ACTA TECHNICA CORVINIENSIS

– BULLETIN of ENGINEERING

fascicule 4
[October - December]
tome VII [2015]
ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

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We are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

AIMS, MISSION & SCOPE

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BULLETIN OF ENGINEERING

ISSN:2067-3809

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BULLETIN OF ENGINEERING

ISSN:2067-3809

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We are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!

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ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

ISSN:2067-3809

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Abstract: *Disaster management is very wide subject and single paper cannot cover all dimensions involved in disaster management, so focus has been placed on modern detection and early warning systems. The threat has made the human being more vulnerable than ever before, mainly due to very fast growing population coupled with poor town planning in most parts of the countries. The developed countries are in effort of establishing strong and well equipped organizations to effectively deal with natural disasters. However the magnitude and area of influence of these natural disasters demands more cohesive and joint efforts. Natural disasters being faced by the Pakistan have also been covered. The early warning implications, as it is different for different types of calamities. Responsibilities of different groups have been discusses to provide early warning and also to ensure that the adequate time is available for the people to safely extricate from the dangerous zone. This paper deals with the latest systems available or being uses by developed countries and some recommendations for an effective early warning system in Pakistan.*

Abstract: *In this paper, we present the results of finite element analysis (FEA) performed to investigate nature of stress and their distribution at optimum point along the two turning tables of a micro-controller based versatile machine tool desktop learning module. Commercial Autodesk Inventor was used to create both three-dimensional (3-D) and 2-D models as well as performing simulation. Dynamics simulation generated the motion load expected to act on the tables when used for real-life operation which were in turn used to perform FEA. The motion of the dc servo motor driving the tables and other parts of the module is designed to be controlled by programmable chips. Before creating FEA simulation for the tables, numerical divergence were prevented by varying the mesh settings to obtain the settings at which the results of the analyses converges which was obtained at 0.03 average element size and 0.04 minimum element size. Finite element analysis carried out on the tables shows that aluminium alloy 4032-T6 chosen will serve in the fabrication of physical prototype. FEA revealed the nature and level of stresses that will be experienced on the tables, it also revealed region where these stresses will concentrate on them. The analysis also estimated the expected weight of the turning tables 1&2 to be 1.23536 to 0.257182 Kg respectively and show that the minimum factor of safety was constantly 15 ul within the tables which shows that they will not fail during operation.*

Abstract: *Non-ferrous metals are among the few materials that do not degrade and do not lose their chemical or physical properties in the recycling process. The most frequently recovered metals are: lead, gold, silver, aluminum, copper and platinum. Therefore, studies are being carried out aimed at developing new processes for the separation of metals, mainly from industrial waste by-products. The handling of e-waste including combustion in incinerators, disposing in landfill or exporting overseas is no longer permitted due to environmental pollution and global legislations. Compared to other waste components, such as plastics, wood or textiles, non-ferrous metals exhibit better reusability and higher market values. In future, new strains have to be identified to improve the metal recovery from solid waste.*

Abstract: *Machine aggregates with controlled drives often need a multi-level hierarchical control. In the basic level of, say a speed system, the angular speed of the motor/drive is controlled by a speed controller, perhaps with the aid of a subsidiary current controller. Modelling of machine aggregates requires systematic approach. There is no general agreement about the definition, structure and classification of subsystems of machine aggregates. In the present paper general principles of modelling of machine aggregates are outlined. Machine aggregate is treated as complete integration of electronic control subsystem, electric driving subsystem and mechanical working subsystem.*

Abstract: *Blood bag manufacturers are very keen to maintain high quality of needle assembly but manual needle assembly process tends to compromise the quality of needle to a certain extent which has lead to overall rejection percentage to be around 3.2%. The objective of the project is to increase the productivity of needle assemblies with higher output, lesser rejections and higher product quality. For achieving this emphasis is given on the design and development of re-capable polypropylene outer protective needle cover. The CAD model of the polypropylene cover is completed using Creo 2.0. The breaking torque for inner PVC cover is found to be 58 N-mm. The strength of proposed PP cover to withstand the calculated pinching torque is validated with a factor of safety of 3.72 using ANSYS 14.0. Autodesk Mold flow simulation software is used to optimize the gate location and mold parameters. The effect of varying wall thickness, melt temperature, and injection time are also analyzed in consideration with the gate location and proper processing conditions for quality result. Through analysis results higher melt temperature of 240° C, injection time of 0.25 sec and wall thickness of 1 mm are recommended to achieve successful molding for PP needle cover. It also provides minimum possibility of part warpage and weld lines throughout needle cover.*

Abstract: *The damping capability of metallic foams is worse than for the solid metal materials will be the result if we make the calculation. This would be the opposite of those statements that underline the significant vibration damping capability of metallic foams. The vibration damping behaviour of solid metal materials can be described with a viscous damping model. It is questionable whether we can use or not the same damping model for metallic foams. In this paper the authors describe a measuring method to determine the vibration damping behaviour of the metallic foams and try to determine which damping model is good to describe the behaviour of metallic foams (Coulomb damping or viscous damping).*

Abstract: *Morocco is a major producer of phosphate, with an annual output of 19 million tons and reserves in excess of 35 billion cubic meters. This represents more than 75% of world reserves. Resistivity surveys have been successfully used in the Oulad Abdoun phosphate basin. A Schlumberger resistivity survey over an area of 50 hectares was carried out. A new field procedure based on analytic signal response of resistivity data was tested to deal with the presence of phosphate deposit disturbances. A resistivity map was expected to allow the electrical resistivity signal to be imaged in 2D. 2D wavelet is standard tool in the interpretation of geophysical potential field data. Wavelet transform is particulary suitable in denoising, filtering and analyzing geophysical data singularities. Wavelet transform tools is applied to analysis of a Moroccan phosphate deposit "disturbances". Wavelet approach applied to modeling surface phosphate "disturbances" was found to be consistently useful.*

Abstract: *The need for aesthetic, strong and environmentally beneficial composites for furniture and fittings was the thrust of this work. The research involves comparative study and analysis of the behavior of brown and white papers when they are mixed with different proportions of cement as binder. Waste papers from offices were sourced locally and were sorted into white and brown papers after which the papers were pulverized and made into slurry. The slurry obtained were compacted into flexural and compressive tests samples with the aid of compacting machine by applying a load of 20 KN for 5 minutes followed by drying at room temperature in the laboratory. Flexural, compressive and water absorption tests were carried out on the samples using universal testing machine and percentage weight different of immersed samples in water respectively. It was observed from the results that, white paper cement bonded samples possessed the best properties in all compared to brown paper cement bonded samples. The results showed that the mixture of 70 % white paper and 30 % cement possess the best combination of mechanical and physical properties and hence, the potential material for paper pulp composite in low cost furniture and fittings applications.*

Abstract: *Rolling mill construction and the art of rolling experienced a sharp growth when production of steel in molten form began and, along with improvements in roll materials, have remained closely connected with the development of the steel industry. Our approaches the issue of quality assurance of the rolling mills rolls, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation. The experimented durability research, as well as the optimization of the manufacturing technology, allows the conclusion of direct results for the rolls. The beneficiaries of these results are the unit in which the rolls are manufactured, as well as the unit that exploits them. The technological manufacturing process of the rolling mills rolls, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation.*

Abstract: *Vibratory feeders are commonly used in industries for part feeding. There are several factors that affect the conveying velocity of parts on the vibratory feeder. Among these, the critical factors such as excitation frequency, amplitude of vibration, mass of part, co-efficient of friction and Length-to-width (L/W) ratio of the part were considered for experimental studies. The percentage of influence of each factor on conveying velocity was determined through ANOVA. Regression and Artificial Neural Network (ANN) models were developed to predict the velocity of prismatic parts on vibratory feeder. Comparison of results with experimental results revealed that ANN was able to predict closer than the regression model.*

Abstract: *There can be practical question in connection with the networks: Do the malfunctions of devices, eruptions of social conflicts, devastations of biological or chemical disasters happen accidentally? The segments of the network can be paralysed by a series of chance events or a well-organized, targeted attack. If we know our system and lead a safety-conscious life we can avoid unpleasant events, system down. The Critical Information Infrastructures has become a complex network. Consequently the items of the system, their mutual effects and links and the map of the network have to be known properly. We have to realize that everything is linked with each other and the physical and logistical networks have mutual effects on each other as well. It is obvious, that the problem of mapping the complexity is very important. One of the most important part of the cognition is the obtainment and sorting of information.*

Abstract: *Fluid extract from the leave of water lily (Nymphaeaceae) was tested as corrosion inhibitor for mild steel in tetraoxosulphate (VI) acid solution. Weight loss and determination of the potential difference (Pd) of the steel samples were measured. The effect of concentration on the inhibitor performance of the extract was studied. The results obtained shown that the leave extract functioned as effective corrosion inhibitor. The fitting of the experimental data to the corrosion rate, potential difference and inhibitor efficiency equations revealed that the organic constituents of the extract were physically adsorbed on the corroding mild steel surface. The findings provide ready friendly application for the problematic fresh water weed water lily.*

Abstract: *The extension of the conventional tourism practices along with fast development in tourism industry (TI) brings considerable benefits to regional economics. there are also negative interferences of some diverge vectors opposing the application of any renovated theories to reach the conventional tourism to Ecotourism i.e. the accessibility of drinking water and the availability of agricultural soil, water consumption, solid waste (SW) disposal and their transfer facility, and tourists transportation. In this regard, this study is the first study put theories with reliable tools for benchmarking the environmental performance (EP) via the assessment of the aforementioned impacts and their Touristic Ecological Footprint (TEF) and the Tourism Ecological Balance (TEB) in a civilized community.*

Abstract: *Forming is an important component in modern industry. As plastic deformities are important to processes, the present paper presents v arious issues of plastic deformities. Under forming, classification of processes, properties of the materials used in the process and the criteria of yield are described. For convenience, the forming processes are classified based on other parameters of the processes, namely, stress, raw material, temperature and induction of force. In addition, yield theories namely, van Mises-Henckyor Distortion energy criterion and maximum shear stress or Tressa criterion are delineated. Thus the forming is an important component in modern industry, as it uses stresses to cause plastic deformation of material without deteriorating their properties. And the present paper presents various issues of forming and plastic deformities. The properties of materials are to be considered as important issue for the production at the required standards. A theory of yielding is also important issue to be understood in the industry, as it is related to the stress state and strength of the material.*

Abstract: *Tobacco plants (Nicotiana rustica, Nicotiana tabacum) produce abundant biomass in more than 100 countries and could be used to produce abundant biofuels since about one quarter of the tobacco plant is cellulosic material . This biomass appears attractive for conversion to ethanol because it contains very low amounts of the hard-to-convert woody material lignin . Microwave (MW) irradiation has a good potential to increase the ability of organic matter for biological degradation so we connected the enzymatic hydrolysis of the cellulose type material of the tobacco plant and the microwave pretreatment. Our results show that microwave pre-treatments was suitable to enhance the biodegradability of tobacco plant and this way the MW pre-treatment was suitable for enhancing the sugar yield. The saccharification time was shortened by the alkali pre-treatment so the combination of alkali pH and MW could be the better solution. The objective of our work was to investigate how to affect the MW pre-treatment on the enzymatic hydrolysis.*

Abstract: *Numerical modeling is widely used in many fields, therefore establishing correlations between properties. In our case, for example, the process and parameters of infiltration, mass parameters modeling, energy equilibriums according to Darcy's equations describe fluid flow in a porous cavity. Using AS-CFD we can improve the infiltration process (with the help of numerical simulation): on the one side analyzing particle interaction and on the other side analyzing the flowing process. In this paper we have analyzed the AS-CFD simulation method applicability for analyzing Al6061 alloy porosity through a pre-established surface. High applicability is encountered when using low diameter particles (required so that the Al6061 alloy passes the ductility test) because in this case the time frame is very high (approximately 30 hours for a standard test).*

Abstract: *In this paper, a non-linear finite element analysis has been done to analyze the deflection in the steel section and internal stresses in the concrete slab for continuous composite girders with rectangular opening in the steel web. ANSYS computer program (version 14.5) has been used to analyze the three-dimensional model. The reliability of the model was demonstrated by comparison with experimental results of continuous composite beam without opening in the steel web carried out by another author. The parametric analysis was executed to investigate the width, height, and position of the opening in one span on the behavior of composite girder under vertical load. The results indicated that when the width of opening less than 0.05 of length of single span and the height less than 0.15 of steel web, the deflection and internal stresses increased less than 10 % comparing to continuous composite girders without opening.*

Abstract: *Nowadays the composites are utilised in all areas of the car industry. We know number of composite materials types, whereby we´ve been concentrated us on composites from carbon fibres. These composites have big potential for car production thanks their excellent strength properties and first of all for their weight. A big concern relating to the wider application of carbon fibres is their fluctuating price and availability in comparison to other structural reinforcements. The presented article deals about mechanical testing of hybrid materials for automotive production. It describes thetest samples production and test processes methods forcomposite material´s testing. We´ve tested hybrid materials clustered from raw fibres of hemp, cotton, sisal and jute in combination with carbon fabric. The objective of the thesis is to present the testing methods for confirmation or declination of the ability of hybrid bio-composites usage in automotive industry. The results are statistically evaluated.*

Abstract: *Electrochemical detection is an attractive alternative method for detection of electroactive species, because of its inherent advantages of simplicity, ease of miniaturization, high sensitivity and relatively low cost. In this paper, we describe the electrochemical analysis of ascorbic acid on a clay modified carbon paste electrode. The electrochemical characterization of adsorbed electroactive AA was evaluated using cyclic voltammetric (CV) and Electronic Impedance Spectroscopy (EIS) analysis. Ascorbic acid (Vitamin C) is a water soluble organic compound that participates in many biological processes. This paper reports the synthesis of Clay modified carbon paste electrode and its application for the electrochemical detection of ascorbic acid (AA). The influence of variables such the concentration of ascorbic acid adsorbed onto Clay, and the pH of solution were tested. The capacity of prepared electrode (Clay-CPE) for selective detection of AA was confirmed in a sufficient amount of ascorbic acid. The observed linear range for the determination of AA concentration was from 1.13 mM to 5.68 mM.*

Abstract: *Power and energy industries have their unique challenges but they all need to rely on the efficient running of their piping systems and therefore optimum design and continual effective maintenance are essential. The ability to ensure accurate delivery of a product and raw materials, especially over long distances and significant elevation change is vital to the overall operation and success of a process plant. For such analysis Flowmaster is a useful code. The purpose of this paper is to model the shutdown cooling system (SDCS) operation for CANDU 6 nuclear power plant in case of LOCA accident, using Flowmaster calculation code by delimitating models and setting calculation assumptions, input data for hydraulic analysis, assumptions for the calculation and input data for calculating thermal performance check for heat exchangers that are part of this system.*

Abstract: *Induction Motors (IM) are applied today to a wider range of applications requiring variable speed. Generally, variable-speed drives for induction motors require both wide operating range of speed and fast torque response, regardless of load variations. In this work, we introduced a new method toward the design of hybrid control with sliding-mode (SMC) plus fuzzy logic control (FLC) for induction motors. As the variations of both control system parameters and operating conditions occur, the conventional control methods may not be satisfied further. Sliding mode control is robust with respect to both induction motor parameter variations and external disturbances. By combination of a fuzzy logic control and the sliding mode control, the chattering (torque-ripple) problem with varying parameters, which are the main disadvantage in sliding-mode control, can be suppressed, Simulation results of the proposed control theme present good dynamic and steady-state performances as compared to the classical SMC from aspects for torque-ripple minimization, the quick dynamic torque response and robustness to disturbance and variation of parameters.*

Abstract: *Polyimides are one of the most important classes of high temperature polymers available today. They find wide spread application due to the wide range of chemistry and properties accessible. Innovative polyimide design has led to their use in aerospace, microelectronics, automotive and packaging industries. Polyimides have become important materials in the manufacture of a large number of technical products, e.g. varnishes, coatings etc, due to their excellent thermal stability and mechanical strength, high stability to ionizing, good film forming ability, and superior chemical resistance. In this research we describe the preparation of polyimide with pyromellitic dianhydride (PMDA) and p-phenylene diamine (PDA) thin films by physical vapor deposition. For this study , FTIR Spectrometer has been used to measure the effect of imidization temperature on the chemical structure of vapor-deposited thin films of the aromatic PI. When temperature increases, a general increase in all the absorption peaks is observed by FTIR . The surface topology of the PI films was further examined by using AFM atomic force microscopy as a function of the imidization temperature at 150,200,250 °C for 1 hour each in an air circulating oven. The thermal stability of polyimide was also improvedby using Thermogravimetric analysis (TGA).*

Abstract: *Smart City concept is a topical issue. The main contribution of this paper is the performance evaluation of topology control algorithms that can be integrated in the Smart City concept. Thus, the following topology algorithms A3, A3 Coverage and EECDS are considered. The parameters evaluated are: the number of active nodes after the topology reduction algorithm is applied, the number of packets sent and the energy consumed for building the topology. From the results we conclude that the topology construction algorithm A3 provides the lowest number of active nodes and is recommended for use in the Smart City concept.*

Abstract: *The humanitarian aid personnel usually work in complex environments where working conditions are often not favourable, which results in putting these humanitarian staff at risk of experiencing traumatic and daily cumulative stresses. As this field of study is relatively new and least addressed, this paper aims to provide a conceptual overview of common themes that have begun to emerge from recent works. Different areas of risks are proposed that are likely to have applicability across different contexts and situations. This includes individual risk factors, health issues and situational risk factors which require Psychological adjustment, medical health and security in promoting safety and wellbeing of individuals.*

Abstract: *The majority of newly developed techniques in the aluminum industry are sometimes destined to make special products which require an elaborate investigation of alloy properties, therefore wasted time and additional costs. In the end, the new techniques cannot specify or simulate the required microstructure, optimal parameters, optimal alloy composition in order to improve the new processes which include Al6061. The majority of Al6061 (Al6xxx series) improvements are closely related to their mechanical properties (which also depend on the microstructural characteristics). Therefore, we can use the process-structure-properties simulation methods for the Al6061 alloy, with good results over the physico-mechanical characteristics or in the recycling process. In this article, using ANN (Artificial Neural Network), we have analyzed the implications which the chemical composition of Al6061-T6 has over the mechanical properties and elaboration temperature. This correlation between the mechanical properties and chemical composition has a high importance for establishing the right path for a product, without additional costs or wasted time, but also improving certain characteristics of the alloy.*

The ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Tome VIII/2015, Fascicule 4 [October–December/2015] includes scientific papers presented in the sections of ***The STUDENTS' SCIENTIFIC SYMPOSIUM – „45 YEARS OF HIGHER EDUCATION IN HUNEDOARA" – Doctoral Studies Section****, organized in Hunedoara (22nd – 23rd May, 2015), by Faculty of Engineering Hunedoara, ROMANIA. The new current identification number of the papers are* ***# 2, 3, 8, 9, 21*** *and* ***30****, according to the present contents list.*
Also, the ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Tome VIII/2015, Fascicule 4 [October–December/2015], includes original papers submitted to the Editorial Board, directly by authors or by the regional collaborators of the Journal.

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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EFFECTS OF SPIN AND DIE CASTING ON MICROSTRUCTURE AND CORROSION BEHAVIOUR OF Al-Mg-Si ALLOY

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Abstract: The microstructure and corrosion behavior of Al-Mg-Si alloy using spin, die and sand casting was investigated. The materials used were aluminium scrap, magnesium and silicon, they were all subjected to chemical analysis using spectrometric analyser. Charge calculation to determine the amount needed to be charged into the furnace was properly worked out and charged into the crucible furnace from which as-cast aluminium was obtained. Density measurements were used as a basis of evaluating the percentage porosity of the cast products; the corrosion behavior of the cast produced in acid 0.1M, 0.3M and 0.5M H_2SO_4 and saline 0.1M, 0.3 and 0.5M NaCl environment were investigated using corrosion rate, mass loss. From the results it was observed that magnesium and silicon were better dispersed in aluminium matrix of the spin casting. However, during the corrosion test in H_2SO_4, die casting exhibited best corrosion resistance followed by spin and sand casting. The spin, sand and die casting all exhibited good corrosion resistance in NaCl.

Keywords: Al-Mg-Si alloy, spin casting, sand casting, corrosion, spectrometric analyser

INTRODUCTION

Casting is one of the oldest manufacturing process, it is a fabrication process whereby a totally molten metal is poured into a mould cavity having the desired shape; upon solidification, the metal assumes the shape of the mould but experience some shrinkage [1]. Casting is the most economical.

A number of different casting techniques are commonly employed, including sand, die, investment, continuous and spin casting. Sand Casting probably the most common method, ordinary sand is used as the mould material [1]. A two-piece mould is formed by packing sand around a pattern that has the shape of the intended casting. A gating system is usually incorporated into the mould to expedite the flow of molten metal into the cavity and to minimize internal casting defects. It has been stated that when pouring temperature is lower than optimum, the mould cavity will not fill the gate or riser will solidify too rapidly and intercept directional solidification.

Die casting is a versatile process capable of being used in mass production of alloys having properties unobtainable by other manufacturing method [2].

Spin casting is both gravity and pressure independent since it creates its own force feed using a temporary sand mould held in a spinning chamber at up to 300-3000rpm as the molten metal is poured. The molten metal is centrifugally thrown towards the inside mould wall, where it solidifies after cooling. The casting is usually a fine-grained outer diameter, owing to chilling against the mould surface. Impurities and inclusion are thrown to the surface of the inside diameter which can be machined away [3].

Aluminium alloys have great use potential in the structural components in the aerospace and automobile industries mainly because of their low density and high specific strength [4], also aluminium alloys have a wide diversity of industrial applications because of their high specific strength, light weight and corrosion resistance. Therefore these alloys motivate considerable interest to the aviation industries [5, 6]. Aluminium alloy for a cast component is based upon mechanical and corrosion properties it can achieve. Aluminium alloy casting properties result from three primary factors: casting alloy, melting and casting methods. The properties obtained from one particular combination of these factors may not be identical to those achieved with the same alloy in a different casting facility.

EXPERIMENTAL MATERIAL AND METHODS

The materials used for the work were scraps of Aluminium purchased from Northern Nigeria Cable Processing Company Limited (NOCACO), Kaduna also Magnesium used. The silicon used was obtained from Engineering Materials Development Institute (EMDI), Akure, Nigeria.

Table 1. Chemical composition of basic materials (after casting)

Si	Fe	Cu	Mn	Mg	Zn	Cr	Ti	Al
0.40	0.24	0.03	0.04	0.55	0.03	0.01	0.02	98.68

The three casting methods were carried out for the work, they are:

(i) Spin casting
(ii) Sand
(iii) Die casting.

The patterns used were made of wood with diameters of 20 mm by 150 mm long. The patterns were made larger than the original dimension to

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compensate for shrinkage during solidification and machining operation. Natural sand was used to prepare the sand mould, a mixture of silica sand with considerable amount of bentonite. The addition of bentonite improved the bonding strength. The moulding of the pattern was carried out using a moulding box comprising of cope and drag that gave rigidity and strength to the sand. Parting sand was properly applied for the easy removal of the mould from the pattern. The gating system was properly designed for smooth channeling of the molten metal into the mould cavities through the sprue, runner, in-gates and riser that were perfectly placed in position. The die mould was prepared with cast iron.

The cast aluminium scraps, magnesium and silicon were carefully worked out and charged into the furnace.

Crucible furnace was used for the melting of the charges. Prior to charging, the crucible furnace was checked to prevent leak of molten metal and also to guide against moisture, which can generate vapour during melting. Metallurgical factors in the choice of melting facilities related to the tendency of the charge to react with its surrounding, affecting composition control, impurity level and metallic yield were considered. The charged materials in the furnace were allowed to melt down (at 700°C) and then the furnace was switched off. The molten metal was tapped from the furnace, poured into the spin casting machine mould and sand mould, both were allowed to air cool.

The removal of the sand which stuck on the surface of the sand cast was carried out with the aid of sand blasting bar, sprue and ingates were also removed using hacksaw. Cleaning operation was also performed by grinding to smoothen the surface and unnecessary attachment on the surface of the metal to improve the appearance.

The determination of the experimental densities of the various casting products were carried out by measuring the weight of the test samples using a high precision electronic weighing balance with a tolerance of 0.1mg. The weights of the measured samples were divided by their respective volume.

$$\text{Experimental density, } \rho = \frac{mass\ of\ the\ sample}{volume\ of\ the\ sample} \quad (1)$$

The percentage porosity of the cast aluminium was determined by use of equation

$$\%\ \text{volume porosity} = \frac{(\rho cal - \rho exp)}{\rho cal} \quad (2)$$

where ρ_{cal} = Theoretical Density (g/cm^3), ρ_{exp} = Experimental Density (g/cm^3) [7, 8]

The environments for the study were acidic and marine environments of different concentrations made from tetraoxosulphate (vi) acid and sodium chloride following standard procedure. The concentrations were 0.1 M, 0.3M and 0.5M respectively made from the stock solutions of H2SO4 (98% purity assay) for the acid. The concentrations for the sodium chloride were 0.1M, 0.3M and 0.5M respectively.

The dimensions of the various samples were carefully calculated, which in turns were used to calculate the surface area with the empirical formular:

$$\text{Surface area (mm}^2) = 2\pi r(r + h)$$

Each of the specimens were carefully washed with distilled water after the specific surface area has been calculated, followed by carefully weighing to ascertain their initial weights, using the digital analytical weighing machine prior to immersion.

The corrosion tests were carried out in H_2SO_4 and NaCl of different concentrations which were 0.1M, 0.3M and 0.5M respectively. The specimen was earlier polished with emery papers starting from 120 grit to 640 grit sizes. The samples were degreased with acetone and rinsed in distilled water before immersion in the prepared solutions of H_2SO_4 and NaCl with different concentrations; which were all exposed to atmospheric air. The results of the corrosion rate, mass loss, electrode potential measurements; the electrochemical experiments were monitored on two day intervals. The samples were exposed in the H_2SO_4 and NaCl solutions for 60 days respectively. Mass loss (mg/cm^2) for each sample was evaluated by dividing the weight loss (measured by digital analytical weighing machine) by its total surface area which is in accordance ASTM standard practice. Corrosion rate for each sample was evaluated from the weight loss measurement following standard procedures.

***Figure 1**. Micrograph of Spin Casting (x400)*

***Figure 2**. Micrograph of Sand Casting (x400)*

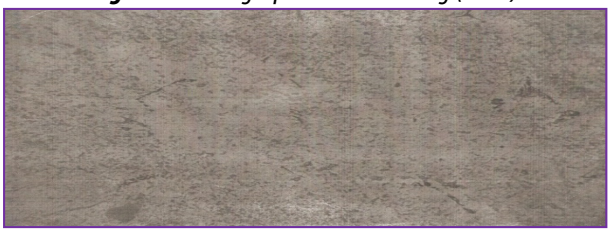

***Figure 3**. Micrograph of Die Casting (x400)*

***Table 1**. Experimental Results – Density Measurement*

Type of casting	Theoretical density (g/cm^3)	Experimental density (g/cm)	Porosity (%)
Spin casting	2.70	2.69	0.37
Sand casting	2.70	2.67	1.11
Die casting	2.70	2.67	1.11

EXPERIMENTAL RESULTS – CORROSION PROPERTIES

Effect of tetraoxosulphate (VI) acid on the corrosion rate

Figure 4.1 and 4.2 presents the corrosion rate and mass loss plot for Al-Mg-Si alloy which were cast with spin, sand, and die casting and their

coupons immersed in 0.1M H_2SO_4. It was observed that the corrosion rate was at the peak for die and sand casting at day two with die castinghigher than sand casting, spin casting reached its peak at day 23 which was far below the peak reached by sand and die casting. The corrosion rate curve reveal that the passive film formed on the specimens were not stable as there were repeated film formation and breakdown which was reflected by an increase in corrosion rate. In Figure 4.10, there is dissolution of the samples in 0.1M H_2SO_4. The anomalous weight loss for 60 days was reasonable due to the localized corrosion of Al-Mg-Si alloy in 0.1M H_2SO_4 which showed discrete in different periods. Similar results have been reported in atmospheric corrosion of stainless steel [9,10,11].

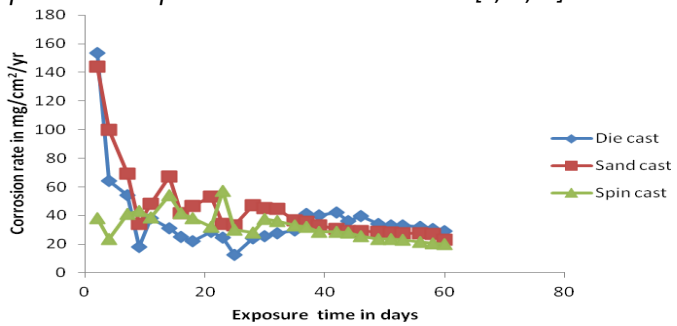

Figure 4.1. *Variation of corrosion rate of cast products in 0.1M H_2SO_4*

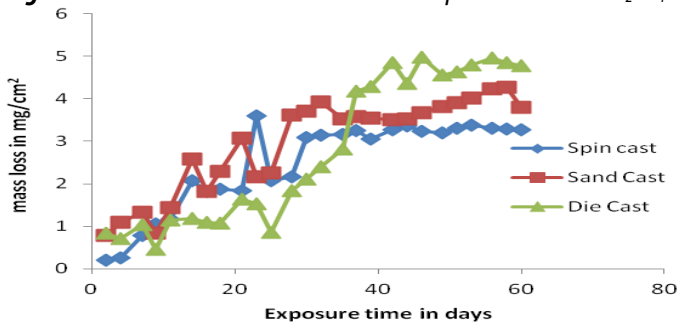

Figure 4.2*- Variation of mass loss against exposure time of cast products in 0.1M H_2SO_4*

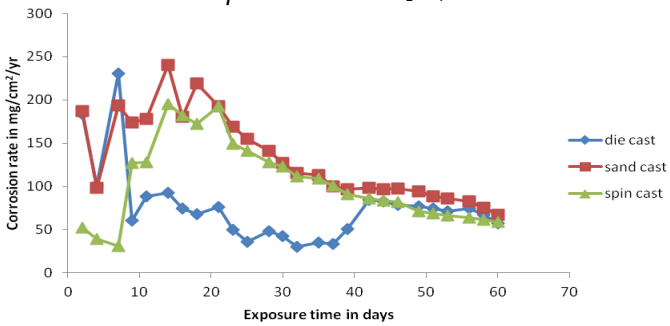

Figure 4.3*. Variation of corrosion rate of cast products in 0.3M H_2SO_4*

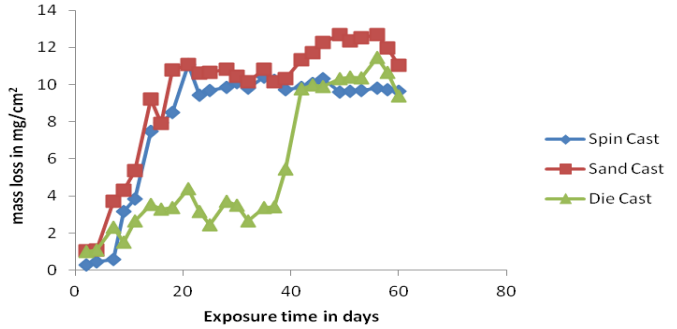

Figure 4.4*. Variation of mass loss against exposure time of cast products in 0.3M H_2SO_4*

Figure 4.3 and Figure 4.4 presents the corrosion rate versus exposure time and mass loss versus the exposure time plot. It was observed that the corrosion rate of the casting products in 0.3M H_2SO_4 shows that sand casting has the highest corrosion rate, while the die casting has the lowest corrosion rate, the corrosion rate for spin casting was low up to day 7 after which there was an increase in corrosion rate, at day 42, the corrosion rate for the three cast product were almost the same, this may be as a result of formation of films on the coupons surfaces.

