linear. An effective method of solution is the method of finite difference in conjunction with quasilinearization as presented in NA [2].

Applied Mathematics, Physics and problems related to engineering exhibit nonlinear phenomena. Most of nonlinear equations do not have a precise analytical solution; so numerical methods are usually applied to solve the governing equations. Some of the analytical methods are perturbation techniques [3], Adomian decomposition method (ADM) (Dehghan [4-5]), homotopy analysis method (HAM), DTM and variational iteration method (VIM). He [6] and Rashidi [7] have studied the generalized differential transformation method to solve differential equations governing flow of fluids.

The MHD flow finds numerous applications in industries such as MHD power generation and MHD pumps (Hayat et al. ([8]) etc. Further, in the field of

heat transfer, the concept of flow through porous media is of great consequence in the modern technology as the porous matrix acts as a good insulator to prevent energy loss. The two relevant properties associated with the study of flow through porous media are porosity and permeability. Porosity basically describes the fraction of total volume which is occupied by the holes. Permeability is a measure of the capacity with which fluids will flow through a porous material. Table 1 presents the numerical values of effective porosity and permeability of materials of common use.

**Table 1:** Porosity and permeability of typical porous materials

Material	Effective porosity	Permeability
Brick	0.12 – 0.34	$4.8 \times 10^{-11} - 2.2 \times 10^{-9}$
Copper powder	0.09 – 0.34	$3.3 \times 10^{-6} - 1.5 \times 10^{-5}$
Leather	0.56 – 0.59	$9.5 \times 10^{-10} - 1.2 \times 10^{-9}$
Limestone	0.04 – 0.10	$2.0 \times 10^{-11} - 4.5 \times 10^{-10}$
Sand	0.37 – 0.50	$2.0 \times 10^{-7} - 1.8 \times 10^{-6}$
Sand stone	0.08 – 0.38	$5.0 \times 10^{-12} - 3.0 \times 10^{-8}$
Silica powder	0.37 – 0.49	$1.3 \times 10^{-10} - 5.1 \times 10^{-10}$
Soil	0.43 – 0.54	$2.9 \times 10^{-9} - 1.4 \times 10^{-7}$
Wire crimps	0.68 – 0.76	$3.8 \times 10^{-5} - 1.0 \times 10^{-4}$

The objective of the present study is to apply DTM, DTM-Pade approximant and Runge-Kutta method to solve modified Navier-Stokes equation for Hiemenz magnetic flow through porous media and to compare the results obtained by the present methods of solution with the results reported in [2] employing finite difference method in conjunction with quasilinearization technique.

**HIEMENZ MAGNETIC FLOW**

The boundary layer equations for Hiemenz magnetic Darcy flows for viscous fluid following [9] are:  
Continuity:

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

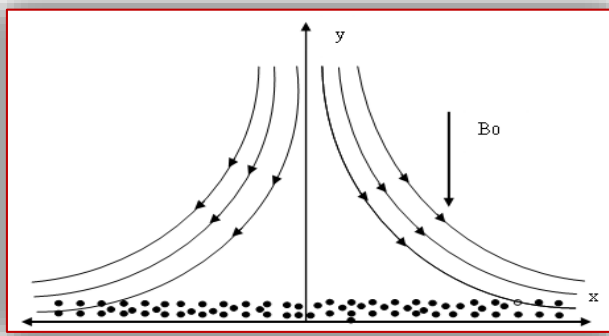
Momentum:

$$u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = a^2 x + \nu \frac{\partial^2 u}{\partial y^2} + \frac{\sigma B^2}{\rho} (ax - u) + \frac{\nu}{K_p^*} (ax - u) \tag{2}$$

subject to the boundary conditions:

$$\left. \begin{aligned} u = 0, v = 0 \text{ at } y = 0 \\ u = ax, \text{ at } y \rightarrow \infty \end{aligned} \right\} \tag{3}$$

where  $u, v, \nu, \rho, K_p^*$  and  $a$  are respectively the  $x$ -component of the velocity, the  $y$ -component of the velocity, the viscosity, the density, the permeability of the medium and a constant known as initial stretching rate (characteristic of the incoming flow) with dimension (time)<sup>-1</sup>. Further,  $\sigma$  and  $B$  are respectively the electrical conductivity and magnetic induction. The last term represents the additional resistance due to porosity of the porous medium. The flow geometry is shown in Figure 1.



**Figure 1.** Flow geometry

The first two prescribed boundary conditions represent neither slip nor mass transfer on the surface where the conditions are at infinity (i.e. ambient state) means that the velocity of the fluid approaches a linear relation with  $x$ .

Introducing the variables

$$u = ax \frac{df}{d\eta} \text{ and } v = -\sqrt{av} f(\eta), \tag{4}$$

where  $\eta = \sqrt{\frac{a}{\nu}} y.$  (5)

the equations (2) and (3) become

$$\frac{d^3 f}{d\eta^3} + f \frac{d^2 f}{d\eta^2} + 1 - \left(\frac{df}{d\eta}\right)^2 + \left(M + \frac{1}{K_p}\right) \left(1 - \frac{df}{d\eta}\right) = 0 \tag{6}$$

$$\left. \begin{aligned} f = 0, \frac{df}{d\eta} = 0 \text{ at } \eta = 0 \\ \frac{df}{d\eta} = 1 \text{ at } \eta \rightarrow \infty \end{aligned} \right\} \tag{7}$$

where  $M = \frac{\sigma B^2}{a\rho}$  is the magnetic parameter and

$K_p = \frac{aK_p^*}{\nu}$  is the dimensionless permeability parameter.

**Case-I:**  $M = 0, K_p \rightarrow \infty$  (for large value of  $K_p$ ), the problem reduces to the flow of fluids without magnetic field and porous medium.

**Case-II:**  $M = 0$  and  $K_p$  finite (for small value of  $K_p$ ), the problem represents Newtonian flow through porous medium without magnetic field.

**Case-III:**  $M \neq 0$  and  $K_p$  finite (for small value of  $K_p$ ), the problem represents the Darcy flow of conducting fluid in the presence of magnetic field with low magnetic parameter.

Solution of equation (6) with boundary conditions (7) is obtained by employing differential transformation method with Pade approximant (DTM-Pade) and Runge-Kutta method. The results of these two methods are compared with the results obtained by finite difference method in conjunction with quasilinearization [2].

**DIFFERENTIAL TRANSFORMATION METHOD**

Differential transformation method is a numerical method based on Taylor's expansion. This method determines the coefficients of series expansion of unknown function by using the initial data on the problem. The concept of differential transformation method was first proposed by Zhou [10]. The DTM-Pade was applied to electric circuit analysis problems and also it was applied to several systems of differential equations for example, initial value problems [11], difference equations [12], integro-differential equations [13], and partial differential equations [14].

**Definition 1.** The one dimensional differential transform of a function  $f(\eta)$  at the point  $\eta = \eta_0$  is defined as

$$F(k) = \frac{1}{k!} \left[ \frac{d^k}{d\eta^k} \{f(\eta)\} \right]_{\eta=\eta_0} \tag{8}$$

where  $f(\eta)$  is the original function and  $F(k)$  is the transformed function.