Figure 4.5 and Figure 4.12 presents the corrosion rate versus exposure time and mass loss versus exposure time respectively in 0.5M H_2SO_4. It was observed that the die casting has the lowest corrosion rate while the sand casting has the highest corrosion rate. After the second day of the corrosion test, die casting corrosion rate drops, this was maintained throughout, this may be due to formation of passive films.

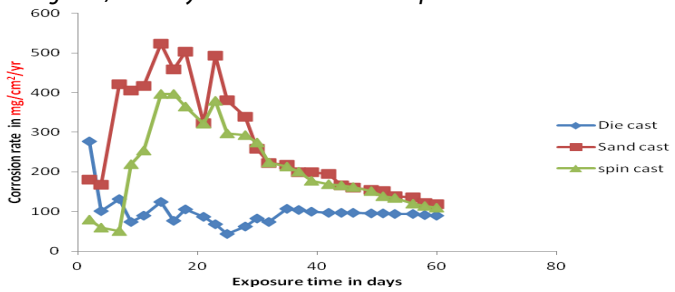

Figure 4.5. *Variation of corrosion rate of cast products in 0.5M H_2SO_4*

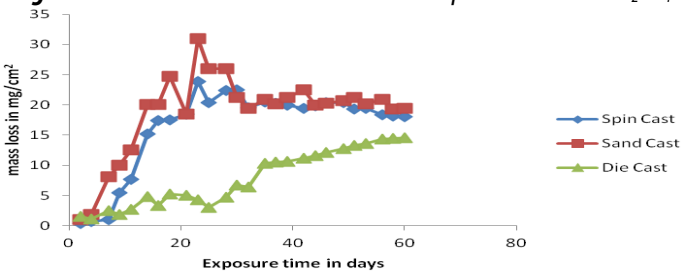

Figure 4.6*. Variation of mass loss against exposure time of cast products in 0.5 H_2SO_4*

EFFECT OF SODIUM CHLORIDE ON THE CORROSION RATE

Presented in Figure 4.6 are the results of corrosion rates versus the exposure time for the Al-Mg-Si alloys which were cast with three different methods namely; spin, sand, and die casting, their coupons were immersed in 0.1M NaCl. It was observed that the peak corrosion rate for each samples was observed at day four, after which there was no significant in the corrosion rate as the exposure time increases. The spin casting had the highest corrosion rate followed by die and sand casting.

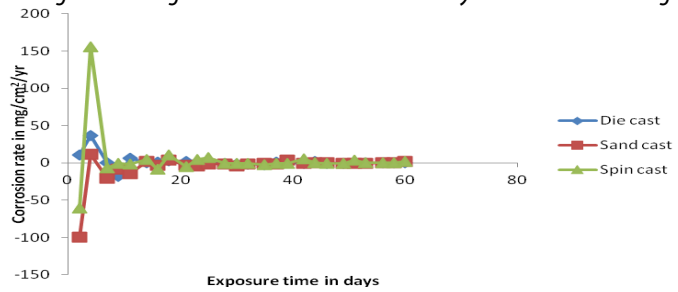

Figure 4.7*. Variation of corrosion rate of cast products in 0.1M NaCl*

The results shown in Figure 4.9 show that the corrosion rates versus the exposure time in 0.3M NaCl also gave an increase in corrosion rate at day four after which there was no significant increase in corrosion rate.

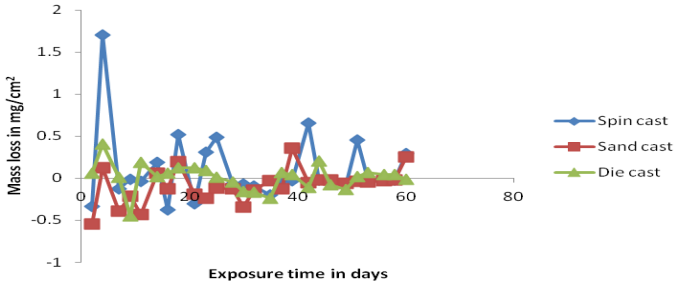

***Figure 4.8**. Variation mass of loss against exposure time of cast products in 0.1M NaCl*

Figure 4.11 also followed the same trend as in Figure 4.6 and Figure 4.8. The decrease in the corrosion rate of the three cast samples in three different concentrations can be attributed to the ability of aluminum alloy to form passive films this is in agreement with Ekuma and Idenyi [12] and Oguzie [13], who studied the influence of alloy compositions on the passivation layer characteristics of Al-Zn alloys systems.

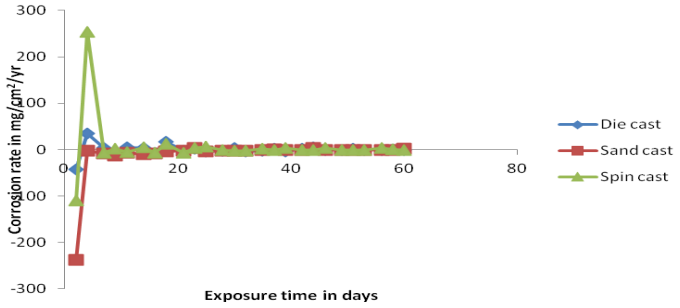

***Figure 4.9**. Variation of corrosion rate of cast products in 0.3M NaCl*

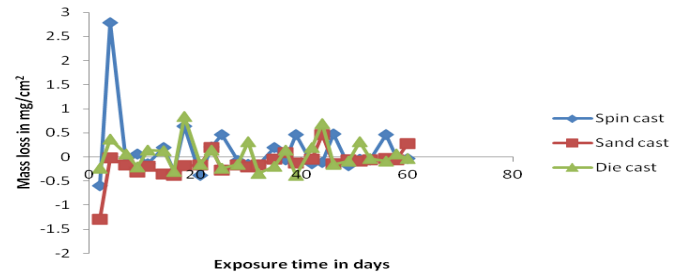

***Figure 4.10.** Variation of mass loss against exposure time of cast products in 0.3 NaCl*

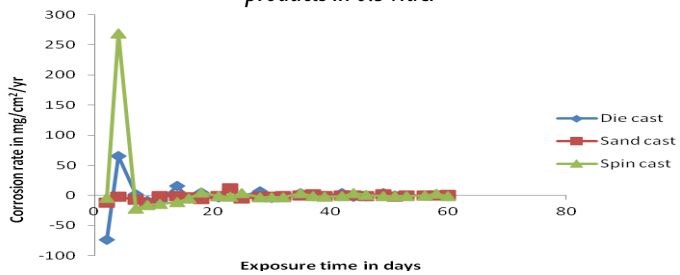

***Figure 4.11**. Variation of corrosion rate of cast products in 0.5M NaCl*

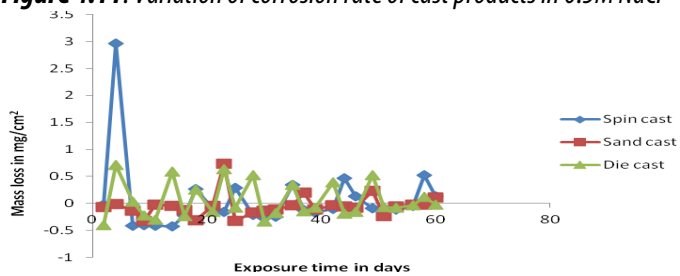

***Figure 4.12**. Variation of mass loss against exposure time of cast product in 0.5 NaCl*

The mass loss profiles in Figure 4.7, Figure 4.9 and Figure 4.12 however show that sand casting has a better corrosion resistance as a result of higher in weight gain while spin casting show high corrosion susceptibility at day four, after which there was drop mass loss, die casting gave a better result as compared to spin casting.

CONCLUSIONS

In the research work, the effect of spin and die casting methods on corrosion behaviour of Al-Mg-Si alloy NaCl and H_2SO_4 were investigated. On the strength of the results presented, the following conclusions were drawn:

- *The microstructure of the spin casting revealed that magnesium and silicon were well dispersed in the aluminium matrix as compared to sand die casting.*
- *The die casting products exhibit better corrosion resistance in 0.1M, 0.3M, and 0.5M H_2SO_4 as compared with spin and die casting.*
- *The products produced from spin, sand and sand exhibit a good corrosion resistance in 0.1M, 0.3M, and 0.5M NaCl.*

REFERENCES

[1.] *Callister, W.D.; Fundamentals Materials Science and Engineering, Ranjbaran , Wiley and Sons Inc. USA, Pp. 364-578, 2010*

[2.] *Adewuyi, B.O.; Omotoyinbo, J.A.; Effect of Cooling Media on the Mechanical Properties and Microstructure of Sand and Die casting Aluminium Alloys. Journal of Science and Technology, Volume 28, Pp. 97-100, 2008.*

[3.] *Polmear, I.J.; Production of Aluminium. Light Alloys from Traditional Alloys to Nanocrystals. Oxford Elsevier/ Butterworth-Hememann, Pp.15-16, 2006.*

[4.] *Yazdiam, N.; Kazimzadeh, F.; Tovoosi, M.; Microstructural Evolution of Nanostructure 7075 Aluminium Alloy during Isothermal Annealing. Journal of Alloys and Compounds, 493 Pp. 137-141, 2010.*

[5.] *Prabhu, C.; Suryanarayana, C.; An, L.; Vaidyanathan, R.; Synthesis and Characterization of High Volume Fraction Al-A1203 Nanocomposite powders by high energy milling. Journal of Material Science Engineering A, Volume 425, No.1-2, Pp.192-200, 2006.*

[6.] *Torralba, J.M.; Velasco, F.; Costa, C.E.; Vergara, I.; Caceres, D.; Mechanical behaviour of the Interphase between Matrix and Reinforcement of Al 2014 Matrix Composites Reinforced with $(Ni_3Al)_p$, 2002.*

[7.] *Hizombor, M.; Mirbagheri, S.M.H.; Abdideh, R.; Casting of A356/TiB_{2p} Composite Based on the TiB_{2p}/CMC/PPS Mortar Roznov pod Radhostem, Czech Republic, Volume 5, Pp.18-20, 2010.*

[8.] *Hashim, J.; Looney, L.; Hashim, M. S. J.; Metal Matrix Composites: Production by Stir Casting Method, Mat. Proc. Tech Volume 92, Pp. 1-7, 1999.*

[9.] *Wang B.B.; Wang Z.Y.; Han W. and Ke W. ; Atmospheric Corrosion of Aluminium Alloy 2024-T3 Exposed to Salt Environment in Western China, Journal of Corrosion Science, Volume 59, Pp. 63-70, 2012.*

[10.] *Liang C.F., Hou W.T.; Twelve year Atmospheric Exposture of Stainless Steels in China, in; H.E. Townsent (Ed.). Outdoor Atmospheric Corrosion, ASTM STP 1421, American Society of Testing and Materials, Philadelphia, Pp. 358-367, 2002.*

[11.] *Wang Z.Y., Li Q.X., Han W., Yu G.C., Han E. H.; Corrosion Behaviour of 316L Stainless Steel Exposed to Qin ghai Salt Lake Atmosphere, 5th Chinese Society for Corrosion and Protection, P. 115, 2009.*

[12.] *Ekuma C.E., Idenyi N.E., Neife S.I.; Comparative Analysis of the Corrosion Susceptibility of Cast Al-Mn Alloys in Acidic Environment. Res. Journal of Environmental Service, 1Volume 4, P. 185, 2007.*

[13.] *Oguzie E.; Corrosion Inhibition of Aluminium in Acidic and Alkaline Media Sansevieria trifaciata Extract . Journal of Corrosion Science, Volume 49, Pp. 1527-1539, 2007.*

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METHODOLOGY FOR AN IMPLEMENTATION OF THE DRAWINGLESS MANUFACTORING

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Abstract: In this paper, there are presented the proposal steps to be taken for smart working of the integrated manufacturing system using no drawings. This contribution deals with the activities which are focused on the devices at our institute. These devices are parts of the computer integrated manufacturing. This paper deals also with knowledge about PMI information, and with the smart working with it in drawingless environment.
Keywords: iCIM3000, drawingless, CIM, PMI

INTRODUCTION

Modern information technology has opened up new possibilities of flexibilization and cost reduction in production. The development of information technology has brought in mechanical engineering the phenomenon of designing in 3D virtual environment, which enables designers to instantly obtain a far greater insight into the structure and level of detail than is possible when designing in 2D environment. One of these possibilities is the manufacturing using no drawings. Nowadays are drawings only information carriers and they are useful only in their electronic forms. Thereforewill be in this article personated some reasons why we have to choose the manufacturing with no drawing and some manners in wich we should move in. In other, there will be presented why is the PMI good for this implementation,and basic steps how to begin work with this information in effective way.

ICIM SYSTEM

Production with integration of computer support in all phases of the production system, in which all of these phases are connected with each other it is called computer-supported production (Computer Integrated Manufacturing – CIM). It is a network of connected computers includes activities related to the production, starting with the product marketing and ending with expedition to the customer [1, 2].

CIM - Computer Integrated Manufacturing - is a concept for the structuring of industrial enterprises. Manufacturing technologies demand a CIM concept which can be realized through the capabilities of information processing available today. The idea of integrating different areas of CIM, such as production planning and control (PPC), computer aided design (CAD) and computer aided manufacturing (CAM), is explained through operating chains and put into a CIM architecture based on a hierarchy of EDP systems [3].

If the CIM is a computer controlled production, iCIM is then open system of computer controlled production of CIM. ICIM 3000 is a training and open model system of CIM made by company FESTO. On Fig.1 we can see the 3D model of iCIM by FESTO. This system consists of stations which are marked on fig. 1 by numerical character 1-8.

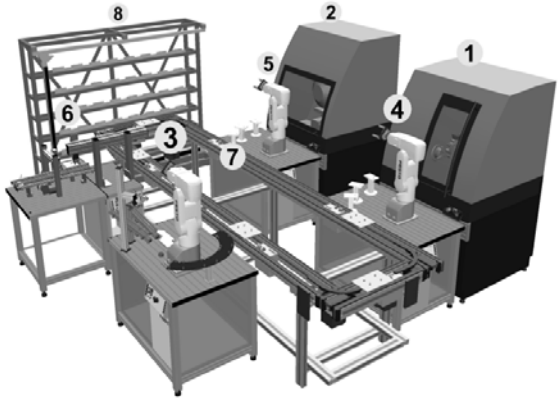

Figure 1. The 3D model of iCIM by FESTO [4, 5]
1-Concept Turn, 2-Concept Mill, 3-Flexible Robot Assembly Cells, 4,5-Service robots of concept machines , 6-Pallet Handling and Quality Station, 7-Pallet Transfer System, 8- Automatic Storage / Retrieval System

Transport system

In the whole system, transport system is responsible for the transport of work-pieces which are placed upon special work-piece carriers.

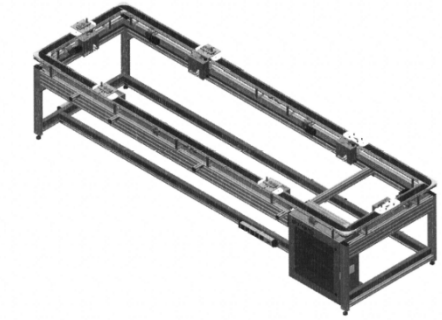

Figure 2. Transport system [4]

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Quality handling station

The quality handling station (fig. 3) is responsible for the work piece (pen holder) testing and the manual feeding of the system with pallets. The pallet handling is done by a linear handling and the testing is executed with an analogue positional transducer and additional camerasystem.[4, 5]

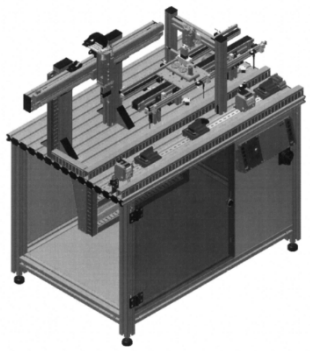

Figure 3. *Quality Handling station [4]*

Robot assembly station

The robot assembly station (fig. 4) has the function to assemble desksets, In dependence of the order, the robot assembles the desk set. Once the desk set has been assembled it is moved to the AS/RS station.

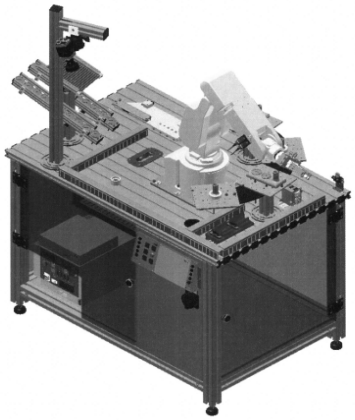

Figure 4. *Robot assembly station [4]*

Once desk set is to be assembled, the requiered paletts, comtaining the necessary components, are requested for placement onto the palette receptions [4, 5].

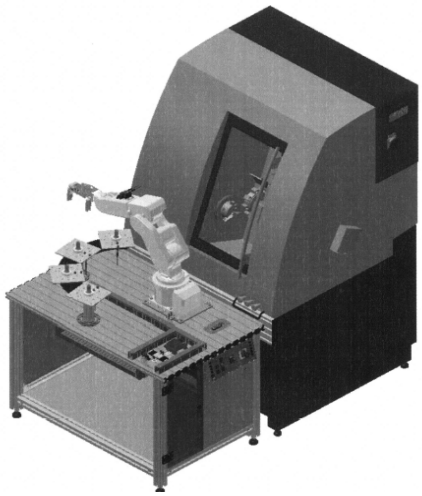

Figure 5. *CNC feeding Turn [4]*

CNC feeding turn

The CNC feeding turn (fig. 5) is responsible to production of single parts. The robot takes the raw parts from the magazines to equip the turn machine. There the workpieces are processed coresponding to their order. Before the workpiece is coming on the conveyor systems, the processed workpieces made available on pallets.[4, 5]

CNC feeding mill

The CNC feeding mill (fig. 6) is responsible to production of single parts. The robot takes the raw parts from the magazines to equip the milling machine. There the workpieces are processed corespondin to their order. Before the workpiece are coming on the conveyor systems, the processed workpieces made available on pallets.[4, 5]

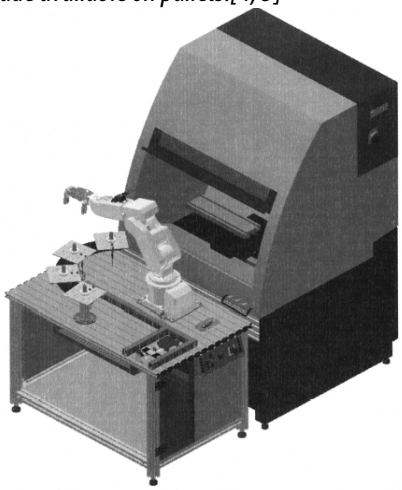

Figure 6. *CNC feeding Mill [4]*

AS/RS station

The AS-RS station (fig. 7.) has the function to provide and store the work-pieces and various paletts.[5]

Figure 7. *AS/RS station [4]*

Steps for implementation of drawingless manufactoring

For smart implementation of the drawingless manufacturing are there necessary to take some steps. These steps are presented below. In this paper is also presented the usage of the PMI information. This PMI information is necessary during the implementation of the drawingless manufacturing. Therefore we presents the smart way of its usage.

First step will be the analysis of the current state of drawingless production software package suitable for production in drawingless environments. The second step will be the creation of a general methodology for implementing drawingless production into FMS. The

next step will be the specification of measures necessary for the implementation of drawingless production in FMS. The last step is the verification and application of established methodology and set the drawingless production into the environment of iCIM system.[3]

We have to in frame of this implementation to prepare analysis of the state of art in field of the drawingless manufacturing. This analysis will focus to necessary hardware and software resources such an organizationally and technical requests for application. On the base of this analysis we will be to create general methodology for application of drawingless manufacturing to the practice. This methodology will be used in the conditions of the flexible manufacturing environment on our institute iCIM3000 presented before.[3]

Use of PMI information

Simple elimination of the risks and the ability to utilize all the information is to concentrate all the information concerning the product in a single source, which should be in my opinion, 3D model of the components. Nowadays the way to set possible manufacturing information into a 3D model, offers use of the PMI, or Product & Manufacturing Information. Possibility of creating PMI information now offer all major CAD systems and PMI information is gradually becoming part of the ISO and ASME standards (ISO 1101:2004, ASME Y14.41-2003).[1, 2]

The aim of the use of PMI is the transfer of a complete set of information necessary to produce the component directly into the 3D model. This information has to be then used in all downstream processes such as CAM, CAE, tolerance analysis, creation of brochures and other visualizations, etc. Finally, the PMI have to use the information to communicate with a supplier or customer in the form of so-called drawingless documentation.[1, 2]

PMI information must to be created and managed using a single module PMI. Tools for creating PMI information provides a comprehensive description of how to use the 3D model itself PMI size dimensions, which can add the necessary dimensional tolerances, and using geometric tolerances of form and position. Other area used to describe a 3D model with information, are PMI manufacturing information such as surface quality, or welding. Among the tools PMI must also find a wide range of tools to create notes that are otherwise shown on the drawings. Finally, the PMI module have to offer tools for creating 3D models of sections or slices that will allow a detailed description of the product.

Important features of all such generated PMI have to be the associativity of generated information of the objects on which the PMI information is created, so it is possible, for example one mark of quality like finishing assign the entire set of surfaces to be machined with the same quality. At the same time, must to be the logic of the individual instruments controlling derived from the tools, for the creating same information that are on the drawing, which makes the transition from 2D to 3D environment much easier.

Penetration of 3d model with PMI information

3D model have to carry the PMI information, serves as a document of controlled documentation, which is managed by the PLM system, providing full data management and control. Approval Data PLM system must be provided through a defined process so that it have to be traceable in every moment when is something happening with that document and what is his actually status.3D model through containing PMI information have to be the only bearer of comprehensive information about the shape, dimensions and manufacturing requirements of a product among all actors across its life cycle.

Communication of PMI data

The only reason why the drawings through the development process still created is its necessity for communication across the development process. This communication, however, today, in the electronic age becomes slow, error - simply out-dated. This chapter should focus on sharing electronic form PMI information between different actors in the development cycle.

It will start with the simplest model of communication, between the entities. These already have their work available to the appropriate imaging tools. These are CAD systems or other DMU systems - Digital Mock-up. These entities have the ability to share information with the support of PMI's own information system format, or PMI have the opportunity to share information via universal formats, such as JT, or STEP (AP242).

It may be a discrete entity that shares the mere discrete data, or it may be a cooperating entity based on controlled database of data.

Other problem is the shearing data with the subcontractors or partners who do not have access to the database, they are dependent on sharing discrete data, they nor have the tools to enable them to collaborate on the basis of information sharing PMI. Even in this case, now there is a very effective way of sharing data in the form of DMU browsers those companies such as Siemens provides free. These are for example browsers as browser JT2Go designed generally for any data in the JT format and viewer Xpress Review, intended for SW NX and Solid Edge development laboratories of Siemens.

The possibility of sharing data including PMI information is now only a matter of wanting to get away from, in my opinion, the obsolete model sharing information using drawings and embark on a new phase of electronic data sharing.

With the current state of computer technology, we are able not only to share this data, but also thanks to PLM systems to manage and control, which is fully completed the process refunds 2D documentation for 3D documentation.[2,4]

The formation rate of PMI information

The formation rate of PMI information is one of the cons of using PMI information. The next step I will show some principles which can the work with PMI information make easier and achieve clearly faster formation, against the creation using combination of the model with the drawing.

The first principle is to simplify. This means it is not necessary at all to create the 3D model information, as in the drawing, but only those which are important for the production, respectively to achieve the desired quality of the components, i.e. only tolerated and check dimensions, geometric tolerances, notes, and other surface quality. Then the number of PMI information decrease.

The second principle is the formation of PMI information already in the actual construction. PMI information is possible (and recommended) already defined in the design work, when designer has already had a clear idea of what requirements must be designed product accomplish. This enables to capture the information immediately at the time of the request. This prevents the complex procedure of inventing and re-thinking all dependencies when creating drawings.

The third method is the conversion of existing parameters. Acceleration of opportunities arises from the conversion of the existing parameters of the components. For example in system NX I will mark only the parameters that I want to convert then with the help of the context menu I will create the PMI information only from chosen parameters.

CONCLUSION

The aim of this paper is the description of iCIM3000 system, which is situated on our institute, and the further drawingless production methodology steps for its implementation.Categorization of these machines, which are presented in this paper, is the first step in the process.

The possibility of sharing data including PMI information is now only a matter of wanting to get away from, in my opinion, the obsolete model sharing information using drawings and embark on a new phase of electronic data sharing.

With the current state of computer technology, we are able not only to share this data, but also thanks to PLM systems to manage and control, which is fully completed by the process refunds 2D documentation for 3D documentation.

Acknowledgement

This paper will be created with support of the OPVaV-2008/2.2/01-SORO – 26220220055 – Laboratory of flexiblemanufacturing systems with robotized manipulation supported by no drawing production.

References

[1.] Košťal, P., Ružarovský, R., Holubek, R. (2014) Teória automatov. Automatizované výrobné a montážne systémy: AlumniPress, 2014. 177 s. ISBN 978-80-8096-194-7

[2.] Ružarovský, R., Holubek, R., Košťál, P., (2013) Novel Trends in Manufacturing systems with view on implementation possibilities of intelligent automation, 2013 World Academy of Science, Engineering and Technology International Journal of Mechanical, Industrial Science and Engineering Vol:7 No:8, 5 s. 109-113 s.

[3.] Grenčík, J., Stuchlý V. (2007) Flexyble manufactoring systems: EDIS, 2007. 47 s. ISBN 978-80-8070-667-8

[4.] Festo didactic GmbH & Co.KG (2013) Manual iCIM: January 2013. Denkendorf

[5.] Hankeová, N., Pecháček F. Description of maintenance activities on devices of computer integrated manufacturing. Academic Journal of Manufacturing Engineering Vol. 11, Iss. 3. s. 20--23. ISSN 1583-7904.

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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THE APPLICATION OF STATISTICAL AND MATHEMATICAL METHODS OF ANALYSIS TO REAL DATA PROCESSING OPERATION OF A BLAST FURNACE

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Abstract: The data collected for the analysis come from the F5 blast furnace from ARCELOR MITTAL Galati, are representative for a period of 30 days, in which he worked and furnace with coal powder injection on at the mouth of windy, to replace a quantity of metallurgical coke, fuel expensive and deficient. In this paper presents a model for application of statistical and mathematical processing real data of a blast furnace, the centralization of data, statistical and mathematical processing, trace correlation diagrams of the main process parameters and functions of significant performance, interpretation of the results.
Keywords: consumption coke, correlation, blast furnace, cast iron

INTRODUCTION

The data collected for the analysis come from the F5 blast furnace from ARCELOR MITTAL Galati, are representative for a period of 30 days, in which he worked and furnace with coal powder injection on at the mouth of windy, to replace a quantity of metallurgical coke, fuel expensive and deficient.

EXPERIMENTAL

For interpretation of results obtained from real data processing operation of a blast furnace from ARCELOR MITTAL Galati, have been used in mathematics and statistical methods of modern data processing.

RESULTS

The objective functions of the correlations were analyzed elected those technological indicators that have a connection and a significant implication on leveraging process iron in blast furnace [1,2,3], namely: daily production of pig iron; daily consumption of coke; specific consumption of fuel equivalent of physical technical; coke pulverized coal methane gas; coke-specific consumption; the yield of carbon dioxide in the gas furnace.

Technological parameters that have a notable influence on the performance of these functions and whose correlation with trial functions have been carried out and plotted were:

- the percentage of crowded, iron
- flow zone of air introduced into the furnace through the mouths of wind
- dust daily consumption of coal used as a substitute for coke,
- specific consumption slacking,-air temperature in a furnace, instilled
- content pig iron Silicon
- simply and complex basicity of ferrous sinter.

Table 1. Results obtained from real data processing operation of a blast furnace from ARCELOR MITTAL Galati

Dust coal comsumption kg/day	Technical coke consumption, kg/tpig iron	Daily production of pig iron t/day	Dust coal specifical consumption kg/tpig iron	Specific consumption of equivalent fuel kg/tpig iron
0	534	2392	0	534
64633	507	3469	18.6315941	525.6315941
25644	537	3151	8.13836877	545.1383688
318210	476	4347	73.2022084	549.2022084
367291	474	4490	81.8020044	555.8020045
368365	488	4658	79.0822241	567.0822241
354711	488	4600	77.1110869	565.111087
377001	496	4491	83.9458917	579.9458918
346822	478	4300	80.6562790	558.6562791
341380	487	4116	82.9397473	569.9397473
160856	544	3868	41.5863495	585.5863495
320664	472	4556	70.3827919	542.3827919
365907	469	4639	78.8762664	547.8762664
363706	456	4547	79.9881240	535.988124
366193	456	4663	78.531632	534.531632
361724	450	4609	78.4821002	528.4821002
365034	450	4701	77.6502871	527.6502872
367805	451	4589	80.1492699	531.14927
366306	451	4568	80.1895796	531.1895797
370388	469	4391	84.3516283	553.3516283
369281	442	4508	81.9168145	523.9168146
374979	445	4688	79.9869880	524.9869881
6716900	15145	128450	1497.60123	16642.60124
216674.1935	488.54838	4143.548	48.3097173	536.8581044

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Correlation charts, results are presented in figures 1-11 shown in R^2 values appearing on each chart between 0.20 and 0.9441 (which means the values of the coefficients occurring between 0,45 and confidence 0.99) that all the correlations can be admitted.

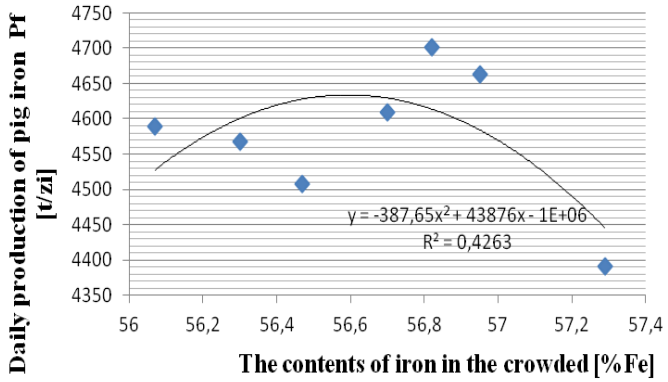

***Figure 1**. Correlation between daily production of pig iron and iron content of the crowded*

From the diagram presented in Figure 1 it is observed that an increase of the content of iron in crowded close to the optimal value of 56.6% leads to an increase in production of cast iron, because the same yield iron crossing of cargo in cast iron, a greater amount of iron in the blast furnace generates a greater amount of cast iron.

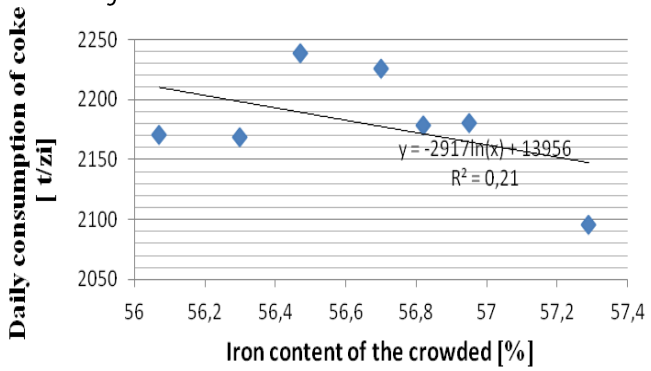

***Figure 2**. Correlation between daily consumption of coke and iron content of the crowded*

In the diagram presented in Figure 2, an increase of the content of iron in the crowded lead to a decrease in the daily consumption of coke, which is beneficial, but decreased conținutui of coke is better motivated by improving the Reducibility of indicators aglomeratului and its permeability.