Let  $f''(0) = 2A$ , where  $A$  is a positive constant. Now, the differential transform method (DTM) will be applied to equation (17) as follows:

$$(k+1)(k+2)(k+3)F(k+3) + \sum_{r=0}^k \{(k-r+1)(k-r+2)F(r)F(k-r+2) - (r+1)(k-r+1)F(r+1)F(k-r+1)\} + \left(M + \frac{1}{K_p} + 1\right)\delta(k) - \left(M + \frac{1}{K_p}\right)(k+1)F(k+1) = 0 \quad (19)$$

The differential transform of boundary conditions are

$$F(0) = 0, F(1) = 0, F(2) = A. \quad (20)$$

Applying the differential inverse transform,

$$f(\eta) = \sum_{k=0}^{\infty} F(k)\eta^k = A\eta^2 - \frac{\left(M + \frac{1}{K_p} + 1\right)}{6}\eta^3 + \frac{\left(M + \frac{1}{K_p}\right)A}{12}\eta^4 + \left[\frac{A^2}{30} - \frac{\left(M + \frac{1}{K_p}\right)\left(M + \frac{1}{K_p} + 1\right)}{120}\right]\eta^5 + \left[\frac{\left(M + \frac{1}{K_p}\right)^2 A}{160} - \frac{\left(M + \frac{1}{K_p} + 1\right)A}{180}\right]\eta^6 \dots \quad (21)$$

**Case I : ( $M = 0.5, K_p = 100$ )**

The DTM expression (21) becomes

$$f(\eta) = A\eta^2 - \frac{1}{4}\eta^3 + \frac{A}{24}\eta^4 + \left(\frac{A^2}{30} - \frac{1}{160}\right)\eta^5 + \frac{11A}{20160}\eta^6 + \left(-\frac{A}{21504} + \frac{A^3}{161280}\right)\eta^7 - \frac{43}{967680}\eta^8 + \left(\frac{A}{552960} - \frac{5A^3}{387072}\right)\eta^9 + \dots \quad (22)$$

Now our aim is to determine  $A$  using the boundary condition

$$\lim_{\eta \rightarrow \infty} f'(\eta) = 1 \quad (23)$$

Applying the boundary condition (23) to [2/2] Pade approximant of the derivative of the polynomial solution (22), we get

$$\lim_{\eta \rightarrow \infty} \frac{2A\eta + \left(\frac{64A^4 + 72A^2 - 81}{27 - 16A^2}\right)\eta^2}{1 - \left(\frac{3A + 8A^3}{27 - 16A^2}\right)\eta - \left[\frac{27 + 112A^2}{24(27 - 16A^2)}\right]\eta^2} = 1$$

which gives  $A = 0.8184854107$ .

**Table 3:** Determination of  $A$

M	$K_p$	A
0.5	100	0.8184854107
1	100	0.8660254038
2	100	0.8918112327
0.5	0.5	0.8011621274
1	0.5	0.9632417272
2	0.5	1.0032411257

Similarly, the following values of  $A$  are obtained for the various values of  $M$  and  $K_p$  as depicted in Table 3.

### NUMERICAL SOLUTION

The governing equation is solved numerically by applying fourth order Runge-Kutta method along with shooting technique. This method has been proven to be adequate and gives accurate results for boundary layer equation. The solution is computed for the dimensionless velocity and shown graphically.

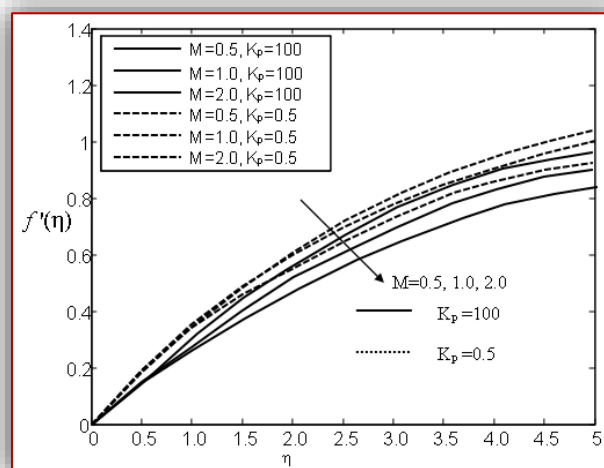
Let  $f(\eta) = y_1, f'(\eta) = y_2$  and  $f''(\eta) = y_3$ . so that

$$y'_3 = -y_1 y_3 - 1 + y_2^2 - \left(M + \frac{1}{K_p}\right)(1 - y_2)$$

with  $y_a(1) = 0, y_a(2) = 0, y_b(2) = 1$ .

### RESULTS AND DISCUSSION

The DTM-Pade approximant and Runge-Kutta method with shooting technique have been applied for solving Hiemenz magnetic flow through porous medium. The solution for the flow without porous medium has been derived as a particular case and the results are compared with the results obtained by the method of finite difference in conjunction with quasilinearization technique in Na [2].



**Figure 2.** Velocity profiles (DTM)

Figures 2, 3 and 4 exhibit the results obtained by DTM, DTM-Pade and Runge-Kutta method associated with shooting technique. It is found that the effect of magnetic parameter is to decrease the velocity of the fluid irrespective of the presence or absence of porous matrix. On careful observation it is further remarked that presence of porous matrix also decreases the velocity profiles at all the points. Therefore, it is concluded that presence of porous matrix as well as magnetic field both decrease the velocity of the fluid at all points of the flow domain. Further, it is seen that rate of decrease is more with

the combined effect of the magnetic field and porous matrix. From figures 3 and 4 it is observed that the attainment of ambient state is faster in case of DTM-Pade in comparison with DTM and it is still faster in case of Runge-Kutta method.

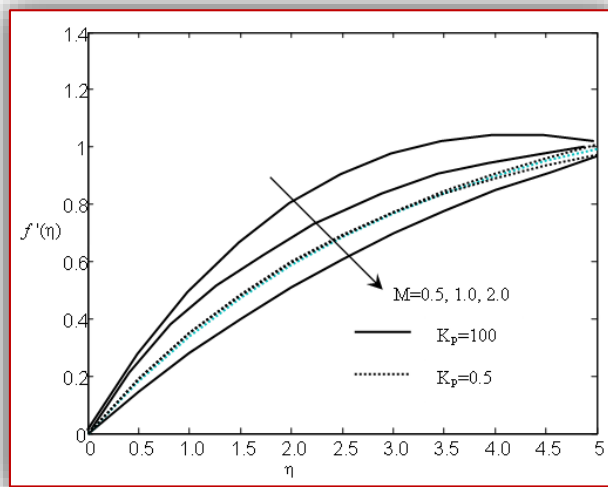


Figure 3. Velocity profiles (DTM-Pade).

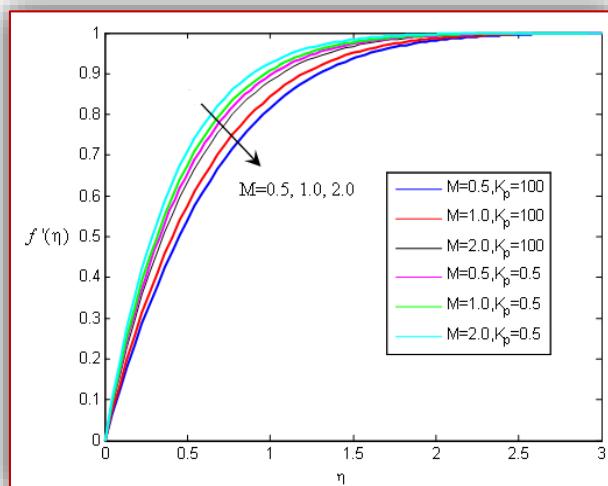


Figure 4. Velocity profiles (Runge-Kutta method).

Table 4: Skin friction coefficient (2A)

M	K <sub>p</sub>	DTM-Pade	Runge-Kutta	Quasilinearization NA [2]
0.5	100	1.6368	1.3832	1.362
1	100	1.7320	1.5885	1.5394
2	100	1.7836	1.8761	1.833
0.5	0.5	1.6023	2.0022	~
1	0.5	1.9265	2.1232	~
2	0.5	2.0065	2.3466	~

Now, the Table-4 presents the numerical values of skin friction computed by different methods. It is evident that skin friction (in magnitude) increases with an increase in the values of magnetic parameter with or without porous medium. It is also seen that presence of porous matrix increases the skin friction

(in magnitude) for a fixed value of magnetic parameter.

Table-4 further reveals that the values of skin friction obtained by (i) Runge-Kutta and (ii) Finite difference in conjunction with quasilinearization agree up to first decimal place. This shows the consistency of the methods applied in the present analysis to solve the modified MHD Hiemenz flow. It is suggested that the accuracy of DTM-Pade method can be improved by employing higher degree diagonal Pade approximants.