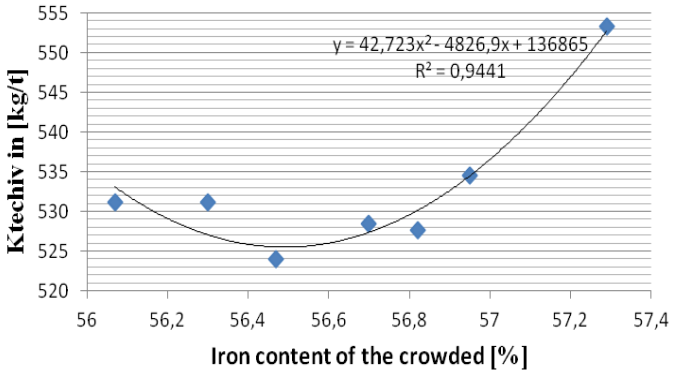

***Figure 3**. Correlation between daily consumption of fuel equivalent and the content of iron in crowded*

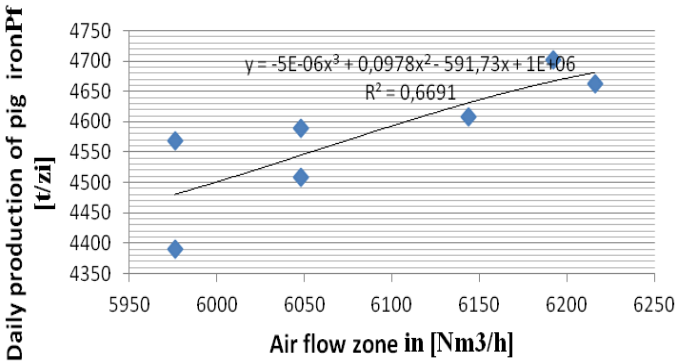

***Figure 4**. Correlation between daily production of cast iron and air flow zone*

In the diagram presented in Figure 3, an increasing content of iron in crowded at about 56%, has a favorable influence on consumption of fuel equivalent.

In the diagram presented in Figure 4, it is observed that an increase in air flow zone leads to increased production of pig iron, which is fully in line with the theoretical and technological logic because the air flow in the blast furnace is the engine of the furnace process.

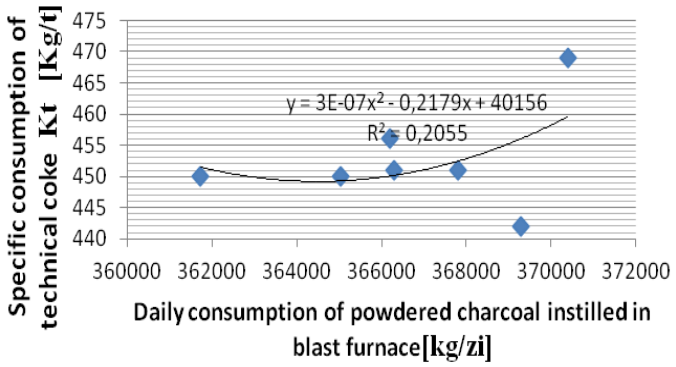

***Figure 5.** Correlation between the specific coke consumption technical Kt and daily consumption of powdered instilled in blast furnace*

In the diagram presented in Figure 5, it is observed that an increasing amount of slacking introduced daily until approx. 36400 kg/day has a favourable influence on the efficiency of process furnace in specific consumption downside of Coke.

In the diagram presented in Figure 6, it is observed that an increase in consumption of coal powder introduced in a furnace has a favourable influence on the efficiency of process furnace in specific consumption downside of Coke, since the aim of the introduction of dust coal fuel auxiliary role is just to replace a quantity of Coke.

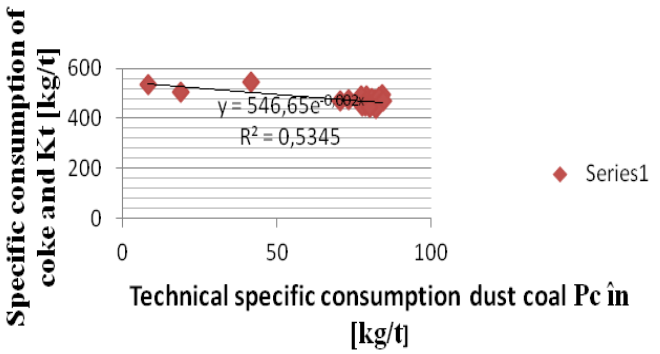

***Figure 6.** Correlation between the specific coke consumption Kt and technical specific consumption dust coal Pc*

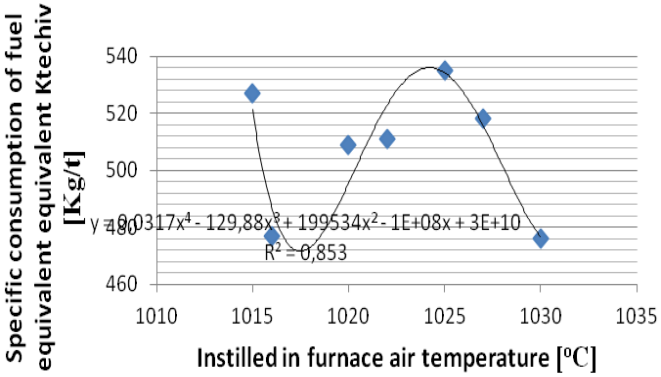

Figure 7. *Correlation between the specific consumption of fuel equivalent Ktechiv and instilled in furnace air temperature*

In the diagram presented in Figure 7, is observed that an increase in air temperature in the furnace up to a value of about 1018°C on the specific consumption of coke and specific consumption of fuel equivalent, what is explained by bringing a additional intake of heat due to air enthalpy, leads to a refilling of a quantity of heat which would derive from the combustion of a carbon amounts entered in a furnace with Coke, leading to lower consumption of coke or fuel equivalent.

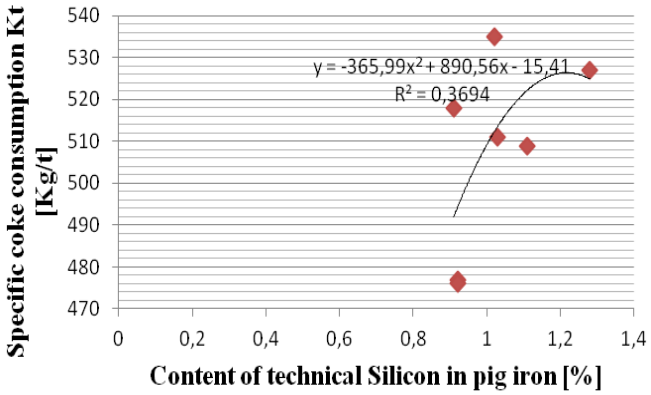

Figure 8. *Correlation between the specific coke consumption Kt and content of technical Silicon in pig iron*

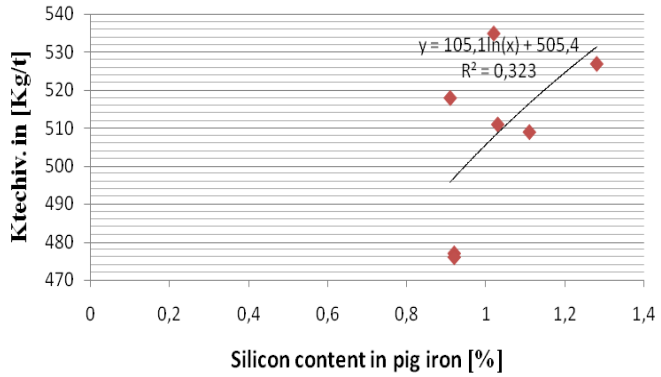

Figure 9. *Correlation between the specific consumption of fuel equivalent (coke + Kt technical slacking Pc) and Silicon content in pig iron*

In the diagrams presented in Figure 8 and 9 it is observed that an increasing percentage of the amount of Silicon in cast iron raises specific consumption of coke and fuel equivalent, which is explained by the fact that getting in Silicon cast iron is made from a strong endoterme reactions, who needs heat what can be ensured only by a greater amount of carbon in the load, retrieved from fuel, so a larger amount of fuel.

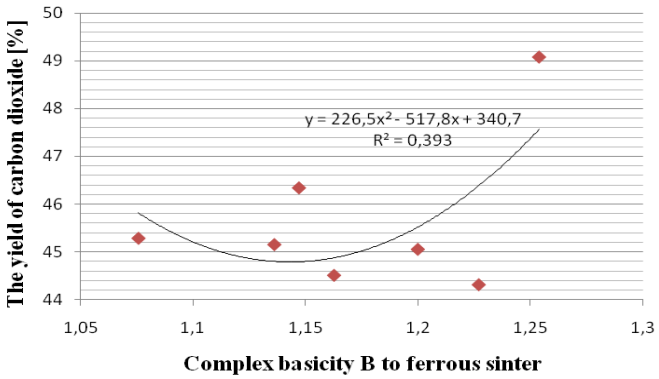

Figure 10. *Correlation between the yield of carbon dioxide in the gas furnace and complex bazicity B to ferrous sinter*

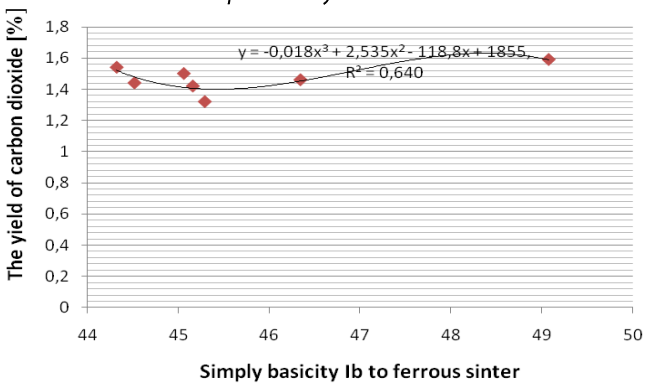

Figure 11. *Correlation between the yield of carbon dioxide in the gas furnace and simply bazicity Ib to ferrous sinter*

In the diagrams presented in Figure 10 and 11, argue it is noted that the value of the sinter ferrous basicity B over 1,15 or a simple basicity Ib over 46 leads to an increase in the efficiency of carbon dioxide in the gas furnace, which means a process of blast-furnace efficiency through effective use of the potential of reducing the gases inside the furnace, which means an increase in the share of indirect reductions with carbon oxide in a furnace and a decrease in the share of direct discounts and a decrease in the specific consumption of fuel to the furnace.

CONCLUSIONS

The analysis of correlation diagrams of the main factors and functions of performance of the process you can deduce the value ranges of variation factors of influence so that for performance functions to obtain the optimal technological values.

The conclusions drawn from the analysis of technological parameters and process functions derived from the calculation of the balance of materials and energy [4,5] to getting the first fusion iron furnace in F5 from Galati in the reporting period are as follows:

- *Load furnace was of good quality, consisting of crowded, pellets and Brazil ore with high content of Fe. Basicity index has remained constant (almost 1).*
- *Blast furnace operation was characterized by a number of stops (small repairs, a low number of hours of work (lack of raw materials, less intensive operation of converters)), which led to a value of index use of time of the order of 95-97%. Under the conditions shown, utilization of production capacity of blast furnace no. 5 ARCELOR MITTAL Galati was 80-85%.*

- *Of technological calculations made on the basis of oxides reduction processes of Fe took place in favourable conditions due to the fact that the operation of the blast furnace was not forced, size of sinteri and pellets loaded and good quality of the value in use (in terms of resistance and size). $\eta_{CO} = 53$ %, comparable to what η was achieved a yield of carbon monoxide is accomplished at blast furnaces with very good indicators.*

Acknowledgement:

This work is supported by the Sectoral Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and the Romanian Government under the POSDRU 2014/ Cod Contract: 134398.

REFERENCES

[1.]Nicolae CONSTANTIN, V. Geantă, D. Bunea, R. Şaban: "Metode analitice şi grafice pentru determinarea rapidă a consumurilor de cocs la furnale în cazul utilizării diverşilor combustibili auxiliari." - revista Metalurgia, nr. 9 - 12, 1990, pag 444-448, ISSN 0461-9579

[2.]Nicolae CONSTANTIN, V. Geantă, R. Şaban, D. Bunea: "Stabilireaprin modelare matematică a consumului teoretic optim de cocs la furnale, în funcție de componența încărcăturii."- revista Metalurgia, nr. 6, 1991, pag14-17, ISSN 0461-9579

[3.]Nicolae CONSTANTIN, Diana Ioniță, Augustin Semenescu, Cristian Viorel Semenescu „Metode analitice pentru eficientizarea elaborării fontei în furnal prin corelare aoptimă a consumului de cocs cu parametrii de suflare la gurile de vânt" – revista Metalurgia, nr.6, 2003, pag. 5-12, ISSN 0461-9579

[4.]Nicolae CONSTANTIN, Diana Ioniță, Augustin Semenescu, Cristian Viorel Semenescu, Mircea Costache „Eficientizarea producerii fontei de prima fuziune prin conducerea asistata de calculator a procesului de elaborare a fontei în furnal. Partea I-a. Realizarea modelului matematic de conducere asistata de calculator a procesului de elaborare a fontei în furnal. Realizarea aplicatiei software "calcul furnal", revista Metalurgia, nr. 7, 2003, pag. 17-28, ISSN 0461-9579

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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CHARACTERISTICS OF THE BULGARIAN ORGANIC AGRICULTURE

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Abstract: *The organic agriculture fuses traditions and innovation for providing fair relationships and a better quality of life for all stakeholders. In Bulgaria, the interest towards this holistic production management system is increasing in the last two decades. The favourable environmental conditions of the country provide excellent basis for organic sector development, which is attested by the main indexes. Beside this, the organic agriculture has become one of the priorities of the Bulgarian agricultural policy with an emerging (EU and national) legal, political and institutional background. This article reviews the evolvement of the Bulgarian organic sector and summarizes its threats and opportunities of a future development.*
Keywords: *Organic Agriculture, Bulgaria, organic land, organic product market, sustainability*

INTRODUCTION

The modern agriculture has two major challenges – to provide the necessary food supply to satisfy the needs of the ever-growing human population on one hand and to reduce the sector's negative impacts on the environment on the other hand. The solution is to develop the agriculture in a sustainable way. Apparently organic agriculture is one of the possible means for that.

Many different definitions of organic agriculture are known, but these contain one common characteristic: it is a system that relies on ecosystem management rather than external agricultural inputs, consequently produces more public goods than the conventional ones. FAO defines the organic agriculture as "a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity" It takes into account that the local systems have to be adapted to the regional conditions, which "is accomplished by using, where possible agronomic, biological and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system." (FAO/WHO, 1999). „ Organic Agriculture combines tradition, innovation and science to benefit to shared environment and promote fair relationship and good quality of life for all involved. " (IFOAM, 2010). In the last thirty years the organic agriculture has gained popularity worldwide, but while in some countries it is only a niche, in others, as the leading European countries, it is getting more and more widespread. (Niggli, 2014)

According to the definition of the USDA National Organic Standards Board, the organic agriculture is an "ecological production management system that promotes and enhance biodiversity, biological cycles and soil biological activity", which is "based on management practices that restore, maintain and enhance ecological harmony." (Gold and Gates 2007).

The organic agriculture's roots go back to the second-third decade of the 20th century, but internationally it has been officially recognised by the Codex Alimentarius Commission (CAC) elaborating in 1991 guidelines in this field (Gomiero at al., 2011). It was not a coincidence that the organic farming movement raised the attention of the consumers in the 1990s as the public concern for the environment and food quality increased. That has undergone national and international institutional regulation (Willer and Yussefi, 2006). It is important to emphasise that although sustainable agriculture practices are adopted by a growing number of farmers, only the organic agriculture is regulated by laws and a specific set of norms is needed to be strictly followed (Gomiero et al., 2011). That characteristic is a strength, however it is represents the risk of the excessive bureaucratic control as well, which can cause economic difficulties for the farmers (Vogl et al., 2005).

Organic agriculture is regulated by international and national institutional bodies, which certify organic products from production to handling and processing (Courville, 2006; EC, 2007; IFOAM, 2008; 2010). Organic agriculture restores a decision-making role to local communities, guaranteeing the right of control over their own resources and engaging their active participation in a value added food chain (Juma, 2007).

THE LEGISLATION OF THE EUROPEAN UNION

In 2007 Bulgaria became a member of the EU, so its regulation is decisive for the Bulgarian organic farming. The following outlines the legal context in a nutshell.

The first EU legislation on organic farming was adopted in 1991. The Council Regulation (EEC) No 2092/91 was in line with the requirements in the CAC Guidelines. The Regulation provided the legal definition of organic farming determining production, control and labelling requirements and rules for importing organic products. The Council Regulation (EC) No 1804/99 which supplemented the original regulation with the rules for the organic livestock and livestock produce. After

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substantially revised, this Regulation has been replaced by the Council Regulation (EC) No 834/2007, which provides a comprehensive framework for the organic farming. It defines in detail not only the methods of production for organic crops and livestock, but also regulates the labelling, processing, inspection and marketing of organic products on the single market and the importation of the organic products from third countries.

On 24 March 2014 the European Commission adopted the legislative proposals for a new Regulation on organic production and labelling of organic products aiming to adjust the EU legislation to the current situation in the EU organic market (COM, 2014). The new regulation is also needed because it is necessary to provide consistency with the new CAP. An overarching objective of the new CAP adopted in 2013 is the sustainable competitiveness to achieve an economically viable food production sector with sustainable management of the land-based resources. The organic farms will benefit from the "greening" component (a payment under the I. pillar received by farmers for delivering environmental benefits beyond the basic requirements). The Rural Development measures will more widely address organic farming during the period 2014-2020. Among others there is a new measure for supporting organic farming through compensation for additional costs or income foregone resulting from the organic conversion or management, or for developing innovative products, processes, practices or technologies, or for cooperation among actors of the food chain. On the other hand the financial resources for rural development remain disproportional compared to the direct payments, which implies that a radical shift to more sustainable farming systems has not happened yet. Nevertheless, the new CAP is more oriented towards a better public good delivery and an enhanced visibility of the organic farming that can contribute to its development (Meredith et al., 2014).

DEVELOPMENT OF THE ORGANIC AGRICULTURE IN BULGARIA

In Bulgaria the environmental resources and conditions are appropriate for agricultural activities, including organic farming. According to the data from the Ministry of Agriculture and Food (MAF) 80% of the agricultural area is favourable for organic farming.

Unlike other developed countries where the soil pollution is much higher than permissible and in which to fulfil the criteria of organic farming raise extra costs, some Bulgarian regions provide almost free opportunities for it.

In Bulgaria after the comprehension of the concept of organic farming by an academic community on the field of plant protection in the late 1980s, the organic agriculture can be dated from the early nineties. In 1993 the first organic pilot farm at the Agrarian University of Plovdiv[1] was established. Between 1996 and 2000 the first activities on this field, such as trainings for farmers, literature release, preparation of the legal framework, were made. In this period started the "Development of organic farming in the Central Balkan Region", financed by the Swiss Agency for Development and Cooperation (SDC) and implemented by the Research Institute of Organic Agriculture (FiBL) and the Foundation for Organic Agriculture Bioselena[2]. In this period were adopted the Law on plant protection promulgated in State Gazette 91/10.10.1997, the Law on foodstuff promulgated in State Gazette 90/15.10.1999 and the Law on animal husbandry promulgated in State Gazette 68/8.8.2000 (all amended in 2004). In the next period, from 2000 to 2004 was published the national organic legislation (Ordinance No 22, promulgated in State Gazette 63/3.8.2001, on organic production of plants, plant products and foodstuffs of plant origin and indicators referring thereto on them and Ordinance No 35, promulgated in State Gazette 80/18.9.2001, on organic production of livestock, livestock products and foodstuffs of animal origin and indicators referring thereto on them). The first organic certification was given in 2001, and the first specialised organic shop opened in Sofia in 2004. From 2005 when the organic food appeared for the first time in the shops of Sofia until 2008, the number of shops selling organic products has passed 1500 throughout the country. (That is the so-called "organic boom".) One year after the accession of Bulgaria to the EU, in 2008 the first compensatory payments for organic farming became available under measure 214 of the national rural development programme. In 2009 the Bulgarian Organic Farmers' Association was established. Even in the period of economic crisis the development, the consolidation of Bulgarian organic agriculture has continued. The evidence for that is the growth realised in 2009-2010 – e.g. the certified land has doubled and the number of operators has increased by 76 %.

It should be emphasised that the driving forces of the Bulgarian organic agriculture's development were internal (agrarian academic circle, NGOs and organic operators) and external (international – foreign programs and organizations) (Stoeva et al, 2014a). In this top-down model the external forces contributed to institutionalization of the organic agriculture in Bulgaria in the middle of nineties by providing financing resources (Swiss government), human resources and capacity building (FiBL) for policy and institutions development. The Organic Farming sector was not initiated by the Bulgarian state[3] and it was not established by farmers' organisations neither.[4] This without a doubt influenced the support of the Bulgarian Organic agriculture. Another characteristic to be underlined is that the representatives of the academic sphere and the consultancy circles played a key role in setting up the national legislation (Stoeva et al., 2014b).

The fact that until 2005 there was no real domestic financial support to the organic farmers is in relation with the above-mentioned particularity concerning the emergence of Organic agriculture in Bulgaria. The small scale support for organic farming in the period before the accession to the EU was provided by international donors, mainly by the Swiss Agency for development and cooperation. In the period 2007-2013 (and currently) the support for organic farming is carried out under the EU Rural Development Program, most directly under Measure 214 "Agro-

[1] *The Agriecological Centre is established at the Agricultural University of Plovdiv in 1987.*
[2] *The Foundation for Organic Agriculture Bioselena is a non-government organisation, established in 1997 by FiBL.*
[3] *As e.g. in the case of Poland.*
[4] *As e.g. in the case of Hungary.*

ecological payments" (which includes subsidies for organic crops, animals and beehives). The farmers – formally certified or in the process of convergence - receive annual payments in a five-year period of an 82% EU co-funding. It has to be noted, that the payments under the Measure 214 are lower compared to other EU Member States. The problem is that because of the minimum size-area requirement (0.5 ha) the small-scale organic farmers (thus near three quarters of all) are not eligible for these subsidies (Kayryakov, 2010). Other possibilities for organic agriculture funding is also Measure 121 "Modernisation of agricultural holdings" (only 5% of that is consecrated to transition from conventional to organic farming), Measure 142 "Setting up producer group" and 111 "Vocational training, information and dissemination of scientific knowledge".

The National Plan for Organic Sector (2007-2013) aimed to achieve 8% of agricultural land under organic farming by 2013 (from 0.3% in 2005) and 3% share of organic food on the market (MAF, 2006).

In the last fifteen years this "young" sector was recognised by the EU and national policies were developed, which provides an economic framework for the agribusiness and creates the conditions for development of the sector as a whole and alternative forms of production such the organic farming (Nikolova, 2013).

As mentioned above the new CAP expectedly will stimulate better the organic farmers, with regard to the target for CAP greening and the new RDP, but there is still no official information from the MAF about the latter. Subsidies varying from 160 to 514 €/ha depending on the crops are expected (USDA, 2014).

THE BULGARIAN ORGANIC AGRICULTURE IN NUMBERS

The 2005-2012 period can be described by the steady growth of the arable area used for organic farming in Bulgaria. While its increase from 2005 to 2006 was almost doubled, in 2007 was became tripled, probably due to the accession to the EU among other factors. (Figure 1)

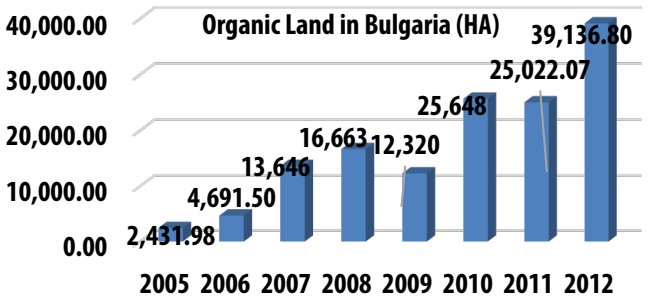

Figure 1. *Source: FiBL&IFOAM*

Table 1*. Fully converted organic area and area under conversion (HA)*

	2006	2007	2008	2009	2010	2011	2012
Fully converted organic area	2 728	8 387	4 236	4 955	12 691	8 902	11 974
Area under conversion	1 964	5 260	12 427	7 365	12 956	16 120	27 164

Source: Eurostat, 2014

According to USDA (2014) an interesting evolution has to be noted in the fast growth of the area under conversion into organic production, compared to the fully converted area as well in the 2006-2012 period. (Table 1). That can be explained by the larger number of start-up organic farms in 2011-2012.

The increasing number of organic operators – farmers, processors and traders – in Bulgaria is presented in Figure 2. The growth was especially spectacular in the period from 2009 to 2012, when this number moved from 446 to 2754. The significant increase of this indicator demonstrates the growing interest in the organic sector.

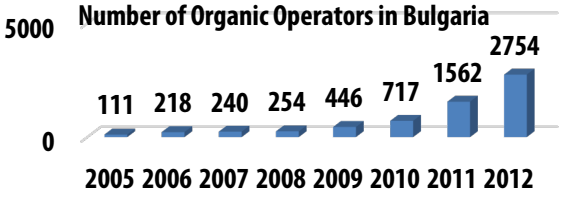

Figure 2*. Source: Bioselena and FiBL&IFOAM*

The share of the organic product market is still modest, but in progress (except the decline in 2009 due to the economic crisis). While the index value was 0.05 % of the total food market in 2005, since 2007 rapid growth can be observed and in 2012 it attainted 1.28%. (Figure 3.) In absence of official data on sales in Bulgaria, the market for organic products is estimated between 6 to 8 million euros (800 000 euros in 2005, 5 million euros in 2008 and 7 million euros in 2010 (Bioselena 2009; FiBL&IFOAM, 2013, 2014).

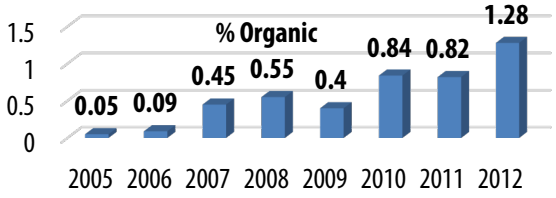

Figure 3*. Source: FiBL&IFOAM*

CONCLUSIONS

Although the Bulgarian organic agriculture is in progress for a few years, the number of producers, operating mostly on small farms, still remains limited (MAF, 2013). The main motivation is to receive subsidies and not the attractiveness of the organic concept or the willingness to respond to the market demand. Presumably, e.g. the support in the three year-conversion period is attractive for the farms, but there is not guarantee that this conversion would be achieved. Another problem in this regard is also that the subsidies are provided per area and there is no obligation and surveillance of the actually produced organic products. On this basis the correlation between increasing organic area and the organic produce volume becomes questionable.

The small domestic market of the organic products is undoubtedly an obstacle for the development of this sector. Partly that is linked to the fact, that for most Bulgarian households low-priced fresh domestic products are available. In Bulgaria the categories "domestic" and "organic" are blurred, while the prices of these are significantly different. The organic is a kind of a "luxury" product, therefore inaccessible for most Bulgarians because of their low income. On the other hand the limited demand of the organic products is due to the low public awareness and the lack of reliable information concerning the organic farming.

One of principal challenges for the Bulgarian organic sector is the organic animal husbandry (five farms in 2012), which can be explained with the lack of financial support (no subsidies for breeding and certification).

The organic production (90-95%) is mostly sold on the international market principally as raw materials and not as processed products. (The Bulgarian top export products are dried wild forest fruits and herbs, frozen fruits – strawberries, raspberries, blueberries, essential oils from rose, lavender and mint, and honey.) At the same time over 80% of the organic products on the local market is imported from the EU. Moreover good Bulgarian brands are missing both on of the domestic and the international market.

The organic agriculture in Bulgaria has a great development potential, firstly because of the quite favourable agro-ecological conditions. In addition, the above mentioned weaknesses of the Bulgarian organic sector could be transformed in strengths (e. g. creating and promoting competitive Bulgarian organic brands; exporting processed organic products). The national legislation laid down the basis of organic farming and on general terms it is synchronized with the EU legislation. As mentioned above, an ambitious National Plan for Development of Organic Farming in Bulgaria was adopted and followed in 2007-2013. Otherwise, it is needed to rethink these goals, because although the area under organic farming and the number of organic sector operators have increased, according to current estimates the value of both indexes remain below/ around 1%.

However, for the development of the Bulgarian Organic agriculture is important to strengthen the motivation for organic farming by higher support with more targeted measures and by simplifying application procedures for subsidies. It is needed to strengthen the link between the production and the market, and to transform the organic farming from a passive economic activity (only subsidy-oriented) to a new market-oriented type of farming.

References:

[1.] *Bioselena (2009): Bulgarian Organic sector survey 2009.*

[2.] *Courville, S. (2006): Organic Standards and certification. In Organic Agriculture A Global Perspective. pp. 201-220. Kristiansen, P., Taji, A., and Reganold, J. (Eds.), CSIRO Publishing, Collingwood, Australia.*

[3.] *EC (European Commission) (2007): Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092.*

[4.] *FiBL&IFOAM (2013): The World of Organic Agriculture. Statistics and emerging trends 2013. Frick and Bonn. https://www.fibl.org/fileadmin/documents/shop/1606-organic-world-2013.pdf (accessed on 07.12.2014)*

[5.] *FiBL&IFOAM (2014): The World of Organic Agriculture. Statistics and emerging trends 2014. Frick and Bonn. https://www.fibl.org/fileadmin/documents/shop/1636-organic-world-2014.pdf (accessed on 03.12.2014)*

[6.] *Gold, M. V., Gates J. P. (2007): Tracing the evolution of organic/sustainable agriculture: A selected and annotated bibliography. http://www.nal.usda.gov/afsic/pubs/tracing/tracing.shtml (accessed on 12.12.2014)*

[7.] *Gomiero, T., Pimentel, D., and Paoletti, M.G. (2011): Environmental impact of Different Agricultural Management Practices: Conventional vs. Organic Agriculture. Critical Reviews in Plant Sciences, 30, pp. 95-124.*

[8.] *Gomiero, T., Pimentel, D., and Paoletti, M.G. (2011): Is there a Need for a More Sustainable Agriculture? Critical Reviews in Plant Sciences, 30, pp. 6-23*

[9.] *IFOAM (International Movement of Organic Agriculture Movements) (2008): Annual report 2008. http://www.ifoam.bio/sites/default/files/page/files/ifoam_annual_report_2008.pdf*

[10.] *IFOAM (International Movement of Organic Agriculture Movements) (2010): Definition of Organic Agriculture. http://www.ifoam.org/growing organic/definitions/doa/index.html (accessed on 13.01.2015)*

[11.] *Juma, M.A. (2007): IFOAM's Perspectives on Organic Agriculture, Food Security and Sovereignty. International Conference on Organic Agriculture and Food Security. FAO, Italy. OFS/2007/INF, pp. 5-7*

[12.] *Kayryakov, N. (2010): Development of Organic Farming in Bulgaria. Trakia Journal of Sciences, 8(3), pp. 147-152*

[13.] *Meredith, S and Willer, H. (Eds.) (2014): Organic in Europe. Prospects and development. IFOAM EU Group, Brussels.*

[14.] *Ministry of Agriculture and Food (2006): National Plan for Development of Organic Farming in Bulgaria. http://www.mzh.government.bg/MZH/Libraries/Organic_Farming/NOFAP_FINAL_en.sflb.ashx*

[15.] *Ministry of Agriculture and Food (2013): Annual Report on the situation and development of agriculture. (Agrarian Report 2013) http://www.mzh.government.bg/MZH/Libraries/AgryReports/2012.sflb.ashx, pp 53-59 (accessed on 10.01.2015)*

[16.] *Niggli, U. (2014): Sustainability of organic food production: challenges and innovations. Proceedings of the Nutrition Society, pp. 1-6; http://europepmc.org/abstract/med/25221987 (accessed on 12.12.2014)*

[17.] *Nikolova, M. (2013): Motivacia za razvitie i efekti ot deinostta na biologochno stopanstvo. (Motivation for development and effects of Organic Farming.) Dialog, 2. pp. 18-31*

[18.] *Stoeva, S., Slavova, P. and Georgieva, Z. (2014a): Development of the Organic Sector in Post-Socialist Bulgaria 1990-2013. In: Rahmann, G. & Aksoy, U. (Eds.) (2014): Proceedings of the 4th ISOFAR Scientific Conference "Building the Bridges". Organic World Congress 2014, 13-15 Oct., Istanbul, Turkey, pp. 93-95.*

[19.] *Stoeva, S., Slavova, P. and Georgieva, Z. (2014b): Organic Farming in Bulgaria: Social and Political Aspects. http://www.arc2020.eu/front/2014/12/organic-farming-the-role-of-the-state-and-eu-subsidies/ (accessed on 05.01.2015)*

[20.] *USDA (2014): GAIN Report. Organic Sector Update. BU 1405.*

[21.] *Vogl, C.R., Kilcher, L. and Hanspeter, S. (2005): Are Standards and Regulations of Organic Farming moving away from Small Farmers' Knowledge? Journal of Sustainable Agriculture. 26(1), pp. 5-26, http://orgprints.org/5448/1/J064v26n01_03.pdf (accessed on 15.01.2014)*

[22.] *Willer, H. and Yussefi, (2006): The world of organic agriculture: Statistics and emerging trends. International Federation of Organic Agriculture Movements (IFOAM), Bonn.*

ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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A MODERN APPROACH TO TIED-ARCH BRIDGE ANALYSIS AND DESIGN

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Abstract: *One of the main feature of the arch bridge is the transmission of external forces to arch ends. When arches are situated under the deck, these external forces are transmitted directly to the land, imposing land with high load capacity and high costs of foundations. In order to reduce foundation costs, tied-arch bridges use the deck to take the role as the tension member taking the forces generated in the ends which make this solution more suitable for openings between 70-200 meters distance range where other type of bridges require large sections or other support systems such as stay cables. The general layout of the hangers have been greatly improved with the development of modern computing technology. The purpose of this paper is to investigate the influence of different hanger arrangements using three-dimensional finite element models and the objective was to determine the most suitable solution for a road bridge, with a span of 100 meters, consisting of two inclined steel arches, located on a road with two traffic lanes, subjected to medium traffic.*
Keywords: *Tied-arch bridge, hangers, efforts, tension*

INTRODUCTION

This paper aims to identify the influence of different hanger arrangements for a tied arch bridge with respect to all the variables such as: efforts in arches, ties and hangers.