### CONCLUSION

The DTM-Pade and Runge-Kutta method are consistent within certain degree of accuracy to solve non-linear boundary value problems and convergence of the method can be accelerated with higher dimension Pade approximant matrices so as to attain the ambient state of the flow which is also assisted by the presence of magnetic field and porous medium. It is further concluded that presence of magnetic field and porous medium is found to be counterproductive in reducing the skin friction at the surface of the plate.

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## THE Matlab ANALYSIS OF SMALL AND POWDERY FERROUS WASTES DESTINED FOR THE PRODUCTION OF BRIQUETTES IN SOME LABORATORY EXPERIMENTS

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**Abstract:** In most industrialized countries pollution of air, water and landscape has a common cause: discharge of manufacturing wastes in the environment without a real concern of avoiding it. Measures needed to combat pollution require considerable investment and significant operating expenses, especially in the steel industry. In the industrial sector, in most cases, in addition to the main product, there are one or more products which can be returned to the steel circuit after a quick processing. By combining economic imperative to maximize the recovery of scrap with the social aspect of action to combat environmental pollution in order to restore and maintain the ecological balance, a particular attention must be paid to waste recovery problem. The paper approaches the problem of fine and pulverous wastes recovery from mining and steel industry.

**Keywords:** pollution, environment, steel industry, usage, wastes, briquetting, Matlab analysis

### INTRODUCTION

The alteration of global ecosystems, because of consumption and production, shows how important is the process of rethinking the use of natural resources by the economy and society. For industry, the problem of managing the recovery (recovery, recycling) is an environmental and economic priority [4,12,13]. For human communities and natural ecosystems in the steel industry and mining sites, pollution and risk do not disappear with the cessation of mining and processing of minerals, furthermore, it continues, the sites remain sources of pollution and risk.

Wastes contain substances resulting from industrial activity where they are produced and disposal of these wastes from the production cycle is achieved by a proper recovery: recovery and / or disposal for recycling and stabilization/solidification for storage in landfills [10,11,13].



Figure 1. The waste management hierarchy

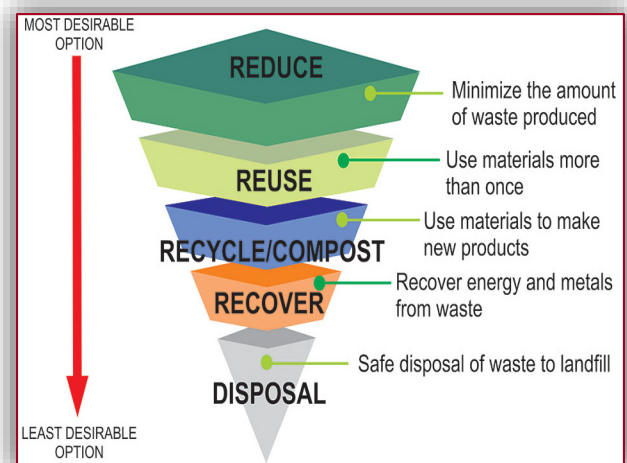


Figure 2. The waste most & least desirable options

Recovery includes the collection, transport, storage, selection and processing of certain waste, which can be returned to a flow sheet by internal and/or external recycling. Internal recycling (direct recycling) consists of reintroducing the recovered industrial wastes in the same flow sheet that

generated them, and external recycling (reuse) is the industrial activity that reintroduces the recovered waste in a flow sheet that is completely different from the one which generated it. By combining economic imperative to maximize the recovery of scrap with the social aspect of action to combat environmental pollution in order to restore and maintain the ecological balance, a particular attention must be paid to waste recovery problem [5–13].

Benefits on economical (chain added value, jobs in the recycling sector, etc.), ecological (increased recycling rates, application of high standard processes, etc.) and social (industrial safety) level are increasing the significance of small and powdery ferrous wastes recycling.

#### LABORATORY EXPERIMENTS

Briquetting is the method by which pieces of spherical, oval or rectangular forms are obtained from fine/small and pulverous waste during compressing operations on specialized equipment, followed by a drying–roasting process in order to increase their mechanical characteristics [5–13]. Briquetting applies to pulverous wastes (powder resulting from dedusting plants) and also to fine products obtained by precipitation. For waste briquetting (at 50–60°C) inorganic binders are used (limewash,  $\text{Na}_2\text{SiO}_3$ ) and sometimes organic binders (sulphite liquor, heavy tars etc.).

Experiments on the production of briquettes were conducted within the laboratory of the Doctoral School of the Faculty of Engineering Hunedoara, University Politehnica Timișoara. Determination of waste chemical composition was carried out in the laboratories of ArcelorMittal Hunedoara Company.

To obtain briquettes, the raw material is subjected to fine grinding, which usually is performed in ball mills. Wastes which are substandard in terms of grain size are ground with these mills. Recipes with pulverous wastes are prepared. Homogenization of waste is done manually or in mixing plant with the addition of binders, and to obtain briquettes, the press is equipped with a mold chosen in accordance with the type of desired briquette. The proportions of wastes were determined in 13 recipes, compliance with these recipes is mandatory in order to obtain briquettes with appropriate quality standards [5–13].

Once the briquettes are obtained, they are subjected to hardening processes after a diagram heating/holding/cooling, and then dried and tested to determine the qualitative characteristics (compression tests to determine resistance to cracking, crushing and grinding interval).

For recovery of small and pulverous wastes as briquettes from steel industry, energy and mining, we considered the following wastes: agglomeration–furnaces dust, steel dust, galvanic sludges (two

different types) and red mud from bauxite refining (bauxite residue). As binder we considered the following three types of powdery materials: limewash, bentonite and graphite [5,6,10–13].

Using the Matlab program, we plotted the dependencies between the same correlation parameters, presented in Figures 3–14. In fact, in this mathematical experiment using the Matlab, we verified the regression equations obtained in Matlab (through the coefficients of multiple determination of the same type of equations), and we plotted the regression surfaces and, additionally, the correlation diagrams for the proportion of the small and pulverous wastes used in the recipes which assure the optimal resistance to crushing and the resistance to cracking of the obtained briquettes.

#### RESULTS OF THE Matlab ANALYSIS

Although polynomial regression is technically a special case of multiple linear regression, the interpretation of a fitted polynomial regression model requires a somewhat different perspective.

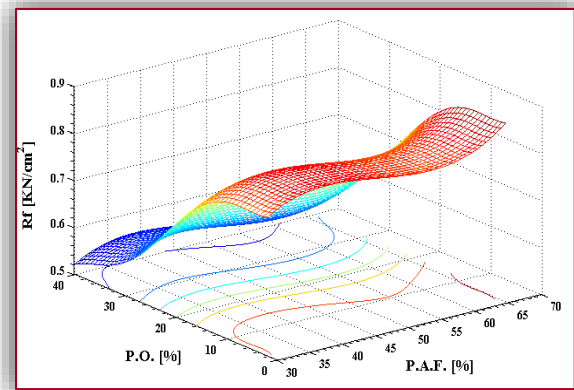


Figure 3. The regression surface determined by the briquettes resistance to crushing depending on the proportion of steel dust and agglomeration–furnaces dust (the coefficient of multiple determination:  $R^2=0.9994282003$ )

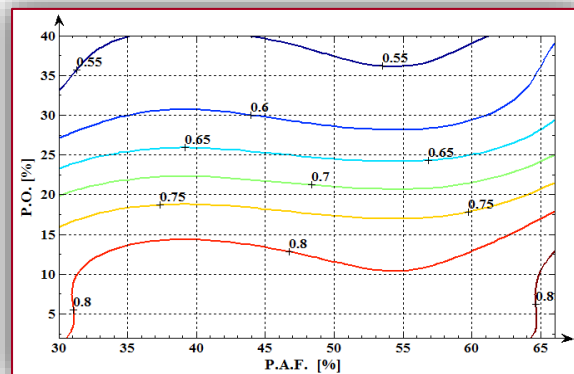
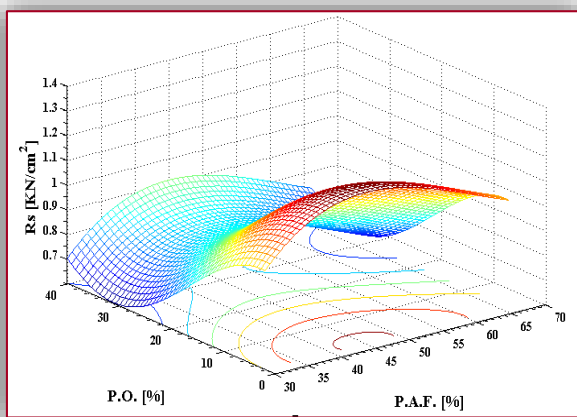
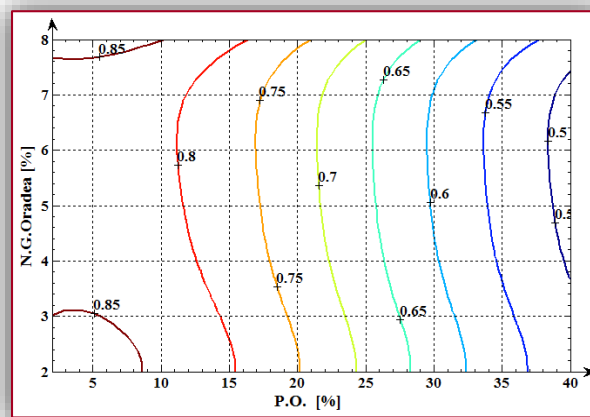


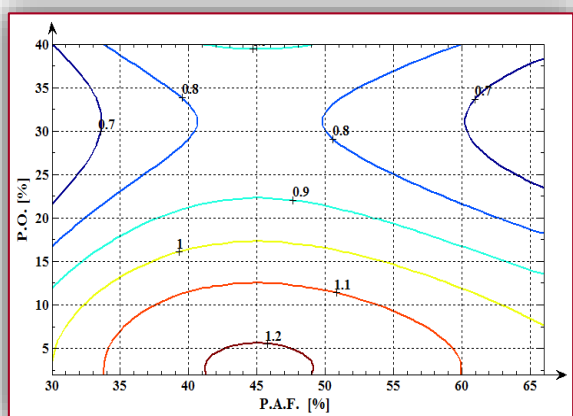
Figure 4. The correlation diagram determined by the briquettes resistance to crushing depending on the proportion of steel dust and agglomeration–furnaces dust (the coefficient of multiple determination:  $R^2=0.9994282003$ )



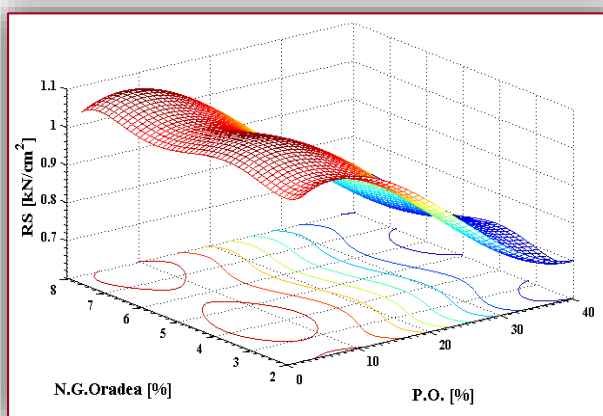
**Figure 5.** The regression surface determined by the briquettes resistance to cracking depending on the proportion of steel dust and agglomeration–furnaces dust (the coefficient of multiple determination:  $R^2=0.9910367990$ )



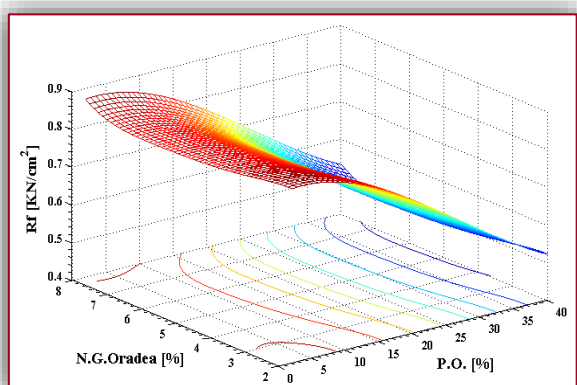
**Figure 8.** The correlation diagram determined by the briquettes resistance to crushing depending on the proportion of steel dust and galvanic sludge 1 (the coefficient of multiple determination:  $R^2=0.9994749743$ )



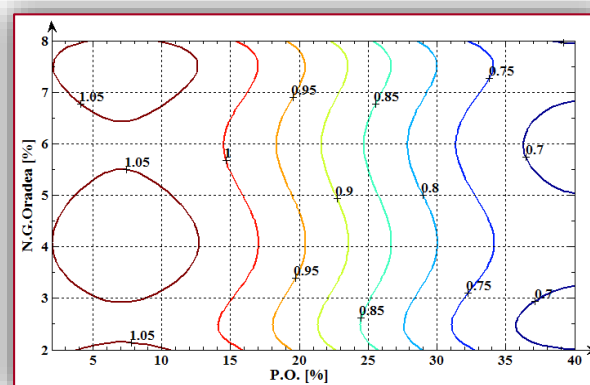
**Figure 6.** The correlation diagram determined by the briquettes resistance to cracking depending on the proportion of steel dust and agglomeration–furnaces dust (the coefficient of multiple determination:  $R^2=0.9910367990$ )



**Figure 9.** The regression surface determined by the briquettes resistance to cracking depending on the proportion of steel dust and galvanic sludge 1 (the coefficient of multiple determination:  $R^2=0.9941040618$ )

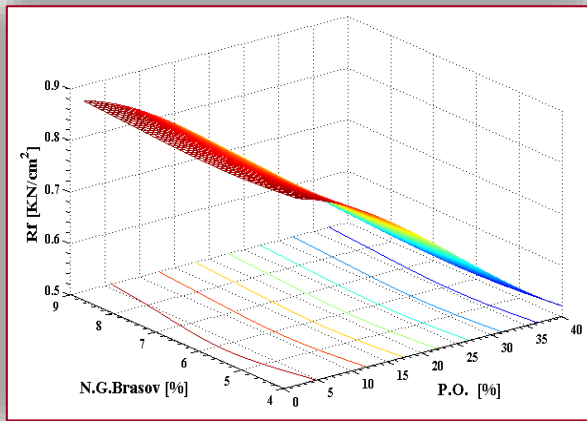


**Figure 7.** The regression surface determined by the briquettes resistance to crushing depending on the proportion of steel dust and galvanic sludge 1 (the coefficient of multiple determination:  $R^2=0.9994749743$ )

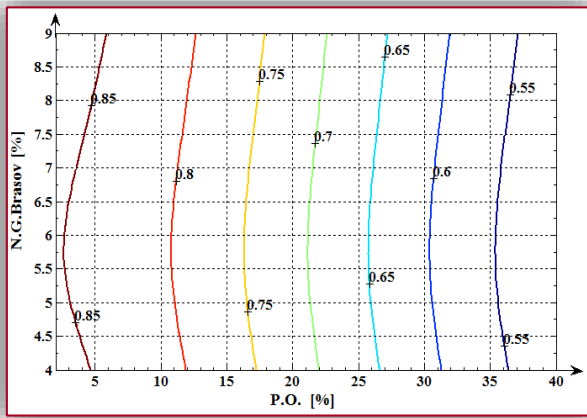


**Figure 10.** The correlation diagram determined by the briquettes resistance to cracking depending on the proportion of steel dust and galvanic sludge 1 (the coefficient of multiple determination:  $R^2=0.9941040618$ )