The tied arch bridges appear in different hanger layouts. The general layout of the hangers have been greatly improved with the development of modern computing technology. Understanding of the behavior of structures with large number of static indeterminacy was conditioned by the development of computers.

Depending on the inclination of hangers for tied arch bridges, in the analysis we considered three different arrangements, as follows:

≡ ***Langer system*** *which requires a deck with high rigidity, who plays the role of a tie for the flexible arches. The deck is suspended by vertical hangers.*

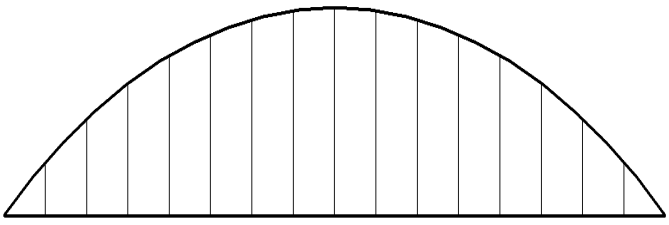

Figure 1*. Tied arch bridge with Langer configuration of hangers*

≡ ***Nielsen system*** *which consists of a single rigid beam, reinforced with a system of hangers. In this system, the hangers are inclined and work as a variable-section truss with rigid bottom "flange". Nielsen system, patented by Danish engineer Octavius F. Nielsen in 1926, was used in the construction of over 60 bridges at that time.*

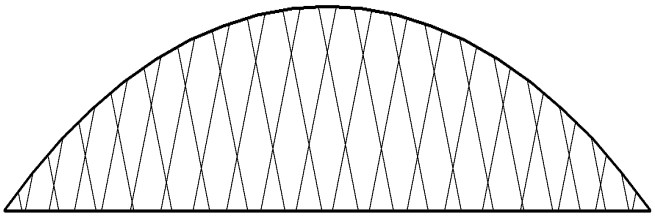

Figure 2*. Tied arch bridge with Nielsen configuration of hangers*

≡ ***The network of inclined hangers*** *as an improved version of the Nielsen system, with the exception that in this case the hangers cross each other at least once. This arrangement of the hangers determine very slender structures and thus reduced material consumption. Inclined hanger network system was patented by Professor Per Tveit from Norway in the 1950s, from the study of the distribution of bending moment bridges Nielsen system.*

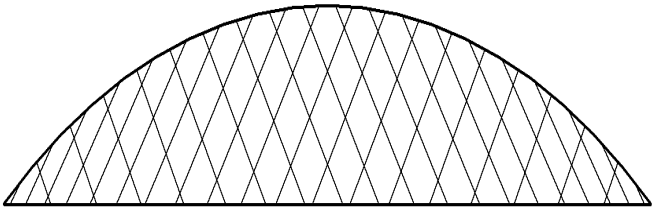

Figure 3*. Tied arch bridge with network configuration of hangers*

Defining parameters to identify the most effective hanger arrangement requires a complex process that involves several variables such as cost, aesthetics, efficiency and some of the local constraints imposed by landscape. Regarding hangers, the demanding criterion is to reduce the number of the compressed hangers and to reduce the maximum axial force in them.

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FIRST ORDER STRUCTURAL ANALYSIS

An analysis was made for a road bridge with 100 meters span consisting of two circular hollow steel arches with a radius of 82 meters and a maximum height of 17 meters, connected at ends by circular hollow section tie-beams. The arches are inclined inward 15 degrees after the tie-beam axis. Arches are connected at the bottom by means of variable height double T section crossbeams positioned at equal distance of 5 meters and at the top are connected by means of circular hollow sections bracings. A reinforced concrete top slab linked by elastic connectors to the crossbeams completes the composite deck.

Hangers were modeled as rigid bar type elements to evaluate the first order efforts. For this study we considered two types of hangers: the rigid tension rod, and Parallel Wire Strand elastic type hanger. Both links at the top with arches, and bottom with tie beams are pined through fork connectors. Each rod is applied an initial unit pretension force. Conditioned by vertical movement of the deck, the tension must be adjusted properly afterwards.

Vertical hanger system (Langer system)

In this configuration the compression forces in the arch increases with the number of hangers. It was observed that with increasing number of hangers, compression increases in the arches, while the shear force decreases, but the number of the hangers did not significantly affect the variation of axial force of arches. Bending moment decreases with the increasing number of hangers, and this difference is remarkable when the number of hangers is lower and the bending moments in the arch grow rapidly.

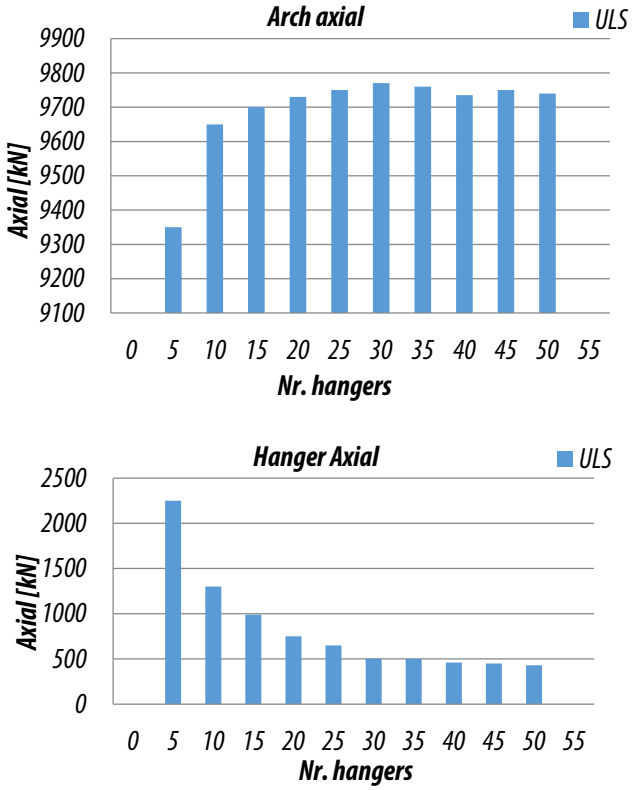


Figure 4. *Variation of axial force at Ultimate Limit State in arch and hangers for a tied arch bridge of 100 m span with vertical hanger system depending on the number of hangers*

The tie beam axial efforts variations do not appear in the system with vertical hangers, but the hanger number variation significantly influences the bending moment in the beam because the hangers play the role of elastic supports for tie beam.

In this configuration the bending moment dictate the arch sections and the best results for the 100 meters span studied was found for the 20 hanger configuration.

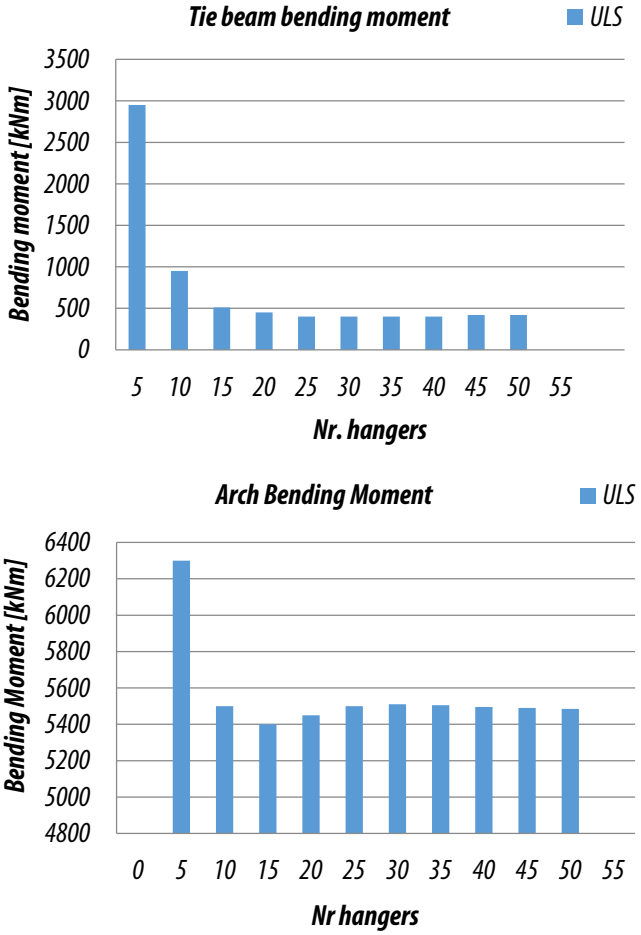


Figure 5. *Bending moment variation at Ultimate Limit State in arch and tie beam for a tied arch bridge of 100 m span with vertical hanger system depending on the number of hangers*

As a consequence, in the arch with vertical hangers, bending is a decisive factor when it comes to the choice of the cross-section of the chords.

Inclined hanger system with constant slope (Nielsen system)

To simplify the manufacturing process and for a uniform distribution of the moment, and to reduce the buckling length in many cases the hangers are disposed at equal distances along the arc. In this case, the unknowns are the locations of nodes on the tie beam. An alternative is to arrange the hangers at equal distances along the tie beam and the arc node locations are the unknowns.

In this system, the hangers are disposed at equal distances along the arches. Angle with the horizontal plane was set 40 degrees.

Relaxed hangers number is relatively high in this way arrangement. As with the horizontal angle is greater, the higher the number of the relaxed hangers. In each case analyzed the hangers at the ends are always relaxed.

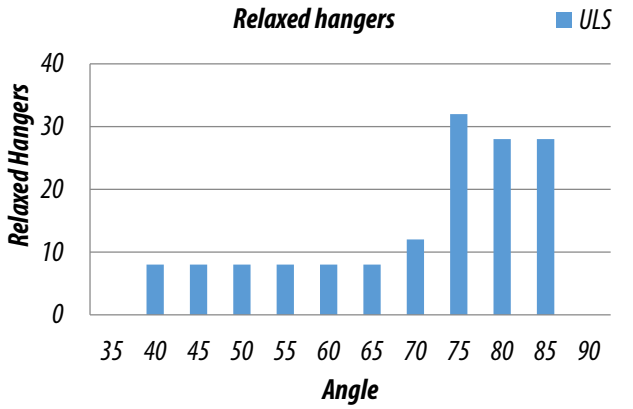
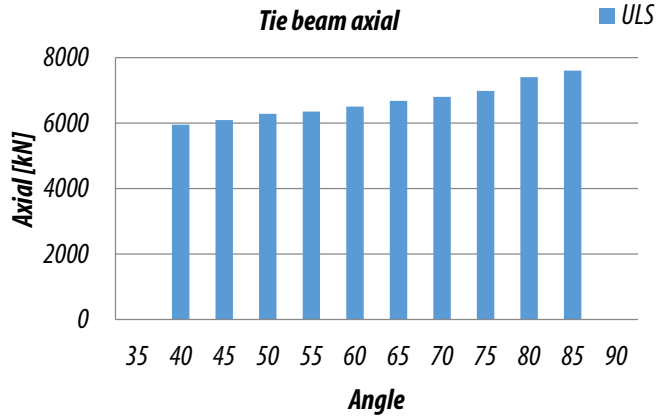


Figure 6. *Variation of axial force in hangers and number of relaxed hangers at Ultimate Limit State for a tied arch bridge of 100 m span with inclined hangers with constant inclination depending on the inclination angle*



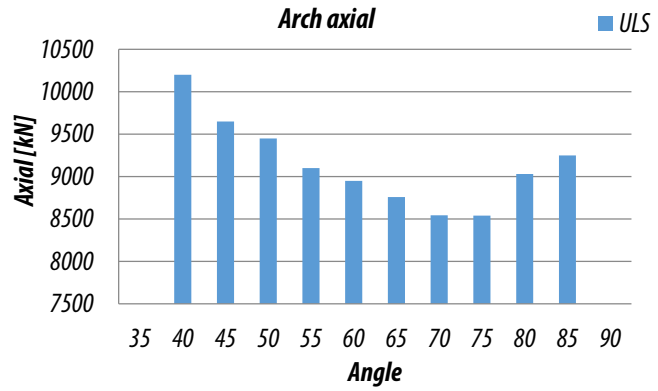
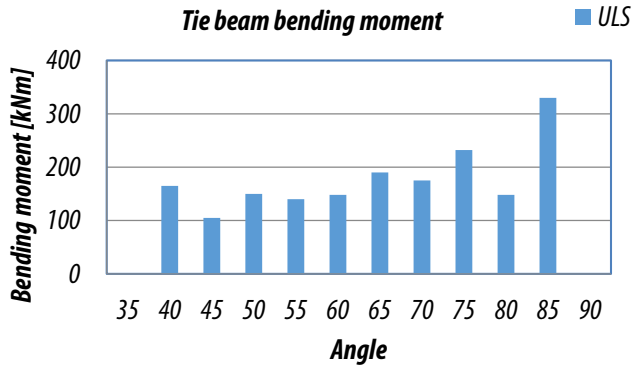


Figure 7. *Variation of axial force at Ultimate Limit State in arch and tie beam for a tied arch bridge of 100 m span with inclined hangers with constant inclination depending on the inclination angle*



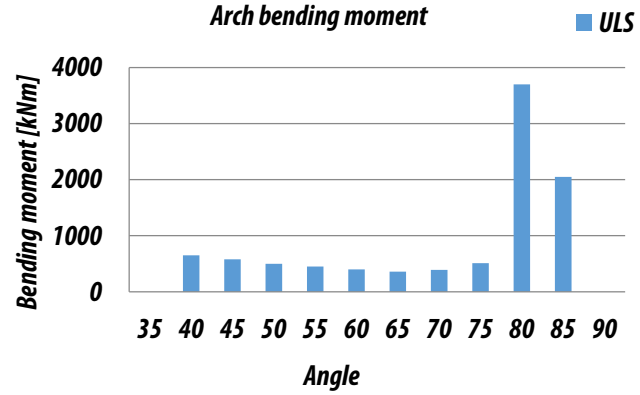


Figure 8. *Bending moment variation at Ultimate Limit State in arch and tie beam for a tied arch bridge of 100 m span with inclined hangers with constant inclination depending on the inclination angle*

Arch compression tends to decrease with the increasing angle to the horizontal plane. This is explained by the fact that more inclined hangers are less tensioned, due to the small horizontal component of the force. The range most effective for this opening is between 60 to 80 degrees. Bending moments in arches indicate that the suspensions above 75 degrees inclinations involves large bending moments in arches.

Tie beam axial force tend to increase with the increasing angle while bending moment is influenced only by the angles over 70 degrees.

As a conclusion to this configuration, the lighter the bridge, more inclined hangers are necessary and more hangers are relaxed. Still, this configuration determine sections that lead to about 40% smaller material consumption than in the vertical arrangement of hangers.

Inclined hanger system with variable slope (Nielsen system)

Unlike Nielsen system, in this system inclined hangers cross each other at least twice. In general this type of arrangement leads to lower consumption of materials and slender structures. In Langer system the asymmetric load produce considerable deformations in both arches and tie beams, while using the inclined system with variable slope can see deformations only on the tie beam which means a better distribution of efforts in the arch.

Favorable behavior of this system is due to the rigidity of the network of hangers and often transverse bending moments are greater than the longitudinal.

This method follows the same concept as the previous system. Unlike constant inclination system, in this system the slope of each rod is variable by a linear function.

An optimization of the "wheel spokes" is documented and Schanack Brunn, who concluded that if every hanger decomposes in two hangers and the resultant hanger forces pairs is orientated toward the center of the circle of which the arc as shown by below. In this case, the only variable involved is the angle between adjacent hangers at their intersection.

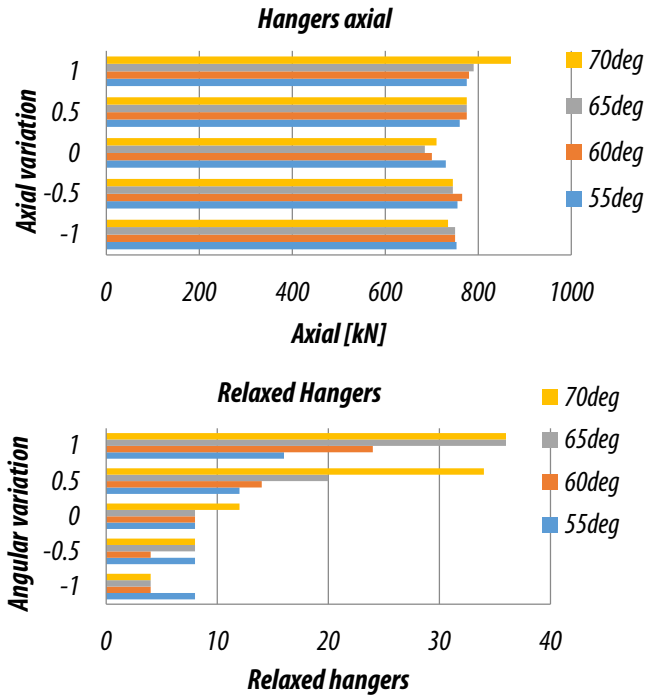


Figure 9. *Variation of axial force in hangers and number of relaxed hangers at Ultimate Limit State for a tied arch bridge of 100 m span with inclined hangers with variable inclination depending on the angle variation*

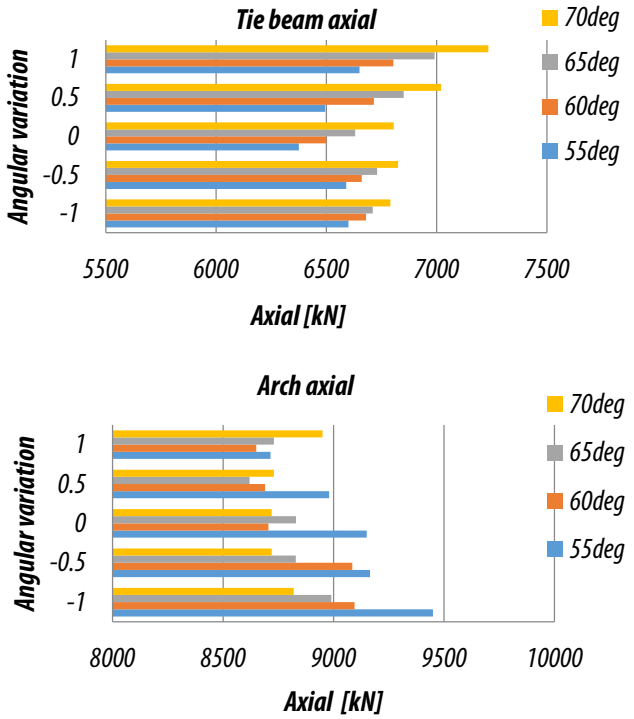


Figure 10. *Variation of axial force at Ultimate Limit State in arch and tie beam for a tied arch bridge of 100 m span with inclined hangers with variable inclination depending on the angle variation*

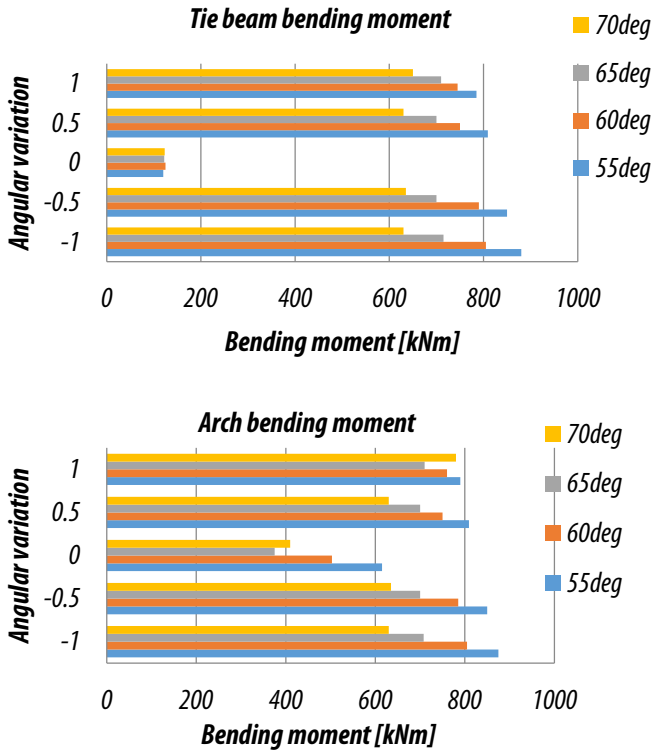


Figure 11. *Bending moment variation at Ultimate Limit State in arch and tie beam for a tied arch bridge of 100 m span with inclined hangers with variable inclination depending on the angle variation*

In this system, each set of hangers starting at angle start and then increase or decrease along the bridge. In this study it was considered a first angle of 55 degrees and a variation of 0.5 degrees / hanger.

Maximum axial force in the arch tends to be smaller as the inclination is greater. Bending moment results from the analysis show that the more inclined hangers, the smaller the bending moment.

The hanger angle variation does not appear to significantly influence the tie beam axial force and bending moments along the beam decreases with increasing angle.

Unlike hanger system with constant inclination, for this span were obtained unfavorable results, which in turn lead to larger sections, namely higher costs. However, comparing to a system with vertical hangers, in this configuration we get a 30% lighter structure and relaxation of the hangers remains the problem.

CONCLUSIONS

In this study, for the opening of 100 m, it can be seen more effective the network system with inclined hangers than the vertical hanger system. This system provides a better structural efficiency compared to the configuration with vertical hangers.

The best solution is the one with constant inclination inclined hangers.

The bending moments in the lower chord depend on the hanger web stiffness, leading to the fact that longitudinal bending does not influence much the network arch design, instead, this leads to a more economical structure, with less consumption of material, and to more slender arch cross-sections. Transverse bending moments are usually greater than longitudinal bending moments, causing transversal loads to determine the design of the concrete or of the composite steel-concrete tie.

The lowest tension in the tie beams is obtained in vertical hanger configuration. However, this configuration shows large arch bending and tie beams moments.

System with inclined hangers with variable inclination is less effective than the system with constant inclination inclined hangers. Bending moments are almost double in both arches and tie beams compared with the constant inclination of the hangers, and the relaxed hangers are found in larger numbers in this system. In general, the relaxed hangers have greater inclination.

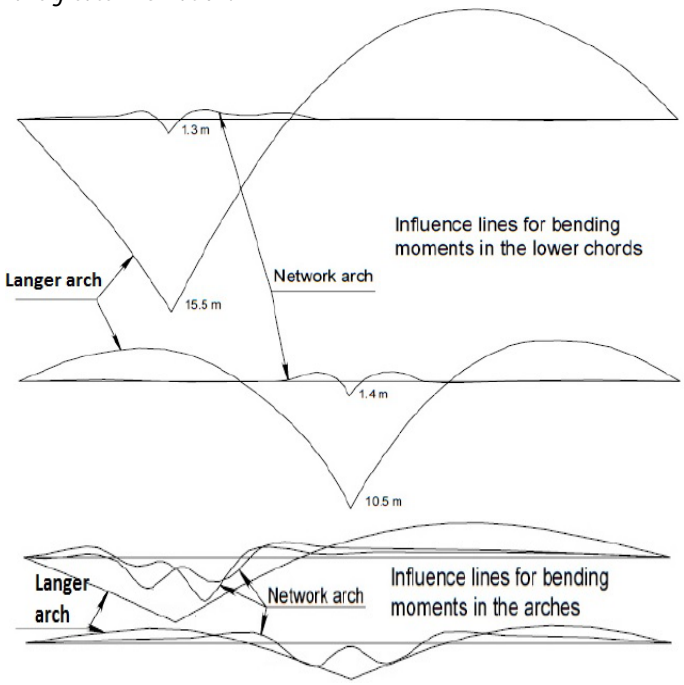


Figure 12. *Influence lines for bending moments in the arches and lower chords*

Maximum tension of hangers not only affects the ultimate limit state, but play a role in resistance to fatigue, so have made a thorough study of the fatigue strength of the hangers.

Buckling length of arch varies depending on the number and position of the hangers. A comprehensive analysis of the phenomenon should be performed to optimize structural buckling of the bridge.

Acknowledgements

This paper is supported by the Sectorial Operational Programme Human Resources Development POSDRU/159/1.5/S/137516 financed from the European Social Fund and by the Romanian Government.

References

[1] *Jose Miguel de Freitas Castro. Design of arch bridges, Department of Civil Engineering of the University of Porto, pg 1-94, 2009.*

[2] *T.J.M. Smit "Design and construction of a railway arch bridge with a network hanger arrangement". Journal of Civil Engineering Research 2013, Delft University of technology, pg 1-214, 2013.*

[3] *Tveit P., Optimal design of of Network Arches, Contribution to the IABSE Symposium in Melbourne, Australia, 2002*

[4] *Tveit P., Preliminary design of network arch road bridges – Examples with spans of 135 and 160 meters, Internet Edition, Grimstad, Norway, 2003. Retrieved from http://pchome.grm.hia.no/~ptveit/on 03/05/2009*

[5] *Tveit P., Preliminary Design of Network arch road bridges, with examples spanning 93 and 120 metres. Internet Edition, Grimstad, Norway, 2003. Retrieved from http://pchome.grm.hia.no/~ptveit/on 03/24/2009*

[6] *Tveit P., Revision of – Erection of optimal Network Arches, Grimstad, Norway, 2003. Internet Edition. Retrieved from http://pchome.grm.hia.no/~ptveit/ on 03/24/2009*

[7] **** European Committee for Standardization, Eurocode 1: Actions on structures – Part 2: Traffic loads on bridges. Brussels. 2003.*

[8] **** European Committee for Standardization, Eurocode: Basis of structural design. Brussels. 2000.*

[9] **** European Committee for Standardization, Eurocode 3: Design of steel structures – Part 2: Steel bridges. Brussels. 2006.*

[10] *Vlad M., Kollo G, Optimization of hanger inclination for a tied-arch bridge. 2nd Conference for PhD students in Civil Engineering CE-PhD 2014, 10-13 December 2014, Cluj-Napoca, Romania, www.cephd.ro*

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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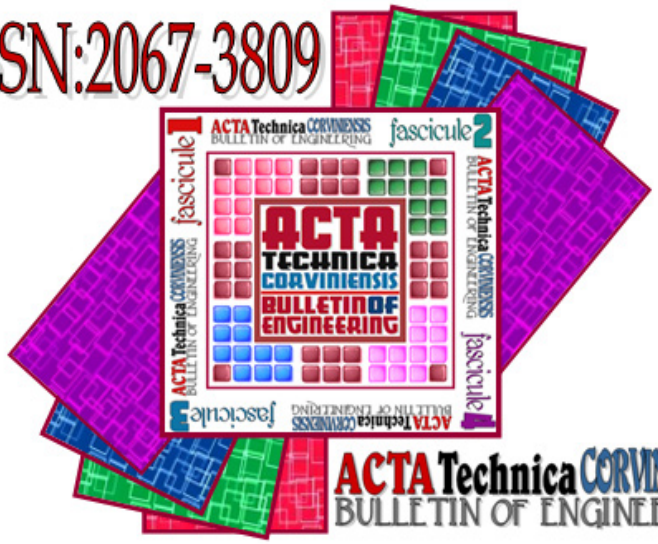
ISSN:2067-3809



ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 1 [JANUARY–MARCH]
ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 2 [APRIL–JUNE]
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ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 4 [OCTOBER–DECEMBER]

fascicule 4
[October - December]
tome VII [2015]

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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THE EFFECTIVNESS OF EARLY WARNING SYSTEMS DURING DISASTERS

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Abstract: *Disaster management is very wide subject and single paper cannot cover all dimensions involved in disaster management, so focus has been placed on modern detection and early warning systems. The threat has made the human being more vulnerable than ever before, mainly due to very fast growing population coupled with poor town planning in most parts of the countries. The developed countries are in effort of establishing strong and well equipped organizations to effectively deal with natural disasters. However the magnitude and area of influence of these natural disasters demands more cohesive and joint efforts. Natural disasters being faced by the Pakistan have also been covered. The early warning implications, as it is different for different types of calamities. Responsibilities of different groups have been discusses to provide early warning and also to ensure that the adequate time is available for the people to safely extricate from the dangerous zone. This paper deals with the latest systems available or being uses by developed countries and some recommendations for an effective early warning system in Pakistan.*
Keywords: *Disasters, vulnerability, safe handling, responsibilities*

INTRODUCTION

Pakistan has been experiencing different disaster intermittently in the past which cost loses to the lives and livelihood of its people. To make the people safer, there is a need to have an effective early warning system which must be people centered and be able to deliver timely information to the public well in time which is at risk. Pakistan, in the beginning remained without dedicated department looking after natural disaster. The Federal Flood Commission was created in 1977. Before that the Irrigation Departments at provincial (PIDs) were looking after the responsibilities of flood protection works. But after the experiencing frequent floods in seventies which left colossal losses to human lives, land and property, the need to have an organization at national level was felt to deal with flood protection and preventive measures across the country. Past experiences of earthquake in the country also supplemented the requirement. Over the last 20 years about 3 million lives have been lost and 1 billion people have been uprooted. The presence of an efficient forecasting and warning systems is necessary as part of effective alert strategies at national and regional level [1]. The aim of this paper is to analyze the early warning and detection organizations/equipment being used in the World with a view to recommend an appropriate system for Pakistan for a quick response at various levels to minimize the hazards.