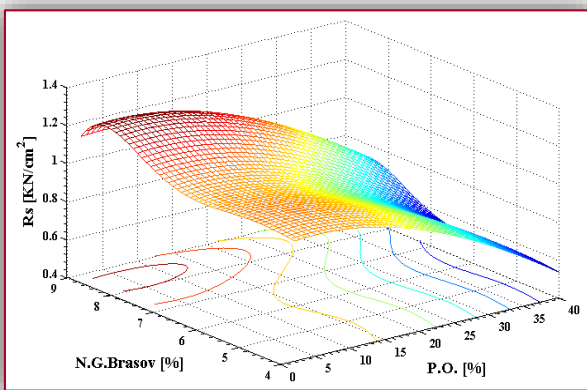




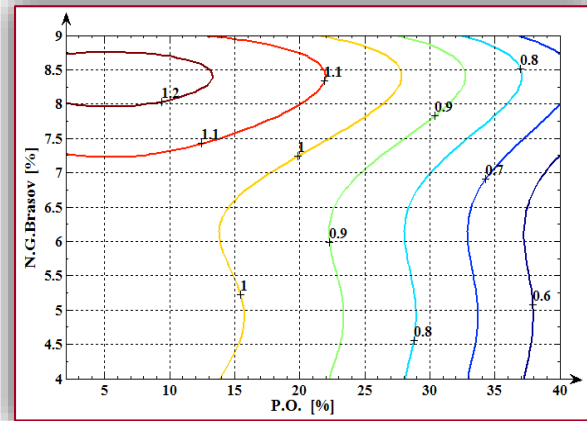
**Figure 11.** The regression surface determined by the briquettes resistance to crushing depending on the proportion of steel dust and galvanic sludge 2 (the coefficient of multiple determination:  $R^2=0.9971393267$ )



**Figure 12.** The correlation diagram determined by the briquettes resistance to crushing depending on the proportion of steel dust and galvanic sludge 2 (the coefficient of multiple determination:  $R^2=0.9971393267$ )



**Figure 13.** The regression surface determined by the briquettes resistance to cracking depending on the proportion of steel dust and galvanic sludge 2 (the coefficient of multiple determination:  $R^2=0.9956932644$ )



**Figure 14.** The correlation diagram determined by the briquettes resistance to cracking depending on the proportion of steel dust and galvanic sludge 2 (the coefficient of multiple determination:  $R^2=0.9956932644$ )

The goal of polynomial regression is to model a non-linear relationship between the independent and dependent variables (technically, between the independent variable and the conditional mean of the dependent variable). In this sense, the experimental data were processed in the Matlab programs. We plotted the regression surfaces and the correlation diagrams between the briquettes main characteristics and the small and pulverous wastes quantities proportion.

Correlation quantifies the strength of a linear relationship between two variables. When there is no correlation between two variables, then there is no tendency for the values of the variables to increase or decrease in tandem. Two variables that are uncorrelated are not necessarily independent, however, because they might have a nonlinear relationship. We use the linear correlation to investigate whether a linear relationship exists between variables without having to assume or fit a specific model to the industrial and laboratory data. Two variables that have a small or no linear correlation might have a strong nonlinear relationship. However, calculating linear correlation before fitting a model is a useful way to identify variables that have a simple relationship.

The realization of the graphic interfaces (Figures 3 – 14) for the representations variation areas of the briquettes chemical compositions in accordance with the mechanical properties of the briquettes (resistance to cracking, resistance to crushing), completes this area of preoccupations within a processing of small and pulverous wastes from industrial steel and mining areas.

These surfaces (described by the equation), belonging to the three-dimensional space can be reproduced and therefore interpreted by technological engineers. Knowing these level curves

(in the correlation diagrams) allows the correlation of the values of the two independent variables so that we can obtain a mechanical properties within the required limits.

### CONCLUSIONS

Most of the reasons we recycle are environmental, although some are economic. One of the main reasons for recycling is to reduce the wastes sent to landfills. Recycling has a variety of economic impacts. For the steel companies that buy used goods, recycle them and resell new products, recycling is the source of all their income. For the industrial cities which have ferrous wastes landfills, like Hunedoara, in densely populated areas that have to pay by the ton for their landfill usage, recycling can shave millions of dollars off municipal budgets. The recycling industry can have an even broader impact. Economic analysis shows that recycling can generate three times as much revenue per ton as landfill disposal and almost six times as many jobs.

As a result of our analyses performed on products obtained by processing small and pulverous wastes from industrial steel and mining areas and the experiments conducted in the laboratory stage, we consider the following remarks:

- » the studied small and pulverous wastes (steel dust, agglomeration–furnaces dust, galvanic sludges) can be processed by using the available technology like briquetting and can be reintroduced into the steel circuit with minimum investment costs;
- » reintroduction of small and pulverous wastes into economic circuit has both economic and ecological effects, by releasing the occupied terrains (ponds, landfills, disused buildings) in case of deposited wastes, vacancy of areas for waste resulting routinely on technology flows.
- » the results of the experiments lead to the conclusion that the analyzed wastes can be processed by briquetting (to provide mechanical strength characteristics superior to those minimum values for this method), this method allows recovery of waste with high variation limits in terms of grain size (desirably under 2 mm);
- » technological alternatives presented have the advantage of offering solutions for all waste generated ferrous powder, regardless of the content of iron and non-ferrous elements, resulting in current technology flows, as well as those stored in ponds and waste dumps.
- » analysis of these technologies provides environmental treatment of these types of waste allowed to be noted that for Romania is a particularly important issue because there is an amount of them deposited as dumps and continues to generate higher amounts.

We consider that can be processed both the wastes resulted in technological flows and those deposited in ponds or landfills.

Economics, as well as environmental considerations, are giving a new impetus to resource recovery and recycling. There are many different ways that materials can be recycled. The technique that is used to create the new materials from the old depends on what the material is. In the case of the present studied small and pulverous wastes within the laboratory of the Doctoral School of the Faculty of Engineering in Hunedoara, University Politehnica Timișoara, respectively steel dust, agglomeration–furnaces dust and galvanic sludges, can be processed by using the available technology like the briquetting process. These kind of small and pulverous ferrous wastes can be reintroduced into the steel making circuit with minimum investment costs. In fact, recycling of small and pulverous ferrous wastes prevents useful material resources from being wasted, reduces the consumption of raw materials and reduces energy usage during the steel manufacturing process, compared to virgin production.

The experimented researches, as well as the optimization of the manufacturing technology of these type of briquettes, allow the conclusion of direct results for these reused wastes. The beneficiaries of these results are the unit in which the briquettes are manufactured, as well as the unit that used them.

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## STRENGTH CHARACTERISTICS OF CONCRETE HAVING CRUSHED BONE AS PARTIAL REPLACEMENT OF FINE AGGREGATES AT DIFFERENT WATER-CEMENT RATIOS

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**Abstract:** This paper reports the results of investigation to find the effects of water cement ratio on some properties of concrete containing crushed cow bone (CCB) as partial replacement of fine sand. Concrete samples containing 20% CCB as replacement of sand were used. The properties investigated are: workability, density and the compressive strength. Slump test and compacting factor test were used to determine the workability while 150 x 150 x 150 mm cubes were used for density and the compressive strength. The water-cement ratios were 0.4, 0.5 and 0.6. The density and compressive strength specimens were tested at 7, 14, 28, 60, and 90 and 120 days of moist-curing. The results showed that: (i) workability, measured in terms of slump loss, increased with water-cement ratios, (ii) compacting factor test may be more appropriate as a tool to assess the workability characteristics of the specimens due to the lower value of the factor, (iii) there are possibilities of producing concretes whose densities fall into more than one density ranges as water-cement ratio is increased, (iv) compressive strengths of the specimens decreased with water-cement ratio.

**Keywords:** Concrete, Fine Aggregate, Crushed Cow Bone, Water-Cement Ratio, Compressive Strength

### INTRODUCTION

Concrete has become the most important man-made construction material in the world produced with four basic components of cement, fine aggregates, coarse aggregates and water. Further it is the single most widely used material in the world (Crow, 2008), whose consumption is surpassed only by water (Mehta and Merman 2009, GEAS, 2010, Ferrari et al., 2012 and Arezoumandi, et al., 2014). One of the many reasons for its prominence is the flexibility it allows to vary part of its composition either partially or fully for a concrete that is strong and durable. In some instances cement has either been partially or fully replaced by some materials like slag, silica fume, rice husk ash, etc. In other instances, the aggregates portion (fine or coarse) have been replaced by any of the mentioned materials to produce concrete with acceptable structural characteristics. Aggregates can be described as granular materials such as sand, gravel, crushed stone, and blast furnace slag, etc., embedded in cement-water paste to form concrete. Aggregates usually occupy approximately 60 to 75% of the volume of concrete or about 70 – 85% by weight. (ACI, 1999). As such, the properties of aggregates

greatly affect properties of both fresh and hardened concrete. Aggregates reduce the dimensional instability of the concrete due to the drying shrinkage and reduce the cost of making concrete because of its cheapness (Duggal, 2008). Unlike cement, which is factory-made, and which is produced under controlled and standard conditions resulting in uniform properties; aggregates properties vary depend on many factors like size, shape, gradations, unit weight, etc. Some of these properties are transferred into the concrete. The properties of aggregates affect the workability of concrete in plastic state. In the hardened state of concrete properties like strength, thermal conductivity, durability, abrasiveness, and density are influenced by the properties of aggregates. While the coarse aggregate gives the bulk to the concrete, the fine aggregate acts as the filler in form of mortar. The materials mostly used for fine aggregates are river sand and crushed stones. In other to obtain river sand, difficult dredging and transportation over long distances are involved. Producing crushed stones to produced fine aggregates is also costly. These, added to the need for the conservation of natural resources made it incumbent on researchers

to find alternatives to fine aggregates in concrete production. Materials that have been found to be suitable alternatives to fine aggregates, usually from agricultural and industrial wastes are: groundnut shell (Sada et al., 2013), iron ore tailings (Kumar et al., 2014, Falade et al., 2013), manufactured fine aggregates (Goncalves et al., 2007), rice husk (Obilade, 2014), stone powder (Mahzuz et al., 2011), waste glass (Malik et al., 2013). All these have been used by these researchers either for normal weight concrete or lightweight concrete in their investigations. Another waste that is yet to be investigated for its suitability as fine aggregates replacement in concrete is the crushed cow bone. In Nigeria, the annual production of cow bone is estimated to be about 5 million tons, which are not properly disposed of, thereby constituting environmental problems (Falade et al., 2011). Using the cow bone as substitute for fine aggregate, if found suitable will help in cleaning the environment and convert waste to wealth. In concrete works, assuming full compaction, and at a given age and normal temperature, the strength of concrete can be taken to be inversely proportional to the water/cement ratio (Neville and Brooks, 2008). But it is to be noted that at the time this Law, attributed to Abram, was discovered, the materials used for fine aggregates in the production of concrete were either sand or crushed stone. Substituting fine aggregates with wastes materials other than sand or crushed stone was not in practice. What is not known is whether the Law could still hold if fine aggregates portion of concrete mix were substituted with any wastes – industrial and agricultural; in this case, crushed cow bone. Thus the aim of this work is to investigate the effect of water-cement ratio on strength properties of concrete with crushed cow bone as partial substitute of fine aggregates. Although Otunyo et al. (2014) had earlier attempted to investigate the possibility of using cow bone as substitute for fine aggregates. Effect of water-cement ratio was not one of the parameters they considered for investigation as in the present work. Also the works of Falade et al (2013a,b) and Falade et al (2014) on cow bones were in relation to foamed aerated concrete in which cement was replaced with pulverized cow bone. In addition, the investigations carried out by Vu et al., 2009, Shamsou et al., 2012 and Reddy and Rao, 2014 in relation to the effect of water-cement ratios on concrete, were not on CCB but were respectively on extreme loading concrete, nano-silica concrete, and high strength self-compacting concrete. The strength properties investigated in this work, using water cement ratios of 0.4, 0.5, and 0.6 and at 20% replacement of fine aggregates with crushed cow bone (CCB) are: workability, density and the compressive strength.

## MATERIALS AND METHODS

### » Materials

The materials used for this investigation are: Portland cement, fine aggregates, coarse aggregates, crushed cow bone and water.

≡ **Cement:** The cement used was Ordinary Portland Cement which conformed to BS 12 (1996) and NIS 444-1 (2014) was used for this investigation.

≡ **Coarse Aggregates:** Crushed granite of maximum nominal size 20mm was used to produce the concrete used for this work.

≡ **Fine Aggregates:** River sand obtained in Ibadan was used as fine aggregates during the execution of this project.

≡ **Crushed Cow Bone (CCB):** the cow bones were obtained from the slaughter slab in Ibadan. The bones had been crushed after they were dried and burnt; the muscles, flesh, tissues, intestines and fats having been separated and removed prior to drying and burning. The crushed cow bone was later allowed to undergo sieve analysis so that the fraction passing through 4.75 mm but retained on the sieve size 0.150 mm, compatible with the sand to be replaced, was separated, packaged in bags and stored in cool dry place, which was subsequently used for this investigation.

≡ **Water:** The water used in mixing is clean potable water, without any visible impurities.

### » Mix Proportions & Specimens Preparation

This investigation is to determine the effects of water-cement ratios on concrete containing crushed cow bone (CCB) as partial replacement of fine aggregates. But preliminary investigation on strength developments of concrete 150 mm cube specimens containing CCB as partial replacement of fine aggregates from 0% up to 100% at interval of 10% were first carried out using the mix in Table 1 for each batch of concrete produced. The concrete mix without CCB served as the control. Strengths were measured at 7, 14, 28, 60, 90, and 120 days of moist curing.

In other to investigate the effects of water-cement ratios on the concrete samples containing the pre-determined content of CCB, water-cement ratios of 0.4, 0.5 and 0.6 were used. The mixing of all the concrete batches was done through concrete mixer from which 150 x 150 x 150 mm cube specimens were cast. The cube moulds were greased to make demoulding easier. Compaction was done using poker vibrator, after which the specimens were kept in a dry ventilated space and demoulded after 24hours. The specimens were then moist-cured in curing tank, filled with water until the day of testing. Prior to casting of the cube specimens, slump tests were carried out on the concrete specimens. A total



number of 594 cube specimens were prepared and tested.

**Table 1:** Concrete mix for Preliminary Strength Development Potential

% CCB in Mix	Mix	W/C Ratio	Cement (kg)	Sand (kg)	CCB (kg)	Granite (kg)	Water (kg)
0	1:2:4	0.5	21	41.66	0.00	83.31	8.4
10	1:2:4	0.5	21	37.49	4.17	83.31	8.4
20	1:2:4	0.5	21	33.33	8.33	83.31	8.4
30	1:2:4	0.5	21	29.16	12.50	83.31	8.4
40	1:2:4	0.5	21	25.00	16.66	83.31	8.4
50	1:2:4	0.5	21	20.83	20.83	83.31	8.4
60	1:2:4	0.5	21	16.66	25.00	83.31	8.4
70	1:2:4	0.5	21	12.50	29.16	83.31	8.4
80	1:2:4	0.5	21	8.33	33.33	83.31	8.4
90	1:2:4	0.5	21	4.17	37.49	83.31	8.4
100	1:2:4	0.5	21	0.00	41.66	83.31	8.4

## EXPERIMENTATION

### » Characterization of the Aggregates

Preliminary investigations were carried out on the aggregates to determine their properties for the purpose of characterization. These properties are: the bulk density, the specific gravity, water absorption capacity, and the mechanical analysis of the aggregates through sieve analysis.

### » Investigation of Strength development of Concrete sample with CCB

The strength development of concrete samples containing crushed cow bone (CCB) as partial replacement of sand was investigated to determine the % replacement at which the strength developed was not significantly different from the concrete samples without CCB at moist-curing period of 7,14, 28, 60, 90, and 120. The mix ratio used was 1:2:4 with water cement ratio of 0.4. The sand in the concrete samples was replaced with CCB from 0 to 100 % at interval of 10%. The concrete samples without CCB served as the control.

### » Investigation of Effect of Water-cement Ratios Concrete Specimens Properties

The concrete properties tested, using samples containing the CCB content for the development of compressive strength that is comparable with the control samples, were: workability, density and the compressive strength

### = The Slump Test

Two methods were used to assess the workability characteristic of the concrete specimens. These are the slump test and the compacting factor test. While the slump test was carried out in accordance with the provisions of BS EN 12350 Part 2: (2000), the Compacting factor test was done in accordance with the provision of BS 1881-103 (1993), also taking into consideration inputs from Bartos et al. (2002).