NATURAL DISASTERS AND EXISTING ARRANGEMENTS

Pakistan has been suffering because of different natural hazards. The effects of these disasters in Pakistan can be measured by the fact that disasters during 2005 in south Asia caused 99,425 deaths, of which 84 per cent were due to one earthquake experienced in Pakistan. The migration of a large proportion of the population towards urban areas for education and employment has also magnified the quantum of threat. The unplanned habitation has made certain areas even more difficult to access. The details of major hazards in Pakistan includes floods, drought and earthquakes [2,3,4].

In Pakistan regular rainfall becomes the main source of water in the rivers which flow irrigates the plain areas. Mainly plain area of the country experiences flood which include the province of Punjab and Sindh. Due to more frequent rain in the mountain flash floods are experienced in the areas of KPK, Balochistan and FATA. Huge losses in terms of lives and property have been experienced during flood in the past. Drought has not been experienced in the past very frequently, in some part of the country where average rainfall is some time very low may suffer drought especially in Balochistan.

Due to the location of Pakistan near earthquake prone area small scale earthquake are very often in the country. This is more alarming as the increasing population and poor quality of buildings has made the area much vulnerable. Pakistan lies in the subduction zone. It is an area where two of the earth's rigid tectonic plates are converging towards one another. During 1935 an earthquake destroyed whole of Quetta. The history event of disaster was experienced in 2005 in which devastating earthquake hit Northern areas resulting death in thousands and huge losses to the property.

NATIONAL DISASTER MANAGEMENT POLICY

It reveals that the Pakistan's Disaster management revolves around flood disasters with more concentration on relief and rescue. Policy sometimes aims strategic preferences those are aimed at protecting important places. The lack of knowledge, threat, its analysis and management, will result into lack of readiness for the disasters. Disaster management policy deals more with post-disaster scenarios and it is not integrated with

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development plan. There is institutional lack of coordination for proper management. Moreover, there is no authority to control disaster management at central level. The structural and nonstructural measures are not given equal importance for disaster management at state-level. And the departments and organizations responsible for disaster management remain unimportant in the government setup [5].

PAKISTAN METEOROLOGICAL DEPARTMENT

This functions under the Ministry of Defence which is dealing with the provision of services in the country [6]. The department is providing data on geophysical and meteorological matters, like generation of meteorological, phonological and geophysical data. It is responsible for the rapid dissemination of data through telecommunication system. It also provides data processing units for Climate for long term weather trends. And it also provides the data analysis system for forecasts and warnings for aviation, shipping, agriculture and irrigation.

DISTRIBUTION OF RESPONSIBILITIES FOR EARLY WARNING

The aims of community response and early warning system are to give sufficient reaction time to the members of effected society so that the losses in term of lives material and property are reduced to the minimum. This system includes risk assessment and monitoring of prevailing risk in order to provide effective early warning. This also includes the degree of exposure of the people thereby enabling the administration to take necessary measure to protect the people and property. Prediction of effects is necessary for developing mitigation and response plans in which schools, NGOs and community based organizations (CBOs) can play a major role [7].

Public awareness and participation are very important for disaster management. Each segment of society plays vital role for prevention, mitigation and recovery before, during and after disaster. They are responsible for people of the victim community must be aware of hazard so that they are able to take precautionary measures. Local Communities are responsible for people knowledge about hazard and precautionary measures to increase safety level. People should have enough acquaintance with hazards and comprehension of instructions received. Local communities should ensure passage of information to the public so that they can increase their safety level.

National government should issue timely hazard warning in an effective way. Ensure timely vacation of dangerous area at the time of need. Regional Institutions must render expert opinion and provide special knowledge to support and enhance the capacity to fight against hazards. Interconnectivity at International for sharing of data advisory information is very important for development of operational capacity at national level.

Early Warning System needs to well linked setup at national and local level within administration authority. These systems should form part of program of national level to reduce the hazards. In all the countries the responsibility for the issuance of early warnings relating all kind of disasters should stay with an organization detailed by the Government. Well known authority be earmarked to make decision on receipt of information of hazard. Well known Warnings System to local agencies. Assessment of the occurrence of hazards be done within Early warning systems. Inclusion of small hazards in early warning system.

Developed countries must render help to developing countries to fight hazards. An audit with effective identification of the needs for early warning capabilities by affected countries is very essential. Global level institutions responsible for dissemination of warnings be well linked with served countries and an effective technical integration is established as per the needs. Preparation of warnings be based on modern knowledge and technology and exchange of monitoring data amongst countries. Warning must be understood and accepted with international standards by all countries.

Predicting effects of geological hazards carries importance but understanding of the consequences of the hazard is foremost important. If an occurrence is reported and information is passed but the magnitude and intensity is not shared then people responsible for response plans will stay in illusion to pass the information for the level of preparation/action [8]. Long-Term Prediction relates to prediction about the happening of natural disasters in the future in an area, it links past happening and its causes. Maintaining the record of such event is helpful to determine the frequency and intensity of the event. This concept has been used to make a form of long-term prediction. Intermediate-Term Prediction relates to indications as a disaster may occur sooner rather than later takes us into the realm of intermediate-term prediction. It is normally correctly predicted other than earthquakes. Approach to this problem has been through the methodology of pattern recognition, which involves linking the numerous parameters that may have something to do with the occurrence of strong earthquakes.

Short-Term Prediction is the most important aspect of the early warning system as it will dictate the reaction time for the people to save their lives. Again as we have seen in the case of intermediate prediction it is difficult in the case of earthquakes. The only option is to detect the initial wave and activate some type of the community alarm. Also the short time available between detection and damage occurrence there has always been doubts as regard the efficacy of this system.

MODERN EARLY WARNING SYSTEMS IN THE WORLD

Prediction of a hazard and its location and magnitude is an uphill task however with the development of technology different means and ways are being used to overcome this need. Different countries have devise system to get early warning about the occurrence of a hazard detection of infrasound is of interest with respect to analysis of building structures, earthquake prediction, and other geometrically large sources [9,10]. Geological Application of Remote Sensing (GARS programme is being run with cooperation and joint efforts by UNESCO and IUGS with the objectives of mapping in tropical environments with new methods and use of multi sensor for improvement. Use of GIS technology based on the satellite data for Landslides mapping and analysis of natural hazards through remote sensing. The Remote Sensing Data Centre (DFD) is an earth monitoring system which can focus with satellite coverage of its highly mobile and flexible stations over an area endangered by environmental problem and the natural disasters.

Warning System in the Pacific (WSP) is allocated to the monitoring of hazards in the Pacific. International Tsunami Information Centre monitors the WSP's and is responsible for its functioning and facilitates transfer technology to other countries for their warning systems. SOS-LIFE Earthquake Early Warning and Detection System were designed for small scale usages for houses and small setup. This is bases on specially developed software. It senses the danger which has happened before, thereby leaving enough time to be on safer site.

To promote international cooperation in flood management, Japan has launched International Flood Network (IFNet) with the help of other international organizations. Which carries following objectives:

- ✓ *Provision of platform to the experts for exchange of information and experiences for efficient flood management.*
- ✓ *The effective early warning programs, establishment of partnership.*
- ✓ *Reduction in losses of life and material in the flood disaster, designing and coordination of efficient measures.*

Delft Hydraulics' Flood Early Warning System provides effective information about flood. The main features of the system are:

- ✓ *The system includes large number of data handling utilities.*
- ✓ *It gives an open connection to a more range of forecasting.*
- ✓ *This is used effectively both in highly complex and basic forecasting systems.*

Delft-FEWS used in multi environment for example alone, manually driven environment. Early Warning System and dissemination of information is very effective adopted by Czech Republic. Main Features of the System are:

- ✓ *Overall responsibility of flood warning rest with The Czech Hydro meteorological Institute (CHMI).*
- ✓ *Office of Civil Defense and the Main Center of Fire Protection Service disseminate flood warnings.*
- ✓ *Parts of the System Joint Flood Forecasting and Warning System are based on multi-sensor including weather information through Satellites. Level of water is taken with the help of Rainfall gauges. Stream flow is continuously observed through gauges.*

Establishment of drought early warning system is very complicated issue. Drought process very slowly and stay for very long time. Therefore its beginning and termination can be gauge correctly. Being slow in nature it gives time for reaction for protection and opportunity to mitigate its effects. At world level institutions are in try to prepare plan for drought and to handle it in better manner. Subsequently, an efficient monitoring and early warning system, Advanced Very High Resolution Radiometer (AVHRR), with operational weather satellites have been used for drought detection and monitoring. It also monitors the rain situation as drought is the result of scanty rain or no rain.

RECOMMENDATIONS

Although accurate and precise early warning of the disasters is difficult to achieve however well coordinated efforts at different levels and cooperation of community can reduce the damages. In the following paragraphs some of the recommendations are highlighted for the same purpose:

- ✓ *The current capabilities of the Pakistan Meteorological Department are insufficient to reduce the hazards of disasters. It is required that the meteorological, hydrological and seismological services of the department must be boosted to meet the future challenges. The department must be upgraded to include the following facilities for efficient and smooth operation for collection of meteorological and geophysical data, rapid dissemination of data and examination Meteorological data for issuance of forecasts and warnings including data processing units for climate for long term weather trends.*
- ✓ *There is a dire need to have disaster prediction study group to address the concerns at world level relating growing trend of development in dangerous areas with low quality of construction. A statistical approach is primarily used for long term earthquake prediction. For example when a prediction is made that "there is a 90% probability of that an earthquake to occur in the next 50 years, it does not mean that this earthquake cannot happen tomorrow or it may not be delayed by 50 years. In previous years, 29 major earthquakes were tested for prediction, 8 of them were followed by strong earthquake, 6 were predicted and 2 were missed. It is no wonder that there is great concern worldwide about the continuing growth of megacities in places of high seismic hazard, and often with low building standards.*
- ✓ *The national seismic center should have technical facility, well trained experts, technicians for functioning round the clock and whole week. The center should perform as central point at national level for interaction at regional and international level.*
- ✓ *Pakistan Meteorological Department must establish a national seismic network. This network should have central recording stations, local seismic networks, tide measurement system for monitoring of sea level and dedicated satellite data links for early warning.*
- ✓ *Central Recording Station at Karachi has already been established by Pakistan Met Department consisting of broad bands sensors. This facility has to be extended to at least two recording stations with one in the northern part of the country due to the fault line passing through our northern areas.*
- ✓ *The whole country should be divided into small regions with seismic networks connected with national network. Central recording stations should be connected to respective local seismic networks.*
- ✓ *Southern early warning system should be established in Balouchistan as Quetta has been a victim of earthquakes in the past. This network should be capable of detecting any earthquake activity in the Balouchistan area. This network should be linked to central recording station at Karachi through satellite.*
- ✓ *The chances of Tsunami in Arabian Sea do exist. There is dire need to have an efficient warning system for tsunami there by enabling the authority to take precautionary measures before arrival of sea waves. A separate network for tsunami detection must be established at Karachi with additional elements i.e. deep ocean buoys and tide gauge network for monitoring of sea level.*

- ✓ *In October 2005, one of the strongest earthquakes occurred in Northern part of the country causing huge damage to both lives and property. This all happened in the absence of early warning system. Therefore, a separate early warning system must be established to cover whole of the northern part of the country. It should have at least 20-25 sensors in the network.*
- ✓ *After establishing a comprehensive network of national level there is a need to augment it with stand alone early warning systems capable of saving lives. There are systems which are light in size and weight and can easily be installed in buildings and even of portable size like SOS LIFE earthquake early warning system and Meir Gitlis Life Saving System.*
- ✓ *Tsunami/flood Early Warning System will be more secure with full backup of communication through satellite. The setup will have the ability to wide range extension ability between the Regional and Main Centre.*
- ✓ *In Pakistan rain fall in the North is more than south the level of rain goes to over 700 mm to 200mm respectively. There is need to have flood forecasting and Warning Centre for provision of information of an impending flood. The development of flood forecasting and warning system is need of the time to meet the requirements of region and national level and is a high priority in Pakistan. The project envisages Flood Forecasting & Warning Centre. This center should be able to monitor glacier, monsoon water, flow of water in the river and temperature effects on snow on the mountains. All data received should be examined to see the possibility of hazard and predict the possibility of flood.*
- ✓ *No accurate systems are available in the World which can accurately predict the occurrence of drought. In this regard a drought study group be maintained at national level to continuously study the prevailing conditions. This group should incorporate all information from the met department to make an accurate picture of the possibility of drought. It is an established fact that satellite provides the best possible warning as regard the occurrence of the drought. Satellite remote sensing offers some unique advantage over conventional method i.e a unique vantage point, synoptic view and data archive.*

Disaster prediction and early warning is one of the important task and challenge for the developing world. Lack of town planning and over population has increased the hazardous effects of natural disasters. There is a dire need for Pakistani government to allocate required efforts in terms of the finance and expertise to reduce the hazard effects.

REFERENCES

[1.] *Muhammad Atiq Ur Rehman Tariq, Nick van de Giesen. (2012). Floods and flood management in Pakistan. Physics and Chemistry of the Earth, Parts A/B/C, Volumes 47–48, Pages 11-20*

[2.] *Ali Asgary, Muhammad Imtiaz Anjum, Nooreddin Azimi. (2012). Disaster recovery and business continuity after the 2010 flood in Pakistan: Case of small businesses. International Journal of Disaster Risk Reduction, Volume 2, Pages 46-56*

[3.] *Mateeul Haq, Memon Akhtar, Sher Muhammad, Siddiqi Paras, Jillani Rahmatullah. (2012). Techniques of Remote Sensing and GIS for flood monitoring and damage assessment: A case study of Sindh province, Pakistan. The Egyptian Journal of Remote Sensing and Space Science, Volume 15, Issue 2, Pages 135-141*

[4.] *Zubair Ahmed (2013). Disaster risks and disaster management policies and practices in Pakistan: A critical analysis of Disaster Management Act 2010 of Pakistan. International Journal of Disaster Risk Reduction, Volume 4, Pages 15-20*

[5.] *Ali Asgary, Muhammad Imtiaz Anjum, Nooreddin Azimi (2012). Disaster recovery and business continuity after the 2010 flood in Pakistan: Case of small businesses. International Journal of Disaster Risk Reduction, Volume 2, Pages 46-56*

[6.] *Syed Ainuddin, Daniel P. Aldrich, Jayant K. Routray, Shabana Ainuddin, Abida Achkazai (2013). The need for local involvement: Decentralization of disaster management institutions in Baluchistan, Pakistan. International Journal of Disaster Risk Reduction, Volume 6, Pages 50-58*

[7.] *M.J. Khan, A. Razzaq, M.K. Khattak, L. Garcia. (2009). Effect of different pre-sowing water application depths on wheat yield under spate irrigation in Dera Ismael Khan District of Pakistan. Agricultural Water Management, Volume 96, Issue 10, Pages 1467-1474*

[8.] *Muhammad Ali, Sher Jamal Khan, Irfan Aslam, Zahiruddin Khan. (2011). Simulation of the impacts of land-use change on surface runoff of Lai Nullah Basin in Islamabad, Pakistan. Landscape and Urban Planning, Volume 102, Issue 4, Pages 271-279*

[9.] *Andrew C. Kerr, Mehrab Khan, John J. Mahoney, Kirsten Ngaire Nicholson, Chris M. Hall. (2010). Late Cretaceous alkaline sills of the south Tethyan suture zone, Pakistan: Initial melts of the Réunion hotspot? Lithos, Volume 117, Issues 1–4, Pages 161-171*

[10.] *Adnan Ahmad Tahir, Pierre Chevallier, Yves Arnaud, Luc Neppel, Bashir Ahmad. (2011). Modeling snowmelt-runoff under climate scenarios in the Hunza River basin, Karakoram Range, Northern Pakistan. Journal of Hydrology, Volume 409, Issues 1–2, Pages 104-117*

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BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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FINITE ELEMENT ANALYSIS OF 3D-MODEL OF TURNING TABLES OF MICRO-CONTROLLER BASED VERSATILE MACHINE TOOLS DESKTOP LEARNING MODULE

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Abstract: *In this paper, we present the results of finite element analysis (FEA) performed to investigate nature of stress and their distribution at optimum point along the two turning tables of a micro-controller based versatile machine tool desktop learning module. Commercial Autodesk Inventor was used to create both three-dimensional (3-D) and 2-D models as well as performing simulation. Dynamics simulation generated the motion load expected to act on the tables when used for real-life operation which were in turn used to perform FEA. The motion of the dc servo motor driving the tables and other parts of the module is designed to be controlled by programmable chips. Before creating FEA simulation for the tables, numerical divergence were prevented by varying the mesh settings to obtain the settings at which the results of the analyses converges which was obtained at 0.03 average element size and 0.04 minimum element size. Finite element analysis carried out on the tables shows that aluminium alloy 4032-T6 chosen will serve in the fabrication of physical prototype. FEA revealed the nature and level of stresses that will be experienced on the tables, it also revealed region where these stresses will concentrate on them. The analysis also estimated the expected weight of the turning tables 1&2 to be 1.23536 to 0.257182 Kg respectively and show that the minimum factor of safety was constantly 15 ul within the tables which shows that they will not fail during operation.*
Keywords: *Turning table, Lathe, Machine Tools, Stress, Displacement, Factor of Safety*

INTRODUCTION

Turning is one of the most common of metal cutting operations. In turning, a workpiece is rotated about its axis as single-point cutting tools are fed into it, shearing away unwanted material and creating the desired part. Turning can occur on both external and internal surfaces to produce an axially-symmetrical contoured part. Turning is an engineering machining process in which a cutting tool, typically a non-rotary tool bit, describes a helical tool-path by moving more or less linearly while the workpiece rotates. [1]

The tool's axes of movement may be literally a straight line, or they may be along some set of curves or angles, but they are essentially linear (in the nonmathematical sense). Usually the term "turning" is reserved for the generation of external surfaces by this cutting action, whereas this same essential cutting action when applied to internal surfaces (that is, holes, of one kind or another) is called "boring". Thus the phrase "turning and boring" categorizes the larger family of (essentially similar) processes. The cutting of faces on the workpiece (that is, surfaces perpendicular to its rotating axis), whether with a turning or boring tool, is called "facing", and may be lumped into either category as a subset [1]. Turning can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator, or by using an automated lathe which does not. Today the most common type of such automation is computer numerical control, better known as CNC. (CNC is also commonly used with many other types of machining besides turning.) This operation is one of the most basic machining processes. That is, the part is rotated while a single point cutting tool is moved parallel to the axis of rotation [2]. Turning can be done on the external surface of the part as well as internally (boring). The starting material is generally a workpiece generated by other processes such as casting, forging, extrusion, or drawing.

The idea of cooperative hands-on active problem-based learning (CHAPL) using desktop learning module (DLM) involves grouping students into home teams (3-5) to complete homework, in class worksheets and projects. Class time itself consists of teams completing worksheets that require hands on use of physical models and active data collection. The focus is always on giving students an active role in their own education in a way to implement Kolb's experimental model (see Plate 1) in a non-lab class using physical models. [3].

Flashlight Survey was conducted on Nigerian students who were taught with hands-on active learning (HAL) pedagogy for a semester by a group of researchers [4]. This was done to assess their own feelings regarding the class experience and utilizes Chickering and Gamson's seven (7) principles of good practice as a basis for question topics [5].The survey revealed that large number of students felt CHAPL allowed them to

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visualize concepts and grasp facts better than a standard lecture. Additionally a significant number of students felt more comfortable in discussions after using the DLMs in a CHAPL setting.

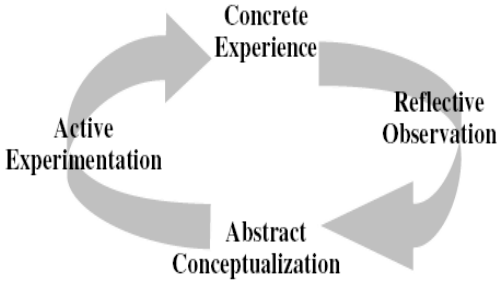

Plate 1. *The Kolb Experiential Cycle [3]*

It has also been identified that students trained totally with traditional lecture format (TLF) tends to wait to be told about problems and still rely on superiors for direction and information in solving them rather than looking for problems to fix. This happens because TLF typically involves the superior, a professor, telling the students how things are done and what the problems are. If there are any questions, the professor is generally the provider of the 'correct' answer. In essence, we are training students to expect this type of knowledge from superiors at workplace [6]. An alternate method of conducting classes is needed if we desire to prepare students to be independent learners who communicate effectively and work well as part of a team.

In today's science and engineering classrooms, passive lecture based teaching is slowly giving way to more well-rounded pedagogies such as POGIL and high performance learning Environment (Hi-PeLE) that incorporate active student participation [7], Motivation for this paradigm shift comes from numerous findings that hands on, active learning possesses advantages over purely aural teaching [8;9].

There are report of existing desktop learning modules (DLMs) which contain a one cubic foot base system with hot and cold fluid reservoirs, flow meters, temperature and pressure readouts and a set of interchangeable unit operations cartridges. They were developed to give students hands-on experience in the selected area [6;10].

Recent efforts to extend the DLM concept to the civil engineering discipline was reported in an article [10], now more concerted effort and rigorous study is taking place in Civil Engineering while expansion to Bio-, Mechanical and Electrical Engineering is underway [11].

Some of the new interchangeable cartridges that are being developed and their utility in terms of concepts and principles that can be learned or reinforced by those using them include Bioengineering Cartridges, Civil Engineering Flume, Misconceptions, and Assessment Strategy, New Chemical Engineering cartridges and Mechanical Engineering Solar Cartridge.

Finally, DLM for Machine tool training/teaching is presently not available in this part of the world where resources are limited. This makes it is more difficult to teach this course using problem based learning (PBL) approach because of infrastructural deficiencies such as desktop size machine tool, electricity and workshops.

To address this issue, new Desktop Learning Modules (DLMs) that contain miniaturized processes with a uniquely expandable electronic system to contend with known sensor systems/removable cartridges were designed. This is expected to be a miniaturized mimics of industrial-scale equipment that will produce process data that agree with correlations developed for large-scale equipment.

Therefore, this article discusses details of modelling and finite element analysis carried out on the turning tables of the designed machine tools desktop learning module (MT-DLM) before developing a physical prototype for cooperative, hands on, active and problem based learning (CHAPL) of turning and related operations which can be done on a lathe in Nigerian higher institutions.

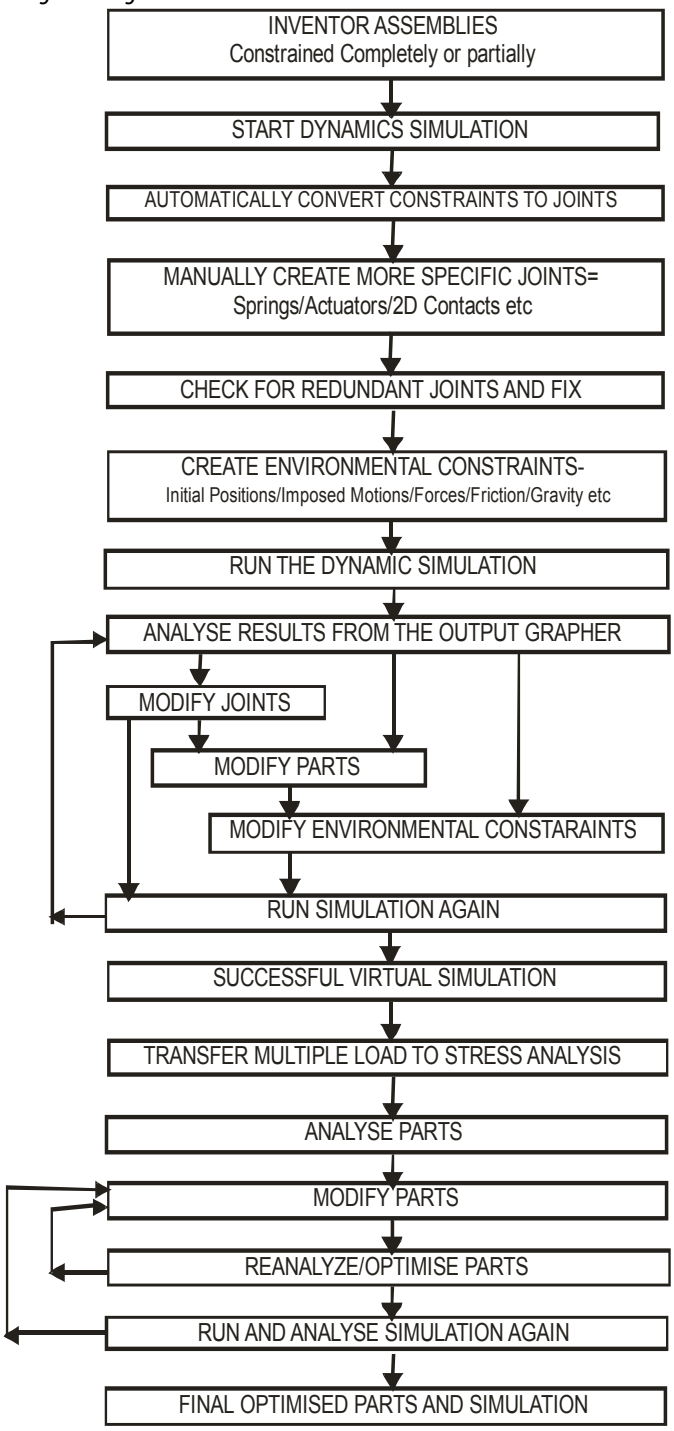

Figure 1. *Motion Simulation and FEA Total Workflow Diagram. [20]*

There are numerous simulation tool available to designer which include Autodesk Inventor Pro, Solid Works Pro, MATLAB & Simulink, Maple Sim

etc., while simulation environments include Finite Element analysis, Dynamic Simulation, Frame Analysis among others. These tools also allows for designers to test for suitability of newly developed materials for their intended designs before purchasing such materials [12]. This reduces the number of physical prototype required before a final component can be produced there by reducing cost, lead time of production and material waste among other benefits.

Lot of research activities that involve the use of finite element analysis on designs with different purposes have been reported, some used it to improve an existing design while some use it to measure the level of stress and deformation expected within a system. [13-19]

A recommended motion simulation and FEA total workflow diagram is presented in Figure 1.

RESEARCH PROCEDURE

Model Creation

The 3D-model of the desktop size lathe as it will be used for machining was created using commercial Autodesk Inventor software package. The software allows for dynamics simulation as well as assigning of material for each component part of the module. The main factor considered during the modelling are;

- *Workpiece Geometry.*
- *Overall weight of the setup.*
- *Ease of casting and machining of the parts.*
- *Availability of the assigned material.*
- *Displacement (Deformation) of the parts.*
- *Factor of safety.*

The workpiece geometries that were used for the creation of the models are 100 mm cylindrical rod of diameter 15 mm for turning operation and 100 mm square plate of thickness 25 mm for milling, drilling, planing and grinding operations. Parametric study was conducted on the turning tables with the aim of optimizing the weight and the level of deformation within it. The study aided in reducing the weight of turning table 1 & 2 from 3.85456 kg to 1.28217 Kg and 1.23536 to 0.257182 Kg while the deformation increased from 0.0000925 and 0.00257 µm to a maximum value of 1.04 and 4.97 µm respectively.

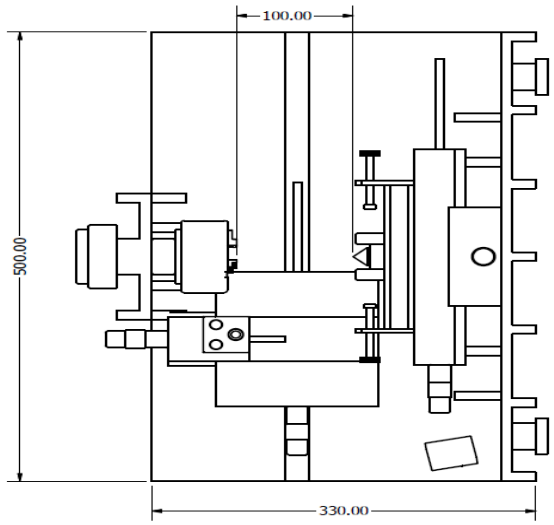

Plate 2. *Plan of the MT-DLM during Turning Operation*

Based on these design considerations, 3D models were created and their 2D Projections are presented in the following plates to show the distance between the spindle jaws and the tip of the tail stock for the turning model and the gap within the locating pins of the milling table.

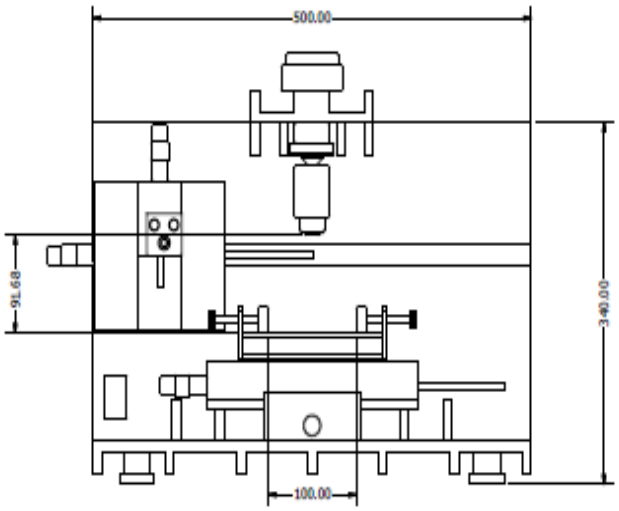

Plate 3. *Front view of the MT-DLM during Milling Operation*

Model Simulation

The procedure for the simulation carried out on the model followed the recommended total workflow diagram (See Figure 1).

Dynamic simulation in Autodesk Inventor

Dynamic simulation environment is located under environment tool bar in Autodesk Inventor. The environment automatically generate standard joints within the model based on the kind of constrains placed on each component during assembly while components were also grouped into grounded and mobile members.

The environment allows for gravitational force and other kind of forces to be applied on the model which are group under external loads section of the environment. Dynamic Motion sub-tab was used to inspect how the parts moved relatively to each other before the simulation was carried out. After the parts moved satisfactorily in respect of others, the simulation was carried out using the simulation player.

The environment automatically generate standard joints within the model based on the kind of constrains placed on each component during assembly while components were also grouped into grounded and mobile members. The environment allows for gravitation force and other kind of forces to be applied on the model which are group under external loads section of the environment. Dynamic Motion sub-tab was used to inspect how the parts moved relatively to each other before the simulation was carried out. After the parts moved satisfactorily in respect of others, the simulation was carried out using the simulation player.

Tracers were attached to the two turning tables to monitor only the vector components of change in position and velocity relatively to the ground. The results of the traces were displayed on the Output Grapher of the environment.

Prior to the running of the simulation, the tables were exported to the FEA environment as they are expected to experience varying forces due to the change in position and motion during the real life operation of the MT-DLM.

The traced results of the output grapher generated the selected parameter in numerous time steps out of which eleven (11) important time steps including beginning and ending time were automatically exported to the FEA simulation environment. The selected time steps are points where some peaks were found on the output of the output grapher traces.

Finite element analysis (FEA)

FEA was done based on the motion loads generated from the dynamics simulation environment for the tables which were exported in eleven (11) time steps. Before creating FEA simulation for the tables, numerical divergence were prevented by varying the mesh settings to obtain the settings at which the results of the analyses converges. The average element size as a fraction of model diameter and minimum element size as a fraction of the average element size were varied to obtain the convergence point. The convergence setting for all the exported part was obtained at 0.03 average element size and 0.04 minimum element size which was used to run the simulations.

Aluminium 4032-T6 was assigned to the two tables during the simulation. This was done to determine if the selected material can withstand the kind of stresses to be generated during operation. The main factor that was used to determine this was the calculated factor of safety from the simulation result. The yield strength, ultimate tensile strength and density used for the simulation were 315 MPa, 380 MPa and 2.68 g/cm^3 respectively. These properties played major role during the simulation.