### = Density and Compressive Strength Tests

Compressive strengths were of concrete specimens measured at 7, 14, 28, 60, 90 and 120 days of curing in accordance with BS EN 12390-3 (2009) using a 1,500kN ELE International compression testing machine (Figure 1).



**Figure 1:** ELE Compression Testing Machine

The specimens used were 150 x 150 x 150 mm cubes. The average failure load of the three specimens was then divided by the area of the specimens to obtain the compressive strength. It is to be noted here that the weight of each cube was measured on a digitally displayed ELE International weighing machine before the compressive strength testing process to determine the density of the concrete, which was done in accordance to BS 12350: Part 6 (2009).

## RESULTS AND DISCUSSIONS

### » Preliminary Investigation

The results of the preliminary investigation on some physical properties of the fine aggregates used, conducted to characterize the aggregates are presented in Table 2. From Table 2, it can be observed that the values of bulk density and the specific gravity, the properties that reflect the weight features of a material, for CCB were lower than that of the fine sand.

**Table 2:** Physical Properties of Fine Aggregates

Properties	CCB	River Sand
Maximum Aggregate Size (mm)	4.75	4.75
Bulk Density (Kg/m <sup>3</sup> )	20.5	58.16
Specific Gravity (SSD)	1.67	2.63
Aggregate Crushing Value (%)	30%	23.19
24-hour Water Absorption (%)	3%	0.15
Fineness Modulus	2.44	2.88



The practical implication of this is that a larger volume of CCB will result for every unit weight of sand replaced, thereby increasing the water demand because of increased surface area. Also, the water absorption capacity of the CCB can be seen to be higher than that of the sand. Thus for the same water-cement ratio, a harsh mix may result from replacing sand with CCB. This may affect the workability. In the same vein, a higher aggregate crushing value obtained for CCB is an indication that CCB may not develop adequate crushing resistance in concrete requiring it, for example, bridge deck and runway. Using the sieve analysis results (Figure 2), the fineness modulus, which is the sum of the total percentages retained on each of a specified series of sieves, divided by 100 was computed to be 2.44 and 2.88 respectively for CCB and sand.

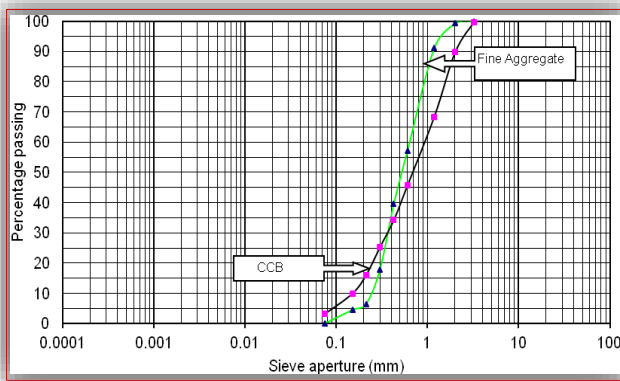


Figure 2: Particle Size Distribution of River Sand and CCB

These values met the requirements of ASTM C 33 specifications for fine aggregates which require fineness modulus not to be less than 2.3 or more than 3.1. Also from Figure 2, it can be observed that the grading for both river sand and CCB is similar. Both can be described as uniform in grading, in which only a few sizes dominate the bulk material. This similarity is further reinforced from the closeness of values of their fineness moduli (Table 2).

» **Strength Development of Concrete Specimens with CCB**

The results of preliminary investigation to determine the strength development potential of concrete samples containing CCB as partial replacement of sand are shown in Table 3. In Table 3, the figures after the “±” represent the standard deviation and the numbers in the parenthesis represent the statistical t-values to determine how significant is the difference in the compressive strength between the samples with CCB and the control samples. Using a confidence interval of 10%, the statistical table t-value is ±2.920 (Kothari and Garg, 2014). From the Table 3, up to 20% sand replacement with CCB have lower calculated t-values. This suggest that there is no significant difference between the compressive

strength of the samples containing up to 20% CCB as a replacement of fine aggregates and the control samples.

Table 3: Strength Development of Concrete Samples with CCB as Replacement of Sand

% CCB in Mix	Curing Age (Days)		
	28	60	90
0	24.62 ± 1.23	25.38 ± 2.23	28.37 ± 2.11
10	22.58 ± 1.30 (2.721)	23.98 ± 2.45 (0.989)	25.88 ± 2.14 (2.013)
20	20.22 ± 2.95 (2.588)	22.28 ± 2.99 (1.794)	24.19 ± 2.99 (2.419)
30	18.11 ± 2.37 (4.751)	20.20 ± 2.78 (3.223)	23.68 ± 2.68 (3.028)
40	16.28 ± 2.34 (6.177)	19.11 ± 2.56 (4.237)	21.12 ± 2.10 (6.239)
50	15.83 ± 2.85 (5.337)	16.29 ± 2.78 (5.657)	19.28 ± 2.01 (7.823)
60	14.56 ± 2.71 (6.765)	15.89 ± 2.23 (7.362)	16.01 ± 2.11 (10.131)
70	13.99 ± 2.90 (6.342)	14.78 ± 2.01 (9.122)	15.56 ± 1.99 (11.139)
80	13.01 ± 2.93 (6.851)	13.89 ± 2.23 (8.914)	14.67 ± 1.89 (12.534)
90	12.87 ± 2.83 (7.182)	13.23 ± 2.11 (9.960)	13.78 ± 1.89 (12.349)
100	12.45 ± 2.95 (7.138)	12.78 ± 2.39 (9.117)	12.99 ± 1.78 (14.947)

Concrete samples containing 20% sand replacement with CCB were produced to evaluate the effects of water-cement ratios on some properties of concrete containing CCB.

» **Workability**

The results of the workability characteristics of the concrete samples containing CCB as partial replacement of sand with different water-cement ratios are presented Figure 3.

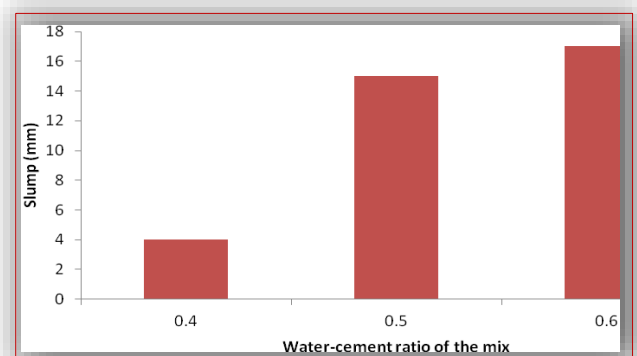


Figure 3: Effect of Water-cement ratio on the slump value of the Concrete Samples

It is obvious in Figure 3 that the workability of the concrete specimens measured in term of slump increased with water-cement ratio. The increase was however at a decreasing rate. For example, between the water-cement ratios of 0.4 and 0.5, the increase was 200%. But between 0.5 and 0.6, the increase was just 13.33%. In addition to seeming

improvement in workability with water-cement ratios, the specimens also exhibited true slump. This means that the concrete is cohesive and showed no evidence of segregation within the ranges of water-cement ratios used for this investigation. The results of the compacting factor test which measures the workability by the way of degree of compaction is presented in Table 4 along with the slump values. Despite increasing slump values with water-cement ratios, the values still fall within the range of concrete with very low workability and this makes the compacting factor test the more appropriate (Neville, 2003).

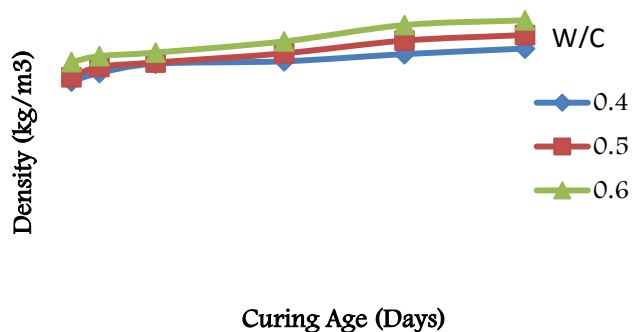
**Table 4:** The Slump and Compacting Factor (CF) Values for the Specimens

W/C Ratio	Slump (mm)	CF
0.4	5	0.75
0.5	15	0.76
0.6	17	0.77

Though the lower values of compacting factor, increased with water-cement ratios, as can be observed in Table 4, they nonetheless fell within the ranges (0.75 to 0.80) for which compacting factor is suggested as a more appropriate means for assessing workability (Shetty, 2009).

#### » Density

The results of the density at all the water-cement ratios are presented in Figure 4 and Table 5.



**Figure 4:** Effects of Water-cement Ratios on the Density of the Specimens

From Figure 4, density of the specimens increased with water-cement ratios. This trend can be explained by the fact that water has been known to aid a more closely-packed internal arrangement of granular materials (Terzaghi et al. 1996). The CCB constituent of the mix has the tendency to absorb water, result in loose internal structure and produce dry mix because the cumulative effect of larger surface area and high water absorption than the sand it replaced (Table 2). Thus the effect of higher water content is to make more water available to the mix, thereby aiding efficient internal arrangement of grains of sand and CCB leading to the densification of the matrix.

From the knowledge that concrete having densities in the range of 300 – 1950 kg/m<sup>3</sup> are classified

lightweight concrete; those in the range of 2200 – 2400 kg/m<sup>3</sup> as normal weight concrete, and concrete with densities greater than 2500 kg/m<sup>3</sup> are regarded as heavyweight concrete (Falade et al., 2011), the following can be observed from Table 5.

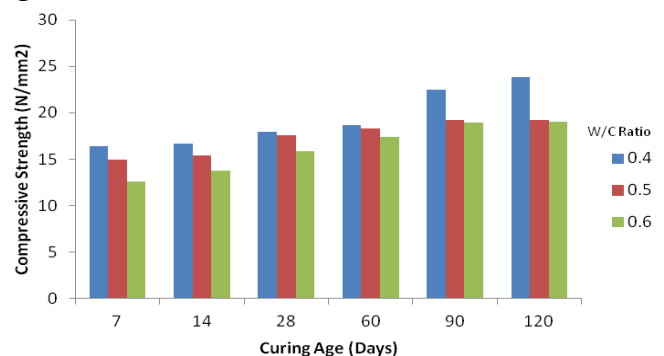
**Table 5:** Effect of Water-Cement ratio on the Density of the Concrete Samples

Curing Age (days)	0.4	0.5	0.6
7	1629.63 ± 7.86	1662.22 ± 7.21	1774.82 ± 7.89
14	1694.05 ± 7.01	1739.26 ± 7.45	1819.26 ± 7.99
28	1762.85 ± 8.10	1771.85 ± 7.89	1845.93 ± 8.10
60	1780.74 ± 6.99	1840.00 ± 8.21	1928.89 ± 8.11
90	1834.07 ± 6.78	1934.80 ± 8.00	2050.37 ± 8.15
120	1875.56 ± 7.78	1976.30 ± 8.02	2085.93 ± 8.22

All concrete with water-cement ratios of 0.4, at all the curing ages considered, are lightweight concrete. At higher curing days however, specimens have water-cement ratios of 0.5 and 0.6 crossed to normal weight concrete. Thus from this results, there seem to be possibilities for differential densities of concrete specimens into more than one classification as the water-cement ratio is increased.

#### » Compressive Strength

The results of the effects of water-cement ratios on the strength development of concrete mix containing CCB as partial replacement of sand are shown in Figure 5.



**Figure 5:** Effect of water-cement ratio on the Compressive Strength of the Specimens

From Figure 5, it can be observed that the compressive strengths of all the specimens decreased with increasing water-cement ratio at all the curing ages considered. Although one may have expected a situation where the compressive strengths would be higher with increasing water-cement ratio, considering that the density increased with water-cement ratio for this particular mix (Figure 4). It is apparent then that unlike in the density where closeness and efficient arrangement of the grains of the particles are the governing factors, compressive strength development is aggregation of strength

from three sources, namely (i) strength of the mortar, (ii) strength of the aggregates particles, and (iii) the bond between the mortar and the aggregates (Neville, 2003). Neville (2003) has shown that at higher water-cement ratios, there is the development of interconnected system of randomly distributed capillary pores throughout the matrix of the mortar. He further stated that these capillary pores made the mortar porous and reduces its capacity to develop higher strength. Furthermore, Shetty (2009) concluded that at higher water-cement ratios, the capacity of the mortar to develop cohesion and internal friction is weakened.

### CONCLUSIONS

From the results of this investigation, the authors conclude that:

- i) Workability of the concrete samples, measured in terms of slump loss, increased with water-cement ratios.
- ii) The use of CCB resulted in a dry mix, as such, compacting factor test may be more appropriate as a tool to assess the workability characteristics of the specimens due to the lower value of the factor,
- iii) The use of CCB in concrete will results in concrete with densities falling into more than one density ranges – in terms of classification - as water-cement ratio is increased
- iv) The compressive strengths of the concrete specimens with CCB decreased with water-cement ratio.
- v) Water-cement ratios seem to be the only determinant factor that governs the strength development of concrete samples containing CCB.

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## MANUSCRIPT PREPARATION – GENERAL GUIDELINES

Manuscripts submitted for consideration to ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering must conform to the following requirements that will facilitate preparation of the article for publication. These instructions are written in a form that satisfies all of the formatting requirements for the author manuscript. Please use them as a template in preparing your manuscript. Authors must take special care to follow these instructions concerning margins.

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The basic instructions and manuscript requirements are simple:

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- » Single-spaced text, tables, and references, written with 11 or 12-point Georgia or Times Roman typeface.
- » No Line numbering on any pages and no page numbers.
- » Manuscript length must not exceed 15 pages (including text and references).
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- » Manuscripts that exceed these guidelines will be subject to reductions in length.

The original of the technical paper will be sent through e-mail as attached document (\*.doc, Windows 95 or higher). Manuscripts should be submitted to e-mail: [redactie@fih.upt.ro](mailto:redactie@fih.upt.ro), with mention “for ACTA TECHNICA CORVINIENSIS – Bull. of Eng.”.

### STRUCTURE

The manuscript should be organized in the following order: Title of the paper, Authors' names and affiliation, Abstract, Key Words, Introduction, Body of the paper (in sequential headings), Discussion & Results, Conclusion or Concluding Remarks, Acknowledgements (where applicable), References, and Appendices (where applicable).

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The title is centered on the page and is CAPITALIZED AND SET IN BOLDFACE (font size 14 pt). It should adequately describe the content of the paper. An

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State the paper's purpose, methods or procedures presentation, new results, and conclusions are presented. A nonmathematical abstract, not exceeding 200 words, is required for all papers. It should be an abbreviated, accurate presentation of the contents of the paper. It should contain sufficient information to enable readers to decide whether they should obtain and read the entire paper. Do not cite references in the abstract.

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The author should provide a list of three to five key words that clearly describe the subject matter of the paper.

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Figures (diagrams and photographs) should be numbered consecutively using Arabic numbers. They should be placed in the text soon after the point where they are referenced. Figures should be centered in a column and should have a figure caption placed underneath. Captions should be centered in the column, in the format “Figure 1” and are in upper and lower case letters.

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Place equations on separate lines, centered, and numbered in parentheses at the right margin. Equation numbers should appear in parentheses and be numbered consecutively. All equation numbers must appear on the right-hand side of the equation and should be referred to within the text.

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A conclusion section must be included and should indicate clearly the advantages, limitations and possible applications of the paper. Discuss about future work.

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An acknowledgement section may be presented after the conclusion, if desired. Individuals or units other than authors who were of direct help in the work could be acknowledged by a brief statement following the text. The acknowledgment should give essential credits, but its length should be kept to a minimum; word count should be <100 words.

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References should be listed together at the end of the paper in alphabetical order by author’s surname. List of references indent 10 mm from the second line of each references. Personal communications and unpublished data are not acceptable references.

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