RESULTS AND DISCUSSION

This section presents results of the simulations done on the designed model of MT-DLM.

Dynamics Simulation

The trace obtained from the output grapher is presented in Figure 3 below. In the figure,3, Trace 1 is for turning table 2 while Trace 2 is for turning table 1.

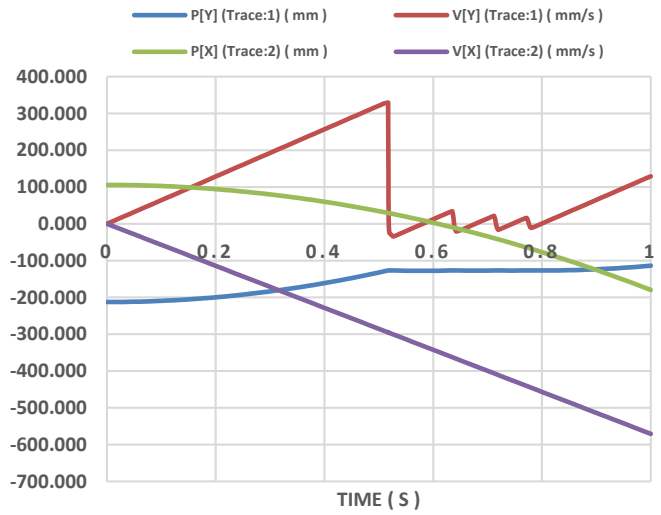

Figure 2. *Turning Operation Dynamics Simulation Trace*

Discussion of dynamics simulation results

The output traces of the dynamics simulation done is presented in Figures 3 above. Dynamics simulations were done to generate the boundary conditions applied to the tables which were exported to the FEA environment for further simulations. The trace shows that the turning table 2 assembly moved with constant acceleration, given the assembly a uniformly increased speed under a constant torque until it has contact with the milling table attached to the other part of the frame. This is a scenario that must be prevented in the physical prototype fabrication. The contact is expected to give a back-movement of the assembly as the speed falls to negative value, this is expected to affect the surface finish profile of the part the model will be used to machine (See Figure 2). The impact of the contact on the assembly was further investigated during the finite element analysis.

The trace also shows that the change in position of the turning table 1 assembly is not linear but parabolic (quadratic) in nature; this is associated with the effect of the turning table 2 assembly attached to it which is moving along another axis perpendicular to its own movement. The speed of the turning table 1 assembly increases at a constant rate with constant acceleration but the effect of the contact of the turning table 2 assembly and the milling table assembly can be seen between 0.5-0.6 s time steps which sharply reduces the speed of the table before the speed continues to increase at the initial rate.

Finite element analysis results

The variations in the stresses and displacement with time for the tables were measured during the finite element analyses. Some of the values were constant throughout the simulation time-steps while some varies. The constant values are summarized on Table 1 below. Maximum equivalent stress was estimated based on von Mises criterion and recorded as von Mises stress. 1st and 3rd principal stresses, shear and direct stresses as well as their strain and displacement were all estimated during the FEA. The variations of the equivalent stress and displacement with time are presented in the following figures. The distribution of the stress and displacement along the tables was probed at the time step where optimum value was obtained which complements the variation.

Table 1. *Constant values obtained from the tables*

Name	Turning Table 1	Turning Table 1 Cover	Turning Table 2
Mass (Kg)	1.28217	0.460092	0.257182
1st Principal Stress (MPa)	1.131	1.336	15.26
3rd Principal Stress (MPa)	-1.163	-1.385	-14.32
Remote Force 1 (N)	31.098	12.965	152.93
Remote Force 2 (N)	1.733	17.575	12.965
Remote Force 3 (N)	17.575	-	106.439
Moment 1 (N mm)	10226.521	7465.64	62.792
Moment 2 (N mm)	87.02	4770.245	6082.745
Moment 3 (N mm)	4770.245	-	5087.37

The variation in other parameters with time and their distribution are presented in the following figures.

Turning table 1

The variation in the von Mises stress and displacement for the turning table 1 is presented in the figures below.

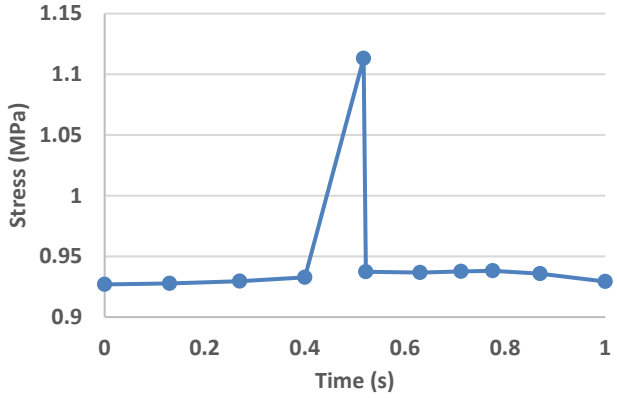

Figure 3a. *Variation of Von Mises Stress with Time*

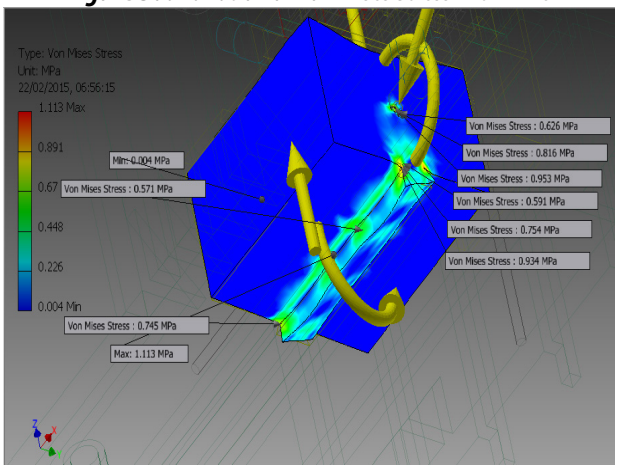

Figure 3b. *Distribution of Von Mises Stress along the Turning Table 1*

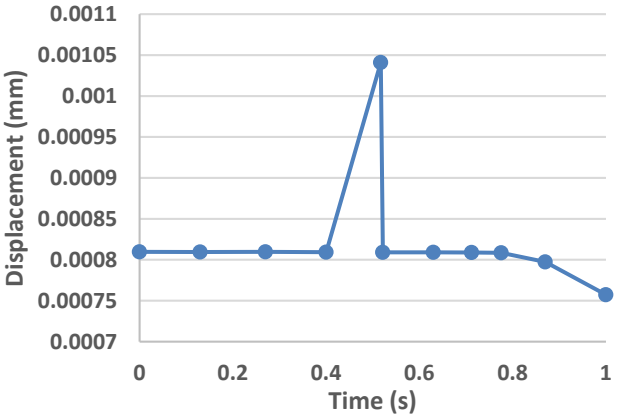

Figure 4a. *Variation of Displacement with Time*

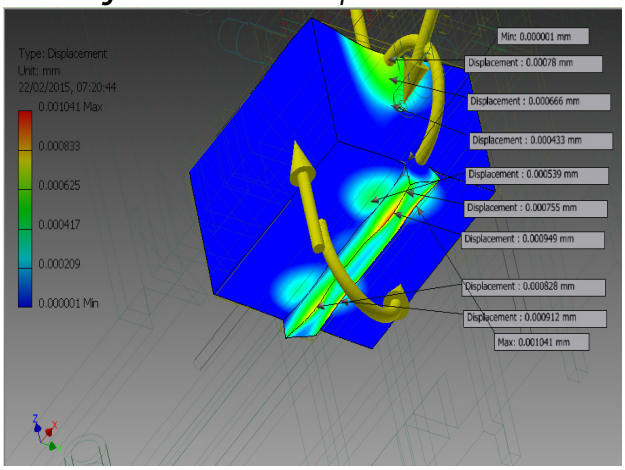

Figure 4b. *Distribution of Displacement along the Turning Table 1*

Turning Table 1 Cover

The variation in the von Mises stress and displacement for the turning table 1 cover is presented in the figures below;

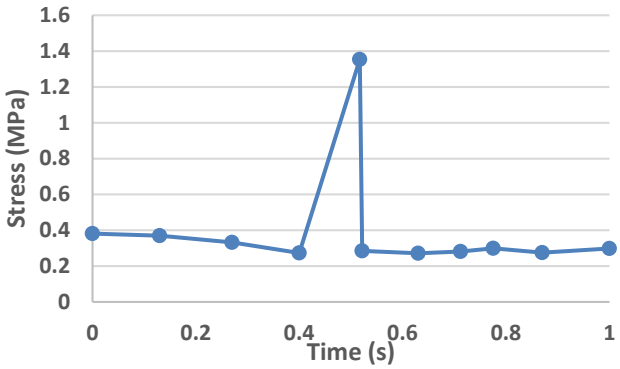

Figure 5a. *Variation of Von Mises Stress with Time*

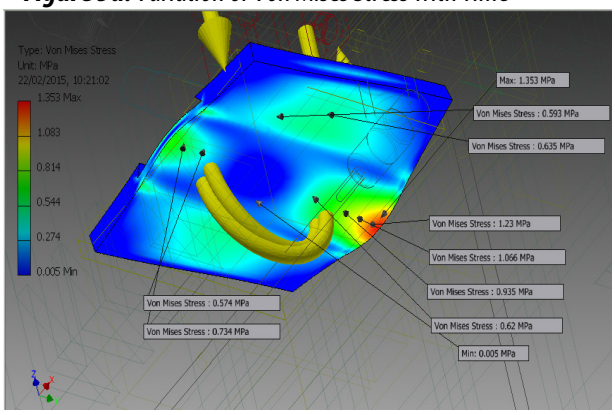

Figure 5b. *Distribution of Von Mises Stress along the Turning Table 1 Cover*

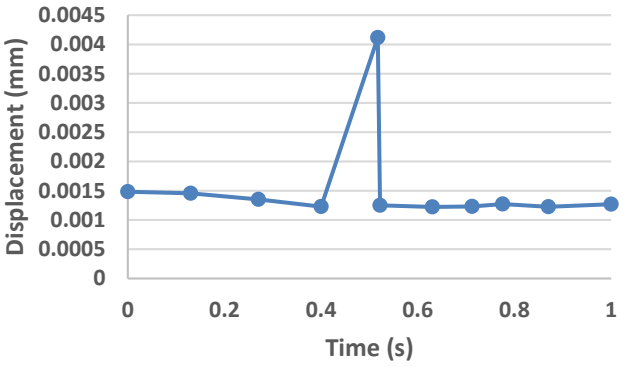

Figure 6a. *Variation of Displacement with Time*

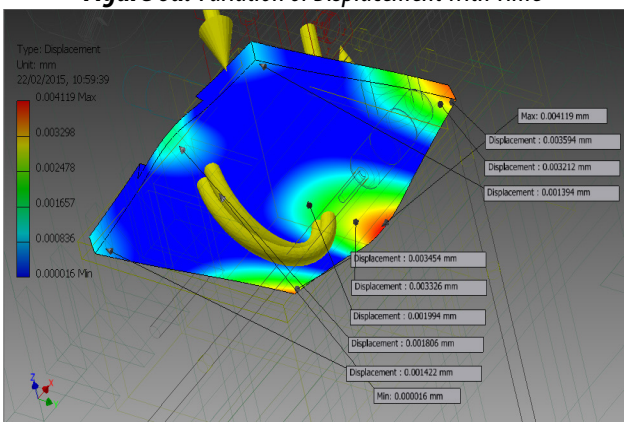

Figure 6b. *Distribution of Displacement along the Turning Table 1 Cover*

Turning Table 2

The variation in the von Mises stress and displacement for the turning table 2 is presented in the figures below;

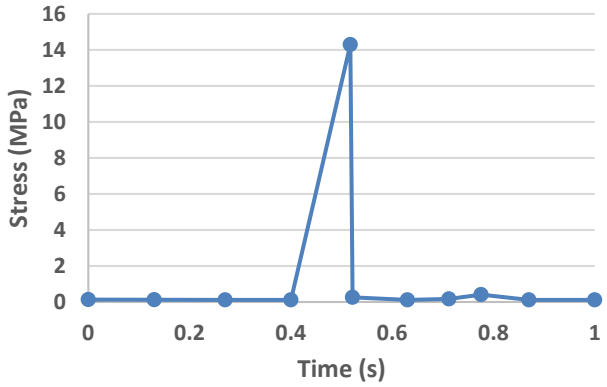

Figure 7a. *Variation of Von Mises Stress with Time*

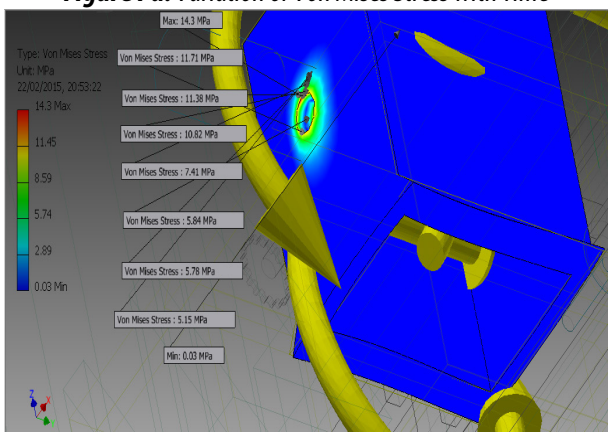

Figure 7b. *Distribution of Von Mises Stress along the Turning Table 2*

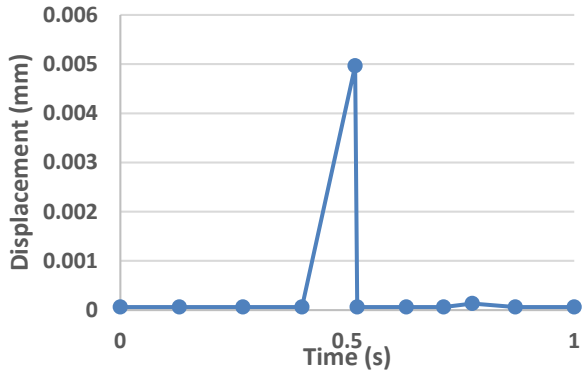

Figure 8a. *Variation of Displacement with Time*

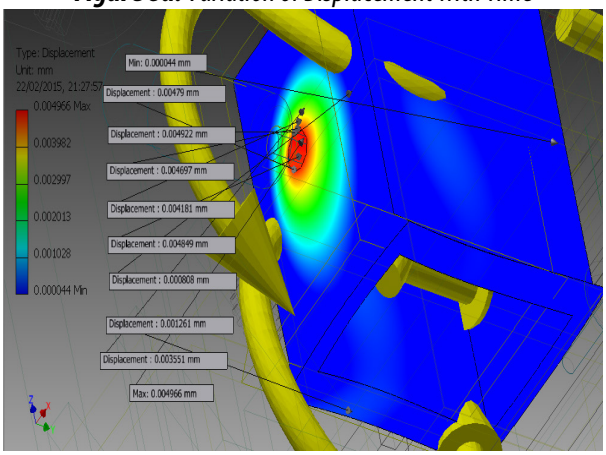

Figure 8b. *Distribution of Displacement along the Turning Table 2*

Discussion of Finite Element Analysis Results

Finite element analysis carried out on the turning table 1 reveals that three (3) remote forces were acting on the table leading to the generation of three (3) moments which were also acting on it out of which only one moment and one force were constant throughout the simulation time steps. The combination effect of the forces and moments led to the generation of three-dimensional loads which in turn developed the equivalent (von Mises) stress based on von Mises criterion within the table. The variation in the developed von Mises stress with time is presented in Figure 5a while the distribution of the stress at the time step where optimum value was obtained is presented in Figure 5b. The results show that the optimum equivalent stress was obtained at 0.51719 s with a value of 1.113 MPa. This time step is the same as the time when the turning table 2 had contact with the milling table during dynamics simulation.

The variations of 1st and 3rd principal stresses follows that of the von Mises stress. The peaks were obtained at the same time step for all the stresses although the values are not the same at those peaks. The probing into the distribution of 1st principal stress shows that there are regions that experienced negative values. This negative value of up to 0.369 MPa implies that there is a compressive stress at those region since the 1st principal stress is expected to account for tensile stress within the body. The same manner, some regions experienced negative 3rd princioal stress, these regions coincide with those that experienced negative 1st principal stress which means they were experiencing tensile stress while other parts of the turning table 1 were experiencing compressive stress and vice versa. This regions are mostly found along the edges of the dove tail where the table is connected to the frame.

The variation in the remote forces and moments with time shows that the maximum values for all the remote forces and moments were obtained at the time step where maximum stresses were obtained from the simulation, this implies that the variation of the forces acting on the turning table causes the variation of stresses experienced within the part. The variation of the displacement with time follows the trends observed in all the stresses measured. The displacement accounts for the level of deformation that will be experienced at those region of the analyzed part. Probing into the distribution of displacement along the turning table 1 revealed that maximum deformation will be experienced at the tin edges of the dove tail attached to the table and the surface where the driving motor and lead screw were attached to it. These are the regions where maximum stresses were experienced during the simulation. The maximum level of deformation expected is 1.06 µm, a displacement that is not expected to give any significant influence on the accuracy of the table movement during operation. This is in line with the submission of (16) on the influence of maximum displacement value on accuracy of analyzed part. Finally, the analysis also revealed that turning table 1 weighs 1.28217 Kg

The results of the FEA carried out on the cover of turning table show that only two remote forces and moments were acting on it although it was attached directly to the turning table 1 which experienced three remote

forces and moments. The values of remote force 2 acting on the cover is equal to that of the remote force 3 acting on the table for all time steps considered during the simulation. The optimum stress and displacement were also experienced at 0.51719 s, the same point where they were obtained from the table.

Probing into the distribution of stresses and displacement along the cover revealed that there are regions that experienced negative 1st and 3rd principal stresses and the maximum displacement was recorded to be 4.12 µm. The mass of the cover was recorded as 0.460092 Kg. the assembly of the turning table 1 which contains the table, its cover, lead screw and motor weighs 1.83983 Kg as revealed by the simulation.

The results of the FEA carried out on the turning table 2 show that it is acted upon by three remote forces and moments as experienced on table 1. The values of the remote force 2 experienced on the table are equal to that of remote force 1 acting on table 1 cover attached directly under the table 2. The variations of the force and moment with time show that both of them attained optimum values at the same 0.51719 s time step, the point where maximum stresses and displacement were also observed.

The probing into the stresses distribution shows that von Mises varies form 0.003 MPa experienced in most part of the body to a maximum value of 14.3 MPa experienced at point where motor and lead screw were attached for moving the table 2 assembly during operation. 1st and 3rd principal stresses also concentrates at the same region where von Mises stress was experienced. There are also regions that experienced tensile stress while other parts were experiencing compressive stress and vice versa as experienced in the turning table 1.

The probe into the distribution of displacement shows that maximum displacement of 4.97 µm concentrated on the same surface where the stresses distribution within the table were experienced although the region is wider (See Figure 8b) even though the optimum value was obtained at the same time step as the stresses. The analysis shows that the table weighs 0.257182 Kg while the turning table 2 assembly which contains table 2, lead screw, motor and tool holder weighs 0.835314 Kg.

CONCLUSION

After the modelling and simulation of the machine tools desktop learning module (MT-DLM), the following conclusions were drawn:

- *A 3D model of the MT-DLM was adequately developed, animated and simulated with the aid of a commercial Autodesk Inventor Package.*
- *Autodesk Inventor Package has enough environment to carry out the modeling of the MT-DLM.*
- *The dynamics simulation carried out on the model prove that the tables will move relatively to each other as desired within the design.*
- *Finite element analysis carried out on the tables shows that the aluminum alloy chosen for them will serve in the fabrication of physical prototype.*
- *Finite element analysis revealed the nature and level of stresses that will be experienced with the tables, it also revealed region where these stresses will concentrate on them.*
- *The finite element analysis also shows that the minimum value of safety factor are well above 15ul which makes them save for use during real life operation.*

REFERENCES

[1] *Koepfer, C: Hard Turning as an Alternative to Grinding, Production Machining [Online], January 22, 2010. [Cited: December 20, 2014.] http://www.productionmachining.com.*

[2] *Todd, R H; Allen, Dell K and Al ting, L: Manufacturing Processes Reference Guide, Industrial Press Inc., 1994. ISBN 0-8311-3049-0.*

[3] *Golter, P: Aligning Assessment, American Society for Engineering Education, 2009.*

[4] *Abdul, B, et al: Evaluation of Pedagogical Gains in a Fluid Flow Class When Using Desktop Learning Modules in an African University, American Society for Engineering Education, 2009.*

[5] *Chickering, A W and Gamson, Z F: Seven Principles for Good Practice in Undergraduate Education. The Wingspread Journal, Winona State University, 1984.*

[6] *Golter, P et al: Practical Considerations for Miniaturized Hands-On Learning Station, American Society For Engineering Education, p. 3, 2006.*

[7] *Arce, P and Schreiber, L: High Performance Learning Environments, Hi-PeLE, Chemical Engineering Education, (Fall Issue), pp. 286-291, 2004.*

[8] *Dale, E: Audiovisual methods in teaching, 3rd Edition, New York, Dryden Press, Vol. I, 1969.*

[9] *Crouch, C H, et al: Classroom demonstrations: Learning tools or entertainment? American Journal of Physics, Vol. 72, pp. 835-838, 2004.*

[10] *Yurt-Beyenal, N: Miniature Open Channel-Weir for the Standard Classroom-Implementation and Assessment, American Society of Engineering Education, 2009.*

[11] *Schlecht, W D: Multi-Disciplinary Project-Based Paradigm that Uses Hands-on Desktop Learning Modules and Modern Learning Pedagogies, American Society for Engineering Education, 2011.*

[12] *Redell, F: Understanding and Applying FEA. Real World Training, Autodesk Manufacturing Academy, 2012.*

[13] *Prasad N S, Sekar A S and Krishnapillai S: Applications of finite element analysis in structural engineering, Proceedings International Conference on Computer Aided Engineering. pp. 38-46, 2007.*

[14] *Jackson, M J, et al: Finite Element Analysis of Desktop Machine Tools for Micromachining Applications, InTech, 2012.*

[15] *Kartal, M E, et al: Effects of Semi-Rigid Connection on Structural Responses, Electronic Journal of Structural Engineering, Vol. 10, pp. 22-35, 2010.*

[16] *Deping, L, et al: Finite Element Analysis of High-Speed Motorized Spindle Based on ANSYS. The Open Mechanical Engineering Journal, Vol. 5, pp. 1-10, 2011.*

[17] *Yung-Chang, Y, et al: Estimation of tool wear in orthogonal cutting using the finite element analysis, Journal of Materials Processing Technology, Vol. 146, pp. 82–91, 2004.*
[18] *Wakchaure, M R and Sagade, A V: Finite Element Analysis of Castellated Steel Beam, International Journal of Engineering and Innovative Technology (IJEIT), Vol. 2, pp. 365-372, 1, July 2012.*
[19] *Ali, B A, et al: Finite Element Analysis of Cold-formed Steel Connections, International Journal of Engineering (IJE), Vol. 5, 2011.*
[20] *Waguespack, C: Mastering Autodesk Inventor 2014 and Autodesk Inventor LT, Indianapolis, Indiana: John Wiley & Sons, Inc., 2014. A book of SYBEX (A Wiley Brand).*

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

Letiția-Roma CÂNDA

NON-FEROUS METALS RECOVERY

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Abstract: *Non-ferrous metals are among the few materials that do not degrade and do not lose their chemical or physical properties in the recycling process. The most frequently recovered metals are: lead, gold, silver, aluminum, copper and platinum. Therefore, studies are being carried out aimed at developing new processes for the separation of metals, mainly from industrial waste by-products. The handling of e-waste including combustion in incinerators, disposing in landfill or exporting overseas is no longer permitted due to environmental pollution and global legislations. Compared to other waste components, such as plastics, wood or textiles, non-ferrous metals exhibit better reusability and higher market values. In future, new strains have to be identified to improve the metal recovery from solid waste.*

Keywords: *non-ferous, recovery, recycling, waste*

1. INTRODUCTION

The demand of electrical and electronic equipment (EEE) increased considerably with technological advances. Significant innovations on electric and electronic technologies have their lives shortened, thus increasing generation of waste from electrical and electronic equipment (WEEE) or electronic waste (e-waste). Global production of electrical and electronic equipment is growing rapidly and it is expected to accelerate in the near future. At the global level, latterly there are generated between 20 and 25 million tons of electronic waste per year, with a high share in Europe, USA and Australia. However, it is expected that Eastern Europe, China and Latin America to become a major producer of e-waste in the next ten years [1].

It is expected that, in Europe, electronic waste production to increase by 45% between 1995 and 2020. Therefore, a three-pillar strategy of prevention, recycling and reuse of waste is necessary to minimize environmental impact and to promote the use of wasted resources efficiently [2].

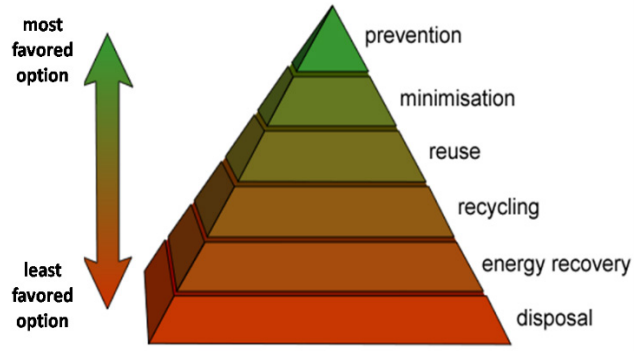

Figure 1*. Suggested activities in waste management [3]*

2. GUIDE LINES

Considering the Waste Framework Directive (Directive 2008/98 / EC), the treatment of municipal mixed solid waste (MSW) in Europe has become mandatory. Most electronic waste ends up in landfill. According to the US Environmental Protection Agency report on electronic waste in 2008, 19% of them are burnt and 81% are eliminated through storage [4]. Underground removal of e-waste has several disadvantages, including the contamination of groundwater, soil, and loss of potential sources of valuable metals. In the last decade, many countries have issued legislation on electronic waste. Underground storage of e-waste incinerators or burning is not permitted without isolation of hazardous materials. Moreover, the export of e-waste in underdeveloped countries is not permitted in accordance with international [5].

Underground removal of e-waste has several disadvantages, including the contamination of groundwater, soil, and the loss of potential sources of valuable metals. In the last decade, many countries have issued legislation on electronic waste. Underground storage of electronic waste or incinerators burning is not permitted without isolating hazardous materials. Moreover, the export of e-waste in underdeveloped countries is not permitted in according to international regulations.

Until 2020, it should be prepared for reuse and recycling at least paper, metal, plastic and glass from household waste and possibly from other origins as far as these waste streams are similar to waste coming of household waste to a minimum of 50% of the total weight. Also, by 2020 should be achieved preparing for reuse, recycling and other material recovery, including operations using waste to substitute other materials, non-hazardous construction waste and demolition waste to a minimum of 70% of weight, excluding naturally occurring material.

The treatment methods aimed to reduce the organic carbon content must be in order to meet the final disposal criteria. Unlike storage, the new processing modes allow the recovery of materials contained in solid waste. This focuses on the recovery of non-ferrous metals. Compared to the other used components, such as plastic, wood or textiles, NF metals are easier to recycle with high market values. NF metal production from

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primary resources is limited and it is a high energy process. Therefore, recycling of metals can contribute greatly to energy saving, reducing carbon dioxide emissions. [6].

***Table 1**. The energy saved by recycling compared with those of extraction of primary resources [7]*

Crt. iss.	Material	Saved energy (%)
1	Aluminium	95
2	Copper	85
3	Iron and Steel	74
4	Lead	65
5	Zinc	60
6	Paper	64
7	Plastic	>80

The overall potential of NF metals from incineration ash and mechanical-biological treatment plants (MBT), depends on the design of the recovery process, employed technologies and efficiency. Many components of the NF concentrate can be extracted by means of eddy current separators, whether incineration ash or during processing in mechanical-biological treatment plants. The separation should be such as to produce metal of sufficient purity to be used as a secondary raw material. The currently used techniques present weaknesses, such as the generation of wastewater and high prices for manual sorting in the European Union. This requires the development of new approaches in accessing resources in waste, while technical requirements depend on the origin of NF concentrate.

Optimised and adapted automated sensor based sorting systems able to identify different nf-metals are considered an applicable solution. However, their application varies considerably depending on the origin of non-ferrous concentrate. This is due to the different distribution of particle size.

Mostly effective screening can be performed automatically, and staff can be used more effectively for manual quality control. Mineral dust layer covering the debris and various metals contained in incineration ash reduce visual selection mode between minerals and metals at a point where manual sorting is not possible.

E-wastes are classified as hazardous materials, therefore, should be managed properly. However, precious metals (PMS) of e-waste, such as gold, silver, platinum, gallium, palladium, tantalum, tellurium, germanium and selenium make them attractive for recycling. In industry there are various metallurgical processes to extract precious metals from e-waste.

3. ANALYSIS

Metal fractions separated from the e-waste during preprocessing may be further processed by hydrometallurgical, pyrometallurgical, electrometallurgical, biometallurgical methods, and combinations thereof. Hydrometallurgical and pyrometallurgical processes are the most important ways of processing waste electrical and electronic equipment. These routes can be followed by electrometallurgical/ electrochemical processes (eg electrowinning or electrolysis) to a particular metal separation and recovery. Currently, trials for processing electronic waste through biometallurgical pathways are not confined to the laboratory, for example, bioleaching of e-waste. However, this route has potential for further development.

E-waste preprocessing is not always necessary in pyrometallurgical route. For example, complex electronic equipment such as mobile phones and MP3 players can be treated directly during the melting process [8]. However in hydrometallurgical processes, pre-processing is required to separate the metal from other fractions. This increases the efficiency of each step associated with hydrometallurgical processes. Each route has advantages and disadvantages that must be taken into account in selecting a suitable recycling process.

Non-ferrous metals, including aluminum, copper, lead, nickel, tin, zinc and others are among the few materials that do not degrade and do not lose their chemical or physical properties in the recycling process. Consequently, nonferrous metals have the ability to be recycled an infinite number of times. Currently, precious metals are used in a wide range of applications, not only in the electronic and communications equipment, spacecraft, jet aircraft and engines, but also in mobile phones and catalytic converters. The most frequently recovered metals are:

- *lead: batteries, nuclear technique, typography, nonferrous metallurgy;*
- *gold: jewelry, electronics;*
- *silver: electronics, industrial applications (catalysts, batteries, glass / mirror), jewelry;*
- *aluminum: nonferrous metallurgy, energy, construction, transport, metallurgy, agriculture etc;*
- *tin: nonferrous metallurgy (bronze), food, solders, etc;*
- *copper: energy, electronics, nonferrous metallurgy (brass), food, transportation of electricity and heat;*
- *chromium and iron alloy (eg stainless steel), nonferrous alloys, superalloys, etc;*
- *nickel: cast iron and alloy steel (eg stainless steel), super alloys etc;*
- *niobium: alloy and super alloy high / low resistance;*
- *manganese cast iron, alloy steel, nonferrous alloys, superalloys, etc.*

Recycling for platinum, palladium, rhodium, gold and silver recovery is made from:

- *catalytic converters*
- *catalysts for oil refineries*
- *industrial catalysts*
- *nitric acid manufacturing plants*
- *carbon catalyst*
- *electronic waste*

Considering that precious metals are rare and have a high price, they continue to be recycled at a high rate of recovery. US Geological Survey estimated that 240 tons of gold wastes (new and old) were recycled in 2012 in the United States, which is more than the total domestic consumption of gold reported. In addition, Census Bureau data indicate that about 14,000 tons of scrap precious metals were exported in 2012 worth US $ 5.5 billion. [9].

Gold recovery

Gold is widely used in computer components. Motherboards and the terminal computers are containing precious metals. Although computers and laptops contain more gold, precious metals are found in everything from coffee makers to cars. Gold of older or obsolete devices can be recovered, but if left in landfills is considered dangerous. Obvious gold deposits from technological and household items can be fragmented.

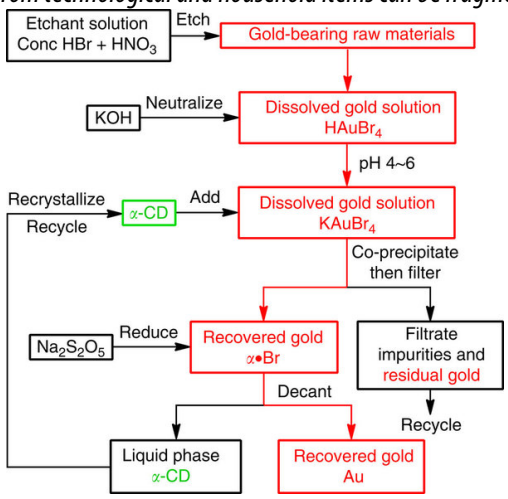

***Figure 2**. Processing flow gold recovery. [10].*

However, gold is very finely layered to be easily removed. CBX solution can be used to extract gold from computer motherboards. CBX underlying material dissolves gold. StripFree is an electrolyte solution using an external source of electricity to remove gold layers with a stainless steel base. StripFree works in the opposite way of galvanization in which electricity is used to cover an object with gold. An old solution for gold recovery is the royal water. A mixture of hydrochloric acid and nitric acid dissolve gold. Gold material is placed in acid and then precipitated using ferrous sulfide.

Platinum recovery

The catalytic converter is a device used to reduce the toxicity of emissions from an internal combustion engine. Widely used for the first time in mass car production on the US market in 1975, to comply with tightening EPA regulations regarding the discharge of gas, catalytic converters are still most commonly used in automotive exhaust systems. A catalytic converter provides an environment for a chemical reaction of combustion and the products are converted to less toxic substances. Opel is the first European producer of catalytic converters mounted on the standard versions of gasoline engines. [11].

The catalytic converter consists of several components:

- *The nucleus or core. In modern catalytic converters, the core is often a ceramic honeycomb, but there are also used stainless steel combs. Honeycomb increase the available surface area for catalyst support, and, therefore, is often referred to as a support "catalyst".*
- *Auxiliary layer. The auxiliary layer is used to make more efficient converters, often with a mixture of silica and alumina. Layer, when added to the nucleus, forming an irregular surface, tough, with a much larger area than the base, which then allows for for multiple places to deposit substances catalysts.*
- *The catalyst itself is often a precious metal. Platinum is the most active catalyst and it is widely used. This is not suitable for all applications because of unwanted additional and / or costs. Palladium and rhodium are two other used precious metals. Platinum and rhodium are used as a reduction catalyst, platinum and palladium while used as oxidation catalyst. Cerium, iron, manganese and nickel are also used, although each has its own limitations. For example, nickel is not legal for use in the European Union (due to reaction with carbon monoxide), while copper can be used, but its use is illegal in North America due to the formation of dioxin. [12]*

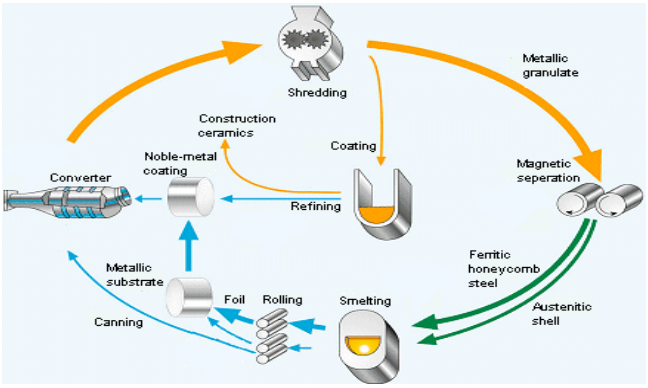

***Figure 3**. Processing Flow Catalytic converters [13]*

While gold is common in electronics because of its superior ability to conduct electricity, platinum is an essential component of catalytic converters. A ceramic honeycomb coated with platinum uses the car engine heat to capture these pollutants. Platinum is the catalyst in a chemical reaction.

A typical catalytic converter contains 1.5 grams of platinum and other metals. The exact amount of platinum depends on the formula used. At the laboratory level, aqua regia dissolution is an excellent way to leach alts of platinum. Salts of platinum can then be further refined to pure platinum. In another technique, sulfuric acid dissolves the ceramic honeycomb, leaving platinum.

Ceramics can be also volatilized and converted to a gas or liquid, a process that may leave behind platinum. Recovery of platinum from catalytic converters and electronic components is much more costly and more difficult than gold recovery. At scrapped, damaged or recovered auto catalysts, from the dismantling car:

- *The amount of platinum can range from 1 g to 15 g (or more for high power machines)*
- *Catalysts for gasoline cars contains about 5 grams of platinum*
- *Catalytic converters for diesel cars even contain 3 times more platinum than gasoline cars, meaning 15 g or more*

Gasoline cars, especially the new generations are equipped with catalysts containing platinum in addition with palladium or rhodium, or both, in different combinations. Diesel engines catalyst contains mainly platinum, palladium and rhodium because they need higher temperatures to become effective or because of chemical reactions that take place. Globally, there is a tendency to remove the platinum catalyst, in particular for gasoline vehicles with new car catalytic converters

containing less platinum and palladium becoming more and rhodium. For diesel versions, platinum will be replaced with gold because pollutants will decrease by 40% compared with platinum and especially the lower price of gold. Platinum is not as pure metal, palpable, it is as an alloy (Platinum, Palladium and Rhodium) and it is dispersed in a kind of ceramic honeycomb (sponge), through which gases are exhausted away. [14].

Lead recovery

The recovery of lead from used batteries is a vast field of research. Lead batteries contain lead alloy, lead sulfate, micro-porous paper and plastic. Every year industry produces about 2.5 mega tonnes of lead worldwide. The most part is used for batteries. The rest is used to cover wiring, plumbing, ammunition and fuel additives. Other uses are as pigments for the paint and plastics from PVC, protection against X-ray, crystal and pesticide production.

Primary lead is produced from sulfide ores containing iron, zinc, copper and other trace elements. The concentrate from the ore and e-waste is treated for the extraction of lead and precious metals. Basically, the process consists in sintering, reduction and refinement. Sintering is carried out to reduce the sulfur content of the material, which is composed of pyrite, limestone, silicon and lead in a high concentration. The reduction is carried out in a blast furnace using the coke in the molten lead by about 85% purity being withdrawn from the bottom of the furnace. The plastic fraction of electronic waste can partially replace coke as a reducing agent during the reduction step and metal fraction reaches the metal phase. In the refining stage, lead dross is processed by adding wood chips, fine coke and sulfur. The sulfur slag produced is separated and transferred into the furnace. The heating of furnace slag separates lead ingots (rich in lead), sulphide copper and other metals.

In the last stage of processing electronic waste by melting method of lead, precious metals and other elements are separated from ingots of lead. The precious metals are separated by Parkes process, in which the zinc forms an intermetallic compound insoluble gold and silver. Other impurities include antimony, tin, arsenic, bismuth, as well as the elements are also separated during the refining step. The end products of the refining stage a concentration of 99.99% lead, precious metals and other elements [15].

Copper recovery

Since the mid-1960s, global demand for refined copper rose by 250% (from 5 million to 18 million tons). Outputs from ores remain vital in order to meet this growing demand. Providing quantity of copper to meet the future society need, means recovery and recycling widespread and substantial investments in the mining industry. Copper is ubiquitous in modern life equipment, high-tech products, electrical installations or engines.

In 2011 the reused amount of copper was 2.1 million tons - an increase of 12% in one year, from end of life products and waste directly recycled manufacturing (direct melting). The increasing percentage of recycling is due to the increasing demand of copper industrial metal worldwide.

According to the report published by Copper Study Group International (International Copper Study Group - ICSG) 41.5% of the copper used in Europe comes from recycling. This reveals that the requirement of recycling of copper is provided, at a rate gradually. Increasing resources meet the growing demand for this metal (250% more than in 1960), while reducing environmental impact of production and ensuring availability for future generations. A computer contains about 1.5 kg copper, a typical home about 100 kg and a wind turbine 5 tons. As the copper can be recycled and reused infinitely without the loss of performance, we must ensure that products and copper waste are processed correctly when they reach the end of their useful life. [16]

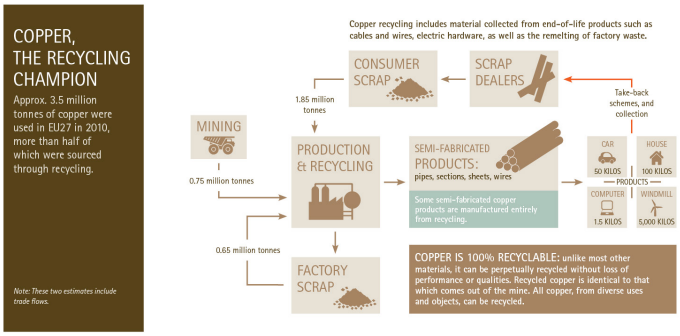

Figure 4*. Copper recycling activities [18].*

Copper smelting is an environmentally friendly process compared with the melting of lead generating toxic gases.

Copper smelting facilities to minimize transportation costs of e-waste and therefore recycling will be improved, allowing copper smelters to be installed near cities where electronic waste is generated. In these processes, precious metals are recovered through conventional electrowinning process, where they are separated from the sludge. [17].

Silver recovery

Silver recovery from waste solutions such as those produced by conventional processing of medical and industrial X-ray films, photographic films and pictures has been practiced for over 100 years. However, the economic viability of the process has changed radically in recent years. Silver is consumed in various ways, from eyedrops lubricants for jet engines. It is used by each hospital, medical clinic and dentist, and photo department processors, printers and anyone achieves photo processing of a wet solution.

Modern methods of recovery offer the opportunity to earn a quick payback, which means faster profits. Different methods are used to recover silver:

1. *Electrolysis – most commonly used. A stainless steel drum with current attracts the silver. The silver is stripped off the drum and the by-product called flake is sent for refining – usually 90% - 95% pure.*
2. *By adding chemicals, which cause the silver to form sludge – this is then dried and refined. The sludge is usually 30% pure.*
3. *Silver Traps – are also used to extract silver. This is a container with a cartridge – the fixer filters through the container and the Silver is trapped in the cartridge*
4. *Researchers have also developed methods for the extraction of silver, using bacteria and enzymes that "eat" the emulsion of gelatin, silver run. This method is not widely used (since 2011).*

X-ray films contain an average of 7.5g per kilogram while negatives have 9g / kg and camera film 2g / kg. Fixer varies according to how the film is processed but average at 3.0 grams per liter.

The legislation states that hospitals and clinics to follow certain rules regarding the disposal of X-ray films. X-ray films are considered private information so they must be completely destroyed, while silver and other chemicals in the film are toxic to the environment. Recovery of silver prevents penetration of metal into the environment, but other products used in the process must be carefully withheld or destroyed. [20, 21]

Aluminum recycling

One of the basic characteristics of aluminum is its versatility, allowing the use of the metal and its alloys in a wide range of sectors, from transportation to construction, electronics, packaging, furniture and industrial installations. For these final destinations, aluminum is used in the production of durable goods, excluding packaging. At end of life, it turns into waste products which are either stored or, alternatively, recycled or reused. In market economy a possible recycling is directly related to the recovery of residual value, in the sense that it will be directly proportional to the capability to strive for such a process. In terms of recycling, aluminum and its alloys are exceptional materials, because as with other non-ferrous metals recycling can be done without significant deterioration of quality.

Almost all of the absorbed energy in the first stage of metal production, namely 95%, is preserved in material and ready to be reused when remelting. As a result, the production of a kilogram of recycled aluminum requires energy equivalent to 5% of the electrolytic production of one kilogram of metal. Secondary aluminum is the equivalent of primary aluminum, even after several cycles of life, so that recycling can:

- *recover valuable material without loss of quality;*
- *save energy compared to primary production;*
- *reduce emissions and gas producing greenhouse;*
- *reduce mining activities;*
- *reduce waste. [22]*

4. CONCLUSIONS

Collection of waste from electrical and electronic equipment is a key step for recycling and efficient management of resources. The main options for collecting post-consumer goods are at the municipal level, to retailers, manufacturers and individuals. The economic policies of each country dictate the balance between different ways of collecting. The collection can be improved by raising awareness and increasing investment in well-organized collection facilities.

WEEE contains limited quantities of precious metals; therefore a long-distance transport is unprofitable. Transport is a significant obstacle and overcome this barrier is to develop preprocessing centers near cities. Such centers could perform sorting, dismantling, shredding and metal fractions from the release of other waste material. The conveyance of metal fractions is the only way to minimize transport costs, which can improve the economy of recycling electronic waste.

The lack of the centers for separation the metal from complex e-waste material is one of the barriers in the extraction of precious metals from e-waste, the issuance / separation during mechanical machining. Initial processing and release of metals are essential for recycling electronic waste.

Preprocessing steps, including sorting, dismantling, crushing and isolate the issue metals, alloys and other material values of a complex of e-waste. Some of the technical difficulties during the melting and refining processes can be reduced to a minimum during the delivery stage. Insulating of precious metals from e-waste is a challenge due to interconnections with other metals from computer motherboards.

Another barrier that affects the potential of electronic waste recycling is the incomplete knowledge of methods underlying melting and refining processes. It is crucial to have knowledge about the composition of the feedstock, and its possible side finished product. Recovery of PMS from e-waste using technologies similar to those applied natural ore is a challenge. [23]

However, according to the Belgian company Umicore (one of the largest recyclers in the world, heavy metals from electronic waste and industrial waste), urban mining could result in 200-250 g gold / tonne of integrated circuit cards and 300-350 g / tonne of mobile phones. This contrasts with the concentrations obtained in the mining of gold core, about 5 g / tonne of crude ore.

Output products contains metals in a higher concentration than primary sources, meaning that it takes typically less energy to extract the same amount of metal. The Umicore recycling unit in Hoboken, Belgium, produces, for example, 70,000 tonnes / year of metal and issues with a megaton of CO_2 less than if the amount of metal was made from raw ore. In Romania, nearly 18,000 tons of electronic waste resulting from the IT, electronics and home appliances were collected in 2008. Using the average of 250-300 g / t, would result between 62 and 70 tonnes of gold that could be recycled in a single year from this source of waste. For example, in Rosia Montana, the Canadian company RMGC aims to extract 314 tons of gold in 16 years. [24]

BIBLIOGRAPHY

[1.] Robinson, B.H. E-waste: An assessment of global production and environmental impacts. Sci. Total Environ. 2009, 408, 183–191.

[2.] European Parliament. Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE). Off. J. Eur. Union 2003, L37, 24–38.

*[3.] Metal Extraction Processes for Electronic Waste and Existing Industrial Routes: A Review and Australian Perspective, Abdul Khaliq, Muhammad Akbar Rhamdhani *, Geoffrey Brooks and Syed Masood*

[4.] Office of Solid Waste. Electronic Waste Management in the United States—Approach 1; U.S Environmental Protection Agency: Washington, DC, USA, 2008; p. 56.

[5.] Puckett, J.; Byster, L.; Westervelt, S.; Gutierrez, R.; Davis, S.; Hussain, A.; Dutta, M. Exporting Harm—The High-Tech Trashing of Asia; The Basel Action Network (BAN) Silicon Valley Toxics Coalition (SVTC): Seattle, WA, USA, 2002.

[6.] *Cui, J.; Forssberg, E. Mechanical recycling of waste electric and electronic equipment: A review. J. Hazard. Mater, 2003, 99, 243–263.*
[7.] *Institute of Scrap Recycling Industries (ISRI). Scrap Recycling: Where Tomorrow Begins; ISRI: Washington, DC, USA, 2003; pp. 16–24.*
[8.] *Anindya, A. Minor Elements Distribution during the Smelting of WEEE with Copper Scrap. Ph.D Thesis, RMIT University, Melbourne, Australia, 2012.*
[9.] *http://www.isri.org/recycling-industry/commodities-specifications/nonferrous-scrap#.VuezSPBh BoN*
[10.] *http://www.nature.com/ncomms/journal/v4/n5/full/ncomms2891.html*
[11.] *http://media.gm.com/media/ro/ro/opel/news.detail.html/content/Pages/news/ro/ro/2014/opel/05_10_25_ani_de_convertoare_catalitice.html*
[12.] *http://en.wikipedia.org/wiki/Catalytic_converter*
[13.] *http://www.emitec.com/en/environmental-protection/environmentally-sound-recycling.html*
[14.] *http://byrev.org/ro/catalizatoare-auto-platina-paladiu-si-rhodiu/*
[15.] *ISO 9001:2008 Certified International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 2, Issue 1, January 2013 Recovery of Lead Metal from Lead Acid Battery by Hydrometallurgical Method, E.Yoheeswaran, Dr.S. Govindaradjane Dr.T.Sundararajan*
[16.] *http://copperalliance.eu/ro/despre-cupru/reciclare*
[17.] *http://biblioteca.regielive.ro/proiecte/metalurgie-si-siderurgie/metode-fizicochimice-de-recuperare-a-cuprului-ecologie-fizica-68565.html*
[18.] *http://copperalliance.eu/ro/despre-cupru/reciclare*
[19.] *http://www.capepreciousmetals.com/silver-recovery/profiting*
[20.] *http://www.capepreciousmetals.com/silver-recovery/profiting*
[21.] *http://www.electrochemsci.org/, Silver Recovery from Radiographic Films Using an Electrochemical Reactor, P.A. Ramirez*, V.E. Reyes, M.A. Veloz, Área Académica de Ciencias de la Tierra y Materiales, Universidad Autónoma del Estado de Hidalgo. Carr. Pachuca-Tulancingo Km. 4.5, Mineral de la Reforma, Hidalgo, CP 42184, México.*
[22.] *http://blog.webphoto.ro/articole/reciclarea-aluminiului-o-afacere-rentabila/*
[23.] *Metal Extraction Processes for Electronic Waste and Existing Industrial Routes: A Review and Australian Perspective, Abdul Khaliq, Muhammad Akbar Rhamdhani *, Geoffrey Brooks and Syed Masood, Faculty of Science, Engineering and Technology, Swinburne University of Technology, Hawthorn, VIC 3122, Australia;*
[24.] *http://totb.ro/deseuri-de-aur/*

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BULLETIN OF ENGINEERING
ISSN:2067-3809

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PRINCIPLES OF MODELLING OF MACHINE AGGREGATES

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Abstract: *Modelling of machine aggregates requires systematic approach. There is no general agreement about the definition, structure and classification of subsystems of machine aggregates. In the present paper general principles of modelling of machine aggregates are outlined. Machine aggregate is treated as complete integration of electronic control subsystem, electric driving subsystem and mechanical working subsystem.*
Keywords: *machine aggregates, modelling, integration*

INTRODUCTION

The machine aggregate in Fig. 1 represents dynamic system to drive a plant and to control the technological process and displays schematics of a modern controlled system. There are three subsystems:

- *the (electric) drive, i.e. the (electro)motor and the gear,*
- *the driven mechanical equipment that represents equipment for electromechanical energy conversion, the actual technological process and the product of the process ,*
- *the control system performing an optimal control of the machine aggregate.*

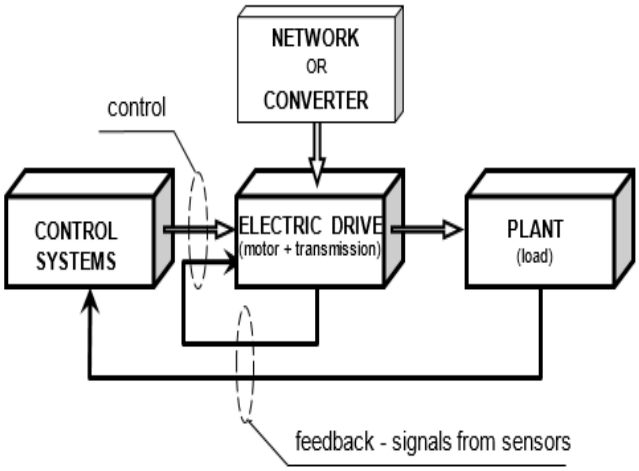

***Figure 1**. Block diagram of the machine aggregate.*

By the quality of the machine aggregates, i.e. by the static or dynamic characteristics of the subsystems are assigned the productivity of the process, the quality (operational stability, accuracy, speed) of the process and the product as well as the static/dynamic loading of the aggregate mechanical, electrotechnical and electronical units. Also the level and type of mechanical load, accuracy of gears, characteristics of drive and control, overall quality etc. obviously influence the motor and control performance conditions [1], [2].

MACHINE AGGREGATE – STATE OF THE ART

A machine aggregate and its intended control functions respecting the mutual energetic interaction of subsystems consisting of:

- *supply and power converter of some kind,*
- *electric AC or DC drive with proper kind of electromotor,*
- *a plant subsystem,*
- *control electronics (analog or digital, if digital than programmable microcontroller system).*

All but the last subsystems are power subsystems. The control subsystem is an information subsystem. Hence, from another point of view, a machine aggregate is an integration of following subsystems:

- *power electromechanic system of machine aggregate and plant generating the torques and forces needed by the process, under prescribed speed, position etc.*
- *energy supplying power electronic system modifying the electrical energy constant parameters of the primary sources to values of the converter postulated by the process,*
- *information control electronics.*

The power electromechanic system together with the energy supplying power electronic system performs an electro-mechanical energy conversion. The goal is an optimal control with respect to the technological process or the dynamics of the aggregate as a whole.

Machine aggregates with controlled drives often need a multi-level hierarchical control. In the basic level of, say a speed system, the angular speed of the motor/drive is controlled by a speed controller, perhaps with the aid of a subsidiary current controller [3].

The control of both current and speed loop controllers can be designed starting with the current controller at the most internal loop in a number of ways. To design the position control systems, the speed control system with speed feedback loop designed above becomes subsidiary to a position control loop. Cascade, parallel and feedback groupings of

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controllers are available, just to refer to some of the design procedures. In the higher control levels of technology control, operational quantities/parameters are managed, with the goal to keep the conditions of the process optimal. The system approach finds machine aggregate to be merely a subsystem, which is internally controlled part of the whole system, see Fig. 2.

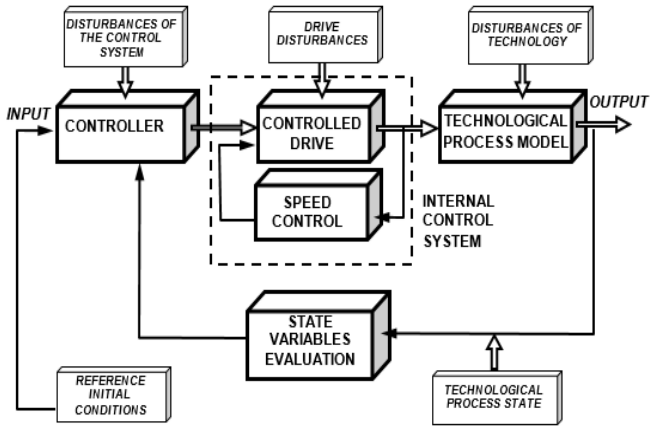

***Figure 2**: Detialed block scheme of machine aggregate.*

Then the machine aggregate MA is an integrated system consisting of three subsystems: electronic control subsystem ECS, electric driving subsystem EDS and mechanical working subsystem MWS. The integration covers design, construction, operation and maintenance with respect to optimal static as well as dynamic attributes of the MA:

- *ECS performs the optimal control of the MA heading the MA objectives: product or/and process,*
- *EDS is an energy electric-to-mechanic converter,*
- *MWS executes the final production or process, following the MA objectives.*

MODELLING THE MACHINE AGGREGATE

Transition from a real machine aggregate to its model is only possible if ideas on the goal of the system, on the states of the system, on the foregoing analysis, on specification of characteristic features for the designed functions of the system are taken into the consideration. There are lot of cases, when the model and simulation are the only way to get some knowledge. Two main aspects of the approach to the task are:

- *creating a proper model (Modelling)*
- *working properly with the model (Simulation).*

Writing the mathematical model in a mathematical form is the first step and is deduced from the proper theory of the investigated subject, namely from known physical laws from all the relevant branches.

The next step is writing the model code as a package of main program and supporting subprograms, using the results of the first step. After the verification of the main program and the whole program package, simulation experiments follow as the step three. The fourth step is verification of the results of the previous steps, probably using some kind of experimentation with physical models, or experimentation with the real object or process modelled.

Synthesis of computational and experimental methods is the basis for modern experimental work and is the most effective method for analysis and synthesis of machine aggregates.

The whole sequence to create a machine aggregate mathematical model as described above has three parts:

1. Modelling of energetic interactions among the subsystems

- *Formulate in natural language and describe mathematically all the individual construction parts of the machine aggregate and interactions among them (Fig. 1).*
- *Create the main program based on the previous point and the subprograms for the main program.*
- *Perform identification measurements on the model, i.e. perform the simulation experiments and postprocess them. Make statement, how truly the model substitutes the real object/process. Understand the numbers, tables, graphs etc. generated, describe the results in the natural language.*
- *Make an expert opinion on the model. The goal is to get the best possible working and simple model of the reality. The quality of the model depends on the quality definition, as an example the quality might be a compromise between the best possible stability of the model, its minimal computational time and accuracy of results.*

2. Reducing the model to formulate the control laws

- *Create a linearized model of control, say, for the machine aggregate with working point shifted within a small displacement zone.*
- *Create a linearized model in the working part of the torque-speed characteristics.*
- *Create a nonlinear model by the constants assigning method for the nonlinear model using the regression principle.*

3. Creating the control law

Verification within the validity area of the reduced model is based on simulation experiments. Numerical or analytical simulation is optional, depends on the CAMS program (program system, package) in use. The MATLAB can work analytically but perhaps its main domain is the discrete simulation. The MATHEMATICA works analytically. As for the dynamic modelling and simulation, the key view is whether the integration of differential equations describing the machine aggregate is performed by symbolic or numerical integration.

The recent works in the machine dynamics deal mainly with discrete parameters, lumped mechanical system models and also with FEM models. Let us have a look into the recent decades to display what is to be done in next ones. The recent works of experts in drive systems treated in-depth the phenomenon of their own, while the mechanics of the plant was treated with a reasonable overlap of both branches. The same is valid for the experts in mechanics. As for experts in control, this branch is rich in experts and literature, both in analogue and digital types of control. Even in well done works from electrical (controlled) drives the mechanical subsystem has been assessed and modelled with reduction to single or two rotating bodies, using an ordinary differential equation of the 1st or 2nd order [4].

Some very specific problems emerge due to the above conventional approach to predominantly machine aggregates. One of them is the time constant: The shortest time constants of a common control subsystem

may be in units of 10^{-3} sec. The shortest time constant of a electrical part of the drives is within orders 10^{-2} - 10^{-1} sec, while for usual mechanical subsystem may be within orders 10^{0} -10^{1} sec. This difference is the source of compatibility problems even for machine aggregate with the most trivial control subsystems. Future research and models have to develop means to cover the mismatch at time constants of physically different subsystems.

CONCLUSION

The structure and principles of modelling of the machine aggregate was analyzed, respecting the interdisciplinary nature of individual steps leading to final global model of machine aggregate as well as respecting the interactions between mechanical and control parts of the drive and the parameters of the plant.

Acknowledgement

The paper was worked out in the framework of the research projects VEGA-1/0694/14 „Increasing the efficiency of technological systems by structural dynamic modification their mechanical subsystems".

References

[1.] Naď M., Riečičiarová E., Oravcová J.: The effect of gearing to dynamical properties of machine aggregates. Machine design, 2009, pp. 197-200, ISSN 1821-1259.

[2.] Mudrik, J. – Ďuriš, R.: Transient phenomena of electric drive with load arising during a technological process. In: International Conference – Modelling of Mechanical and Mechatronical Systems – MMAMS 2007, pp. 147-177, Herľany, ISBN 978-80-8073-874-7.

[3.] Kratochvíl, C. - Březina, T.: Complex driving systems, In: Simulation Modelling of Mechatronic Systems, Březina T. (Ed.), 2005, pp. 111-119, Brno UT, ISBN 80-214-3144-X, Brno.

[4.] Kratochvíl, C. - Březina, T.: Modelling and analysis of dynamic properties of small electro-mechanical drive system I. In Proceedings of the 9th International Seminar of Applied Mechanics, Zeszyty naukove Politechniky Slaskej, No. 28/5, 2005, pp. 89-98,Wisla, Poland.

[5.] Mudrik, J. - Kráľ Š. - Labašová, E.: Contribution to the dynamics of machine aggregate with gearing. In: Proceedings of National Conference with International Participation - Engineering Mechanics'96, Svratka, 1996, pp.161-166.

[6.] NAĎ, Milan - STEINHAUSER, Jozef - ROLNÍK, Ladislav. Mechatronic approach to the modeling of machine aggregates. In Applied Mechanics and Materials. ISSN 1660-9336, Vol. 693 (2014), s. 317-322. Projekt: 1/1041/11 113.

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IMPROVING PRODUCTIVITY THROUGH DESIGN AND DEVELOPMENT OF RE-CAPABLE NEEDLE COVER FOR BLOOD BAG NEEDLE ASSEMBLY

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Abstract: Blood bag manufacturers are very keen to maintain high quality of needle assembly but manual needle assembly process tends to compromise the quality of needle to a certain extent which has lead to overall rejection percentage to be around 3.2%. The objective of the project is to increase the productivity of needle assemblies with higher output, lesser rejections and higher product quality. For achieving this emphasis is given on the design and development of re-capable polypropylene outer protective needle cover. The CAD model of the polypropylene cover is completed using Creo 2.0. The breaking torque for inner PVC cover is found to be 58 N-mm. The strength of proposed PP cover to withstand the calculated pinching torque is validated with a factor of safety of 3.72 using ANSYS 14.0. Autodesk Mold flow simulation software is used to optimize the gate location and mold parameters. The effect of varying wall thickness, melt temperature, and injection time are also analyzed in consideration with the gate location and proper processing conditions for quality result. Through analysis results higher melt temperature of 240° C, injection time of 0.25 sec and wall thickness of 1 mm are recommended to achieve successful molding for PP needle cover. It also provides minimum possibility of part warpage and weld lines throughout needle cover.

Keywords: Needle assembly, PP cover, Pinching torque, Injection molding, Mold parameters optimization

INTRODUCTION

Blood bags produced at HLL Life care Limited are sterile, single use PVC Plastic collapsible container system for blood collection. Needle assembly is the most critical part of blood bag system. Quality of needle assembly plays a vital role in blood bag production because it is the only component which comes in direct contact with the human. Painless blood donation is one of the prime aspects to promote blood donation, so as to improve the donor comfort and eliminate the donor complaints. The needle assembly consists of three components; a needle holder (Hub), stainless steel needle (16G / 17G) and a poly vinyl chloride needle cover as shown in Figure 1. The needle is placed inside the needle holder and is bonded using UV curing adhesive. The cover is fixed on the needle holder so as to protect the needle. Hereafter, the assembly becomes tamper evident. At the time of usage, the cover shall be twisted open and perform the veni-puncture (Inserting the needle into the donor's vein) for blood collection.

Figure 1. Needle assembly components

With current annual requirement of 9 million pieces for needle assemblies in the company, the existing method for production is found to be manual assembly, by using some fixtures, jigs and some stand-alone equipment. Since it is fully operator oriented process, there are chances for human errors which has lead to quality issues like wrong bevel orientation, absence of required quantity of adhesive, improper needle siliconization, needle tip damage due to manual handling, improper glue application, improper alignment of needle cover with holder owing to higher rejection rate of up to 3.2 %. Manual needle assembly has also lead to higher manpower requirement as the output per person is on lower side. Rejected components study revealed that about 60% of rejection is resulted due to needle tip damage as shown in Figure 2.

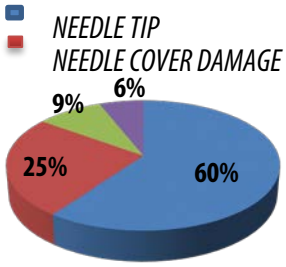

Figure 2. Rejection percentage chart

Since the produced needle is a non re-capable type (without any protective cover) there is rejection while transportation and packaging of blood bag as the needle tip may damage or it may pierce into the PVC cover. Non recap-able needle cover has also lead to safety issues as the contaminated needles, left exposed; present a serious risk to healthcare workers and other personnel in the clinical and hospital setting, including laundry and waste removal staff. Emergency situations and time pressures often result in inadvertent mishandling. Needles used for

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repeated injections in the same person are frequently set aside uncapped, also presenting a hazard.

With the rise in demand for needle assemblies, there is been a concern about the quality issues and resolving these issues is a priority for the company. Through many brainstorming sessions and cause effect analysis it is found that a new recap-able protective cover and cost effective automation is the solution for the current problem. In this project, emphasis is given on the design and development for recap-able protective needle cover. The material used for protective cover is polypropylene which is outside the inner PVC cover. In order to pinch off the inner PVC cover a breaking torque is been applied. Ansys 14.0 finite element tool is used to find the value of torque. Structural analysis for the proposed Polypropylene cover is done in order to validate that the PP cover does not break off when pinching torque is applied. Optimization of gate cover location with respect to various flow parameters for injection molding of PP cover is also analyzed. Effect of variation in melt temperature, injection time, needle cover thickness to injection quality is studied and injection molding parameters are determined.

LITERATURE REVIEW

The design process consists of a sequence of process and a set of guidelines that helps define a clear starting point that takes the designer from visualizing a product. Hence;

" ... before designers can solve a design problem they need to understand some basics – such as what they are designing, what it should do and who should use it, and under what circumstances" (Randall, Harper and Rouncefield 2007)".

A lot of studies is been carried out on the current product design and development procedure. Ulrich K.T, Eppinger S.D[1] and Kevin Otto[2] briefs about the current product design pattern. Shikawa and Kaoru[3] provides an overview on the root cause analysis using fish bone diagram for quality control. Ola Isakssona, et al.[5] research is based on the implementation of Product service system in various manufacturing firms in order to reduce cost and increase productivity. G.J. Micheal and R.A. Millen[6] justifies the cost effectiveness of automation based on literature review and results of interviews with executives of manufacturing firms. Du Hwan Chun, et al.[8] presented the optimum gate filling location for needle housing with increased wall thickness, lower melt temperature, and longer injection time. The results indicated that higher melt temperatures were recommended to achieve successful molding and injecting the polymer at a longer time (1.2 second) leads to a significant increase in flow stresses. S.R. Pattnaik, et al.[9] and Yathish Kumar K.R, Prof. Nagaraja R[10] also shows the variation of flow parameters on the product quality in plastic injection molding process. Wong C.T, et al.[11] and J. P. Beaumont, et al.[12] presents the design and simulation of plastic product using Pro-E parametric software. The predicted weld lines and air traps were also analyzed.

METHODOLOGY

In order to design and develop a needle cover, a series of product development procedure is been followed starting from the concept generation to prototype fabrication as shown in Figure 3.

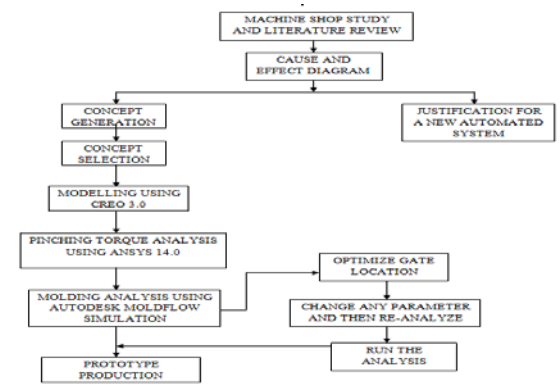

***Figure 3**. Methodology flowchart*

DESIGN OF RECAP-ABLE NEEDLE COVER

In order to find potential root causes for the above mentioned problem several brainstorming sessions were conducted. A well known brainstorming tool used here is "Ishikawa's Fish bone diagram". Because of its function it may be referred to as a cause and-effect diagram. The problem, which is decrease in productivity and increase in rejection rate, is placed at the fish's head and their causes are laid along the fish bone. Figure 4 shows the fish bone diagram.

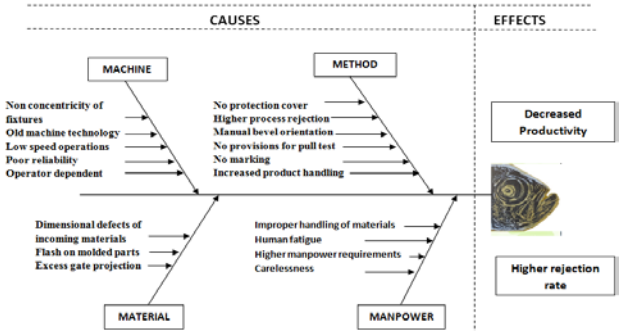

***Figure 4**. Cause and effect diagram*

According to fish bone diagram, cost effective automation and development of recap-able needle cover are the solution for the given problem.

Concept Generation

For the given needs importance rating were given and remarks for good design were noted. Table 1 shows the concept generation chart. Based on this concept different concept ideas were produced and evaluated.

***Table 1**. Concept generation method*

NEEDS	IMPORTANCE	REMARKS
FUNCTIONALITY		
• Act as a protective cover for the needle.	5	Flexible – PP cover
• Provides correct orientation and locking mechanism.	5	Stiff locking
• Need to hold cover after pinching.	5	Extend up to needle hub
OPERATION		
• Easy to hold and assemble.	4	Flexible design
• Adaptable to current manual needle assembly operation.	5	
SAFETY		
• No sharp edges or corners.	3	Check for material and safe design.
• Approved.	5	
MANUFACTURABILITY		
• Easy to cast for large assembly.	4	Less than Rc 1.
• Low cost.	5	
ERGONOMICS		
• Pleasant look.	3	No gap between PP and PVC cover.
• Tight tolerance without any gap.	5	

Concept Selection

Weighted matrix method is used for selection of different concepts. The selection is made in view of product functions needed. Appropriate weightings for each function are given. Out of three different concepts;

PP cover with zip lock, outer PP cover, PP cover with press fit lock Table 2 shows that concept 3 is the most appropriate with highest rating.

***Table 2**. Weighted matrix*

CRITERIA / WEIGHTINGS		CONCEPTS: PVC COVER INSIDE PP COVER FITTED TOGETHER	PP COVER WITH ZIP LOCK	COVER WITH PRESS FIT LOCK
ADAPTABILITY	0.2	30 / 6.0	100 / 20	100 / 20
MANUFACTURABILITY	0.15	50 / 7.5	40 / 6.0	40 / 6.0
ERGONOMICS	0.1	50 / 5.0	80 / 8.0	70 / 7.0
SAFETY	0.2	70 / 14	30 / 6.0	90 / 18
COMPLEXITY	0.15	30 / 4.5	80 / 12	70 / 10.5
COST	0.2	60 / 12	85 / 17	80 / 16
OVERALL RATING		49	69	77.5

MODELLING AND ANALYSIS

Finite Element Analysis

Cad model, as shown in Figure 5, is been made using Creo 2.0 as per the given dimension.

***Figure 5**. Creo model for PP cover*

In order to remove the inside Polyvinyl chloride cover during usage a breaking torque is applied on the cover so that it pinches off from the needle hub. Since the proposed Polypropylene cover is outside the PVC cover, it will also be subjected to the above mentioned torque. Hence, ANSYS 14.0 is used to determine the value of pinching torque applied on the PVC cover. The hence obtained pinching torque is given as input to determine the stress distribution in the PP cover.

Meshing

Material properties for inner PVC cover are given with density = 1420 kg/m^3 and modulus of elasticity = 3.37 E+09. Fine mesh is done with element size of 2mm as shown in Figure 6. On meshing, the no. of nodes obtained is 3198 and no. of elements used is 1641.

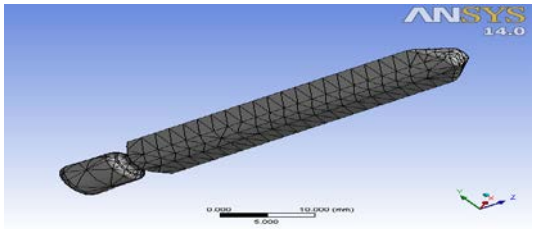

***Figure 6**. Meshed model*

Analysis Result

In order to find the breaking torque Von-mises stress calculation is been done. The tensile yield strength of PVC cover is 19.6 MPa and the corresponding breaking torque required to pinch off the PVC cover from the needle hub is found to be 58 N-mm for a total deformation of 0.089 mm shown in the Figure 7. The value obtained for breaking torque is then applied to the designed PP cover to validate its strength.

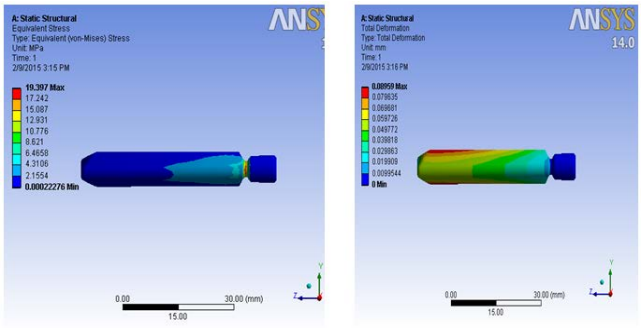

***Figure 7**. Von misses stress and total deformation*

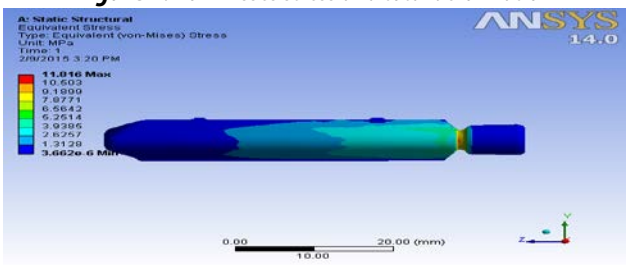

***Figure 8.** Stress distribution of needle cover*

Figure 8 shows the stress distribution for the given PP cover. For an input breaking torque of 58 N-mm, the maximum von-mises stress acting on the PP cover is found to be 11.816 MPa. The tensile yield strength of Poly propylene is 41MPa which is well above the obtained breaking torque with a factor of safety of 3.72. Hence, the proposed PP cover is safe.

MOLD FLOW SIMULATION

Injection molding is one of the most popular manufacturing methods for the cost-effective mass production of the plastic parts. In order to investigate the process conditions of molten polymer, filling analysis is done. Autodesk mold flow simulation is a powerful simulation tool to optimize the gate location and to predict the production time required at the lowest possible cost. Verification using simulation requires achieves quality results within minimum time, and with no material costs, as compared with the conventional trial and-error methods on the production floor. In order to validate appropriate gate location for a POLYPROPYLENE NEEDLE COVER, mold quality and defects are analyzed for different gating options and operating parameters are compared. Figure 9 shows the suitable location for the gating system from best to worst scale. Based on this result optimum number of gates to be used are analyzed.

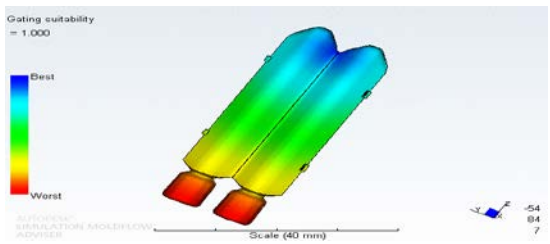

***Figure 9**. Suitable gate location*

For an injection pressure of 38.67 MPa, melt temperature of 220°C and injection time of 0.232 sec quality prediction for one gating system and two gating system is been done as shown in Figure 10.

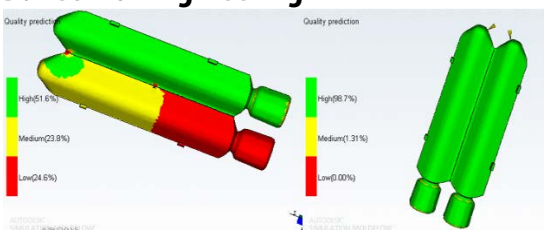

***Figure 10**. Mold quality prediction for one gate system and two gate system*

Analysis result shows an increase in mold quality to 98.7% with two gating system. Based on the results, the optimum gate location for the minimum flow stresses and uniform fill patterns is selected. The effect of increasing injection time and varying melt temperature for a given injection pressure of 38.67 MPa is also analyzed. Lowering injection time to less than 0.2 sec is not practically possible as there will not be proper filling in the mould. In Figure 11 quality of the PP cover is checked for longer injection time of 0.4 sec. Change in mold flow quality is also analyzed for lower melt temperature of 200℃ and higher melt temperature of 240℃ as shown in Figure 12.

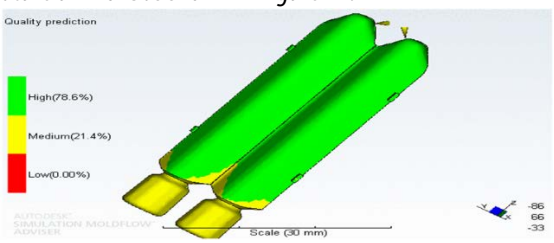

***Figure 11**. Quality prediction (0.4 sec injection time)*

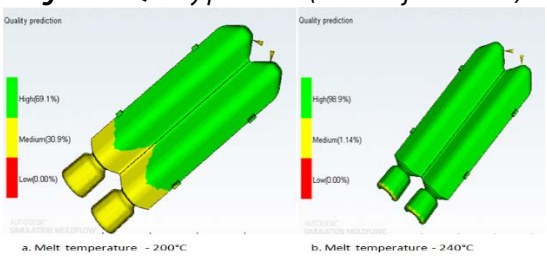

***Figure 12**. Quality predictions for varying melt temperature*

***Figure 13**. Weld line defect*

The recommended wall thickness for polypropylene material is 0.635 to 3.032 mm. The selected wall thickness is 1mm. Analysis result shows that with increase in wall thickness mold quality reduces. Since two gate system are prone to mold defects such as weld lines. Figure 13 shows the weld defects. Higher melt temperature of 240℃, injection time of 0.25 sec and wall thickness of 1 mm is selected as the optimum mold flow parameters for needle cover.

CONCLUSION

Improving overall productivity is the main objective for all manufacturing sector. With increasing competitiveness increase in quality has become the measuring parameter for company's success. Increase in rejection rate to 3.2% had an alarming effect on the profit. The cause-effect diagram highlights all the relevant solution for the mentioned problem. Design of recap-able outer polypropylene needle cover is done in reference to the product development methods starting from concept design to prototype fabrication. Cad model is generated using Creo 2.0. Static structural analysis is done using ANSYS 14.0 and the strength of the proposed PP cover is validated for the calculated pinching torque with a factor of safety of 3.72. Autodesk Moldflow simulation is done to optimize the mold parameters. Through analysis it is found that higher injection times leads to decrease in quality. The results of analysis on varying melt temperature, and longer injection time indicated that higher melt temperatures and normal injection time are recommended to achieve successful molding. Thus it also provides minimum possibility of part warpage and weld lines throughout needle cover.

ACKNOWLEDGMENTS

The authors would like to thank Product Improvement (PI) Department of HLL Lifecare Limited, Akkulam, india factory for their support.

REFERENCES

[1] *Ulrich K.T. and Eppinger S.D, 2007, "Product design and development"; CITY: McGraw-Hill.*
[2] *Kevin Otto, Kristin Wood ; "Product Design: Techniques in Reverse Engineering and New Product Development" December 8, 2000;*
[3] *Shikawa, Kaoru, "Guide to Quality Control"; Tokyo, Japan: Asian Productivity Organization (1986).*
[4] *American Society for Quality, Fishbone diagram; http://www.asq.org/learn-about quality/cause-analysistools/overview/fishbone.html.*
[5] *Ola Isakssona, Tobias C. Larsson and Anna Ronnback, "Development of Product-Service Systems: Challenges and Opportunities for the Manufacturing Firm"; Journal of engineering design, Vol- X.*
[6] *G.J. Micheal and R.A. Millen; "Economic justification of modern computer based factory automation: A status report"; Annals of operation research 3(1985), pp- 25 to 34.*
[7] *Ullman. D. G., 2003. "The Mechanical design process"; 3rd ed. New York: McGraw-Hill.*
[8] *Du Hwan Chun, Byoung Hee You1, and Dong Joo Song, "Injection Molding Analysis of a Needle Cover – Optimum Filling for Gate Location Design"; Fibers and Polymers 2012, Vol.13, No.9, 1185-1189.*
[9] *S.R. Pattnaik, D.B. Karunakar, P.K. Jha," Application of computer simulation for finding optimum gate location in plastic injection moulding process", International Journal of Advanced Engineering Research and Studies, Vol-1, 159-161.*

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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MEASURING METHOD TO DETERMINE THE VIBRATION DAMPING BEHAVIOUR OF METALLIC FOAMS

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Abstract: The damping capability of metallic foams is worse than for the solid metal materials will be the result if we make the calculation. This would be the opposite of those statements that underline the significant vibration damping capability of metallic foams. The vibration damping behaviour of solid metal materials can be described with a viscous damping model. It is questionable whether we can use or not the same damping model for metallic foams. In this paper the authors describe a measuring method to determine the vibration damping behaviour of the metallic foams and try to determine which damping model is good to describe the behaviour of metallic foams (Coulomb damping or viscous damping).
Keywords: metallic foams, vibration damping, damping model

INTRODUCTION

The technological development brought close to avail metallic foams for designers in industrial use. Many Hungarian institutions are manufacturing and working with metallic foams such as the University of Miskolc And The Bay Zoltán Nonprofit Ltd. in Miskolc, or in Budapest, the Budapest University of Technology and Economics.

The name metallic foam indicates such a solid metallic material, which has more than 90% porosity (some manufacturer produces 'metal foams' less than 90% porosity). The density of this kind of materials is less by one order of magnitude. Metallic foam has several properties that make its use desirable in engineering. These properties are energy-absorbing, heat conduction, damping, sound-absorbing and filtering abilities. Metallic foams have two types; the open-cell and closed-cell ones. Most of the cases the material of the metallic foam is aluminium-alloy but metallic foam also can be created from other materials (steel, copper, silver and titan). [1], [2]

Many researches were carried out to determine physical, chemical and mechanical properties of metallic foams. Properties of metallic foams depend on the size of the cells, the thickness of the walls (bridges) between the cells and the shape of the cells if the material is the same. With the use of the modified ratio between the solid metal density and the foam metal density, we can approximately determine foam material properties. The computational equation is equation (1).

$$\frac{P}{P^0} = k \cdot \left(\frac{\rho}{\rho^0}\right)^n \qquad (1)$$

where, P: a kind of property, ρ: density, 0: index for metals, without index 0 is for metal foams, n, k: can be chosen according to Table 1, parameters from measurements.

Table 1. k and n factors to determine parameters of metal foams

Property	k	n
R (Ωm)	1	-1.6÷-1.85
λ (W/mK)	1	1.6÷1.85
E (GPa)	0.1÷4	1.8÷2.2
σ (MPa)	0÷1.0	1.5÷2

Literature is short-spoken in the point of view of the damping behaviour of metallic foams. About the damping behaviour of solid metals many literature publish data such as logarithmical decrement or Lehr's damping ratio. [3], [4].

That would be obvious to use equation (1) to determine the damping capability of metallic foams. The damping capability of metallic foams is worse than for the solid metal materials will be the result if we make the calculation. This would be the opposite of thosestatements that underlinethe significant vibration damping capability of metallic foams. We can determine that equation (1) cannot use for determine vibration damping capability of metallic foams.

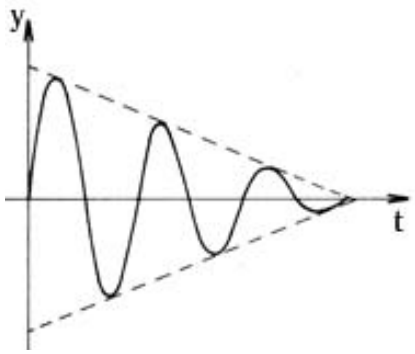

Figure 1. The nature and the envelope of Coulomb damping

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The vibration damping behaviour of solid metal materials can be described with a viscous damping model (Figure 2). It is questionable whether we can use or not the same damping model for metallic foams.

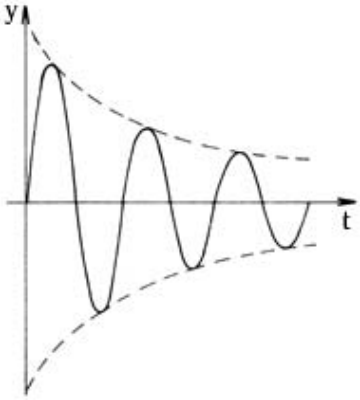

***Figure 2**. The nature and the envelope of viscous damping*

Next chapters will be described a measurement, which can help to determine the vibration damping behaviour of metallic foams and the value of logarithmical decrement.This paper introduces the next step of the research introduced in [1].

THE SHAPE OF THE SAMPLE AND THE LAYOUT OF THE MEASUREMENT

We made beams with rectangular cross-section from the metallic foam material. The beam was made from a greater metallic foam plate with a milling machine.

***Figure 3**. The metallic foam beam*

The dimensions of the metallic foam beam: 35.5mm x 27mm x 300mm, weight 92 g (Figure 3).We fastened a weight to one of the ends of the beam with a screw fastening (it is signed with $m_0$in Figure 6), in this way set up the sample (Figure 4).

***Figure 4**. The sample*

We fastened the free end of the assembled sample with a fixed support (Figure 5).

We placed load to the sample with another weight, with a help of a fishing line(signed with m in Figure 6).After cutting the fishing line which held the (m) weight we measured the displacement of the free end of the beam.The displacement was measured with a laser displacement meter(signed with L in Figure 6). The sketch of the measurement can be seen in Figure 6, and real measuring in Figure 7.

***Figure 5**. Fasten of the sample*

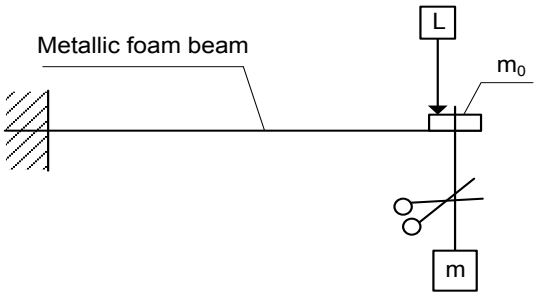

***Figure 6** .Sketch of the measurement*

***Figure 7**. Real environment of the measurement*

We lead the fishing line of the weight trough the bore in the fasten screw of the $m_0$weight. We chose this type of line leading to prevent the sample to make vibration outside the vertical plain. Measurements were made with 1kg, 2kg, 3kg loads. Beside the measurements with loads, we made knocking measurements too. We compared the two types of measurement.

MEASURED DATA

The displacement of the free end of the metallic foam beam we saw on the computer monitor.A picture from the computer monitor can be seen in Figure 8.

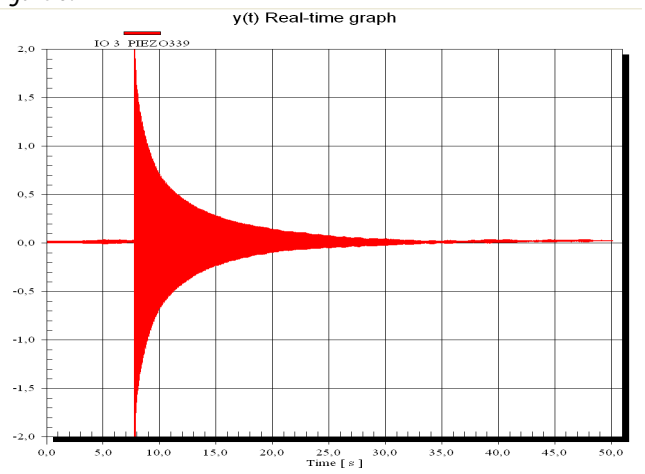

***Figure 8**. Displacement of the end of the beam depending on time*

The measurement software is able to export the measured data into Excel format. Further processing was made in Microsoft ™ Excel ™. Excel file contains the measured data (displacements) in one column. We need to modify the measured displacement data to get result from that.

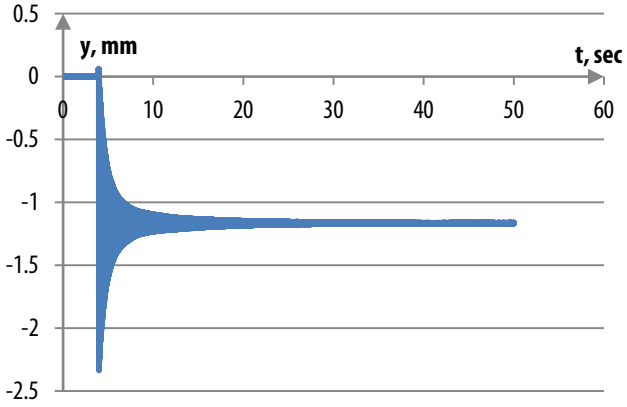

***Figure 9**. Displacement of the rod end after the line was cut (1kg load)*

Modifications were the following:

- *remove data before the line was cut,*
- *remove data after the vibration ends,*
- *place the curve symmetrical to the abscissa.*

After modification, we received such a curve, where we could determine the logarithmical decrement. After the analysis, we experienced that the value of the logarithmical decrement was not permanent during the vibration. According to the results we concluded that the damping behaviour of the metallic foams is not the classical viscous damping type.The curve does not fit to the Coulomb type damping, where the damping coefficient is increasing with the vibration time. This symptom leaded us to carry on to analysing the measured data. We made other modifications on the measured data. We filtered the peak values of the vibration wave and used just the positive values.

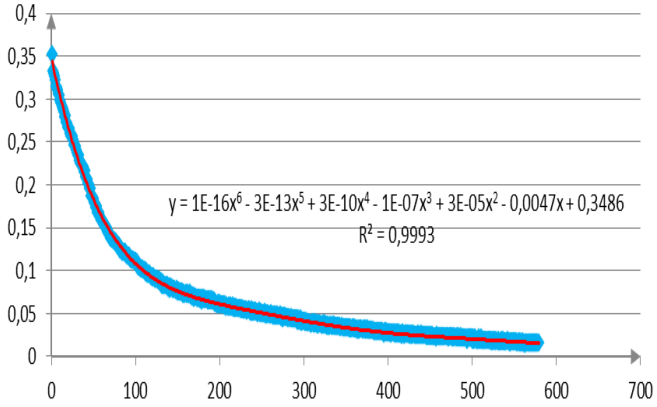

***Figure 10**. The diagram shows the positive amplitudes (abscissa: number of positive peaks, ordinate: the value of the peak in mm).*

In Figure 10 the curve generated by points of positive amplitudes of the vibration can be seen. The figure also shows the trend line of the curve and the determination coefficient (R^2). The equation of the trend line also can be seen in Figure 10, which is a sixth grade polynomial. The value of the determination coefficient is almost 1, that is to say it is a good approximation. This is not fit nor to Coulomb type damping nor to viscous damping. If we observe Figure 10, approximately at the 70th peak, the curve of the trend line suddenly turns aside. We divided the curve into two parts, and examined them separately. The first part of the curve can be seen in Figure 11. We placed a new trend line to the curve of Figure 11. In Figure 11 the equation of the trend line and the determination coefficient also can be seen. The approximation of the point is good, because the R^2 is 0.9915.

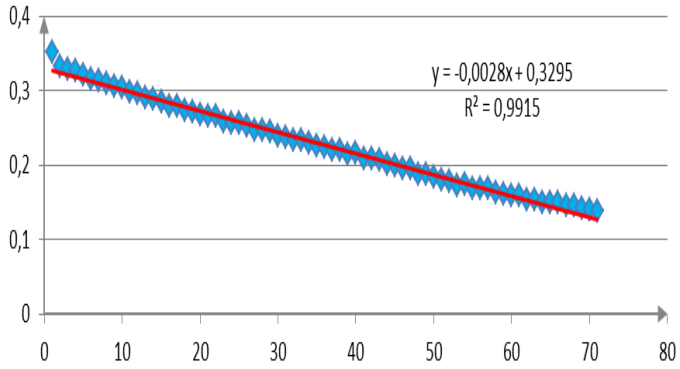

***Figure 11**. The first part of the curve, the new trend line (abscissa: number of positive peaks, ordinate: the value of the peak in mm)*

The curve of Figure 11 is almost line, which is continuously decreasing. This type of envelope is the type of the Coulomb damping envelope (Figure 1). If we examine the other part of the original curve (Figure 10), we get another new curve (Figure 12). We placed again a new trend line, which is fit to the points of Figure 12 (points after 70th peak). Figure 12 shows the equation of the 3rd curve and the determination coefficient, which is 0.9853. This approximation is also a good one.

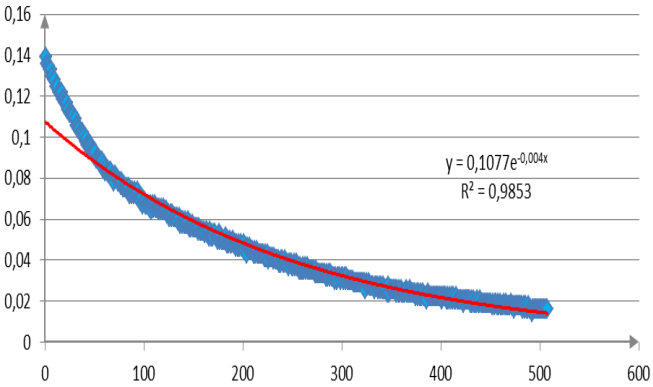

***Figure 12** .Curve after the 70th peak (abscissa: number of positive peaks, ordinate: the value of the peak in mm)*

EVALUATION OF RESULTS

Conclusion from the measured and calculated results is that the vibration damping behaviour of the examined metallic foam until approximately the first 70 peak is Coulomb type damping, after the first 70 peak is a viscous damping type. The behaviour of metallic foam was independent from the loads (1kg, 2kg, 3 kg).

ACKNOLEDGEMENT

The research work presented in this study based on the results achieved within the TÁMOP-4.2.1.B-10/2/KONV-2010-0001 project and carried out as part of the TÁMOP-4.1.1.C-12/1/KONV-2012-0002 „Cooperation between higher education, research institutes and automotive industry" project in the framework of the New Széchenyi Plan. The realization of this project is supported by the Hungarian Government, by the European

Union, and co-financed by the European Social Fund. Admatis Ltd. gave us the metallic foam materials.

REFERENCES

[1.] Sarka F. – Döbröczöni Á.: Using Metal Foams in gear-drives to reduce the emitted noise. Design of Machines and Structures, Vol. 4, No. 1 (2014), pp. 65–75.

[2.] Orbulov I. N.: Szintaktikus fémhabok. PhD értékezés, 2009.

[3.] Korposné Kelemen K. – Kaptay Gy. – Borsik Á.: Fémhabok – A géptervezés potenciális szerkezeti anyagai.

[4.] Makhult M.: Gépágyazások rezgéstani méretezése, Akadémiai Kiadó, Bp.,ISBN963 05 0064 7.

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

ISSN:2067-3809

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Saad BAKKALI

USING MORLET WAVELET FILTER TO DENOISING GEOELECTRIC "DISTURBANCES" MAP OF MOROCCAN PHOSPHATE DEPOSIT "DISTURBANCES"

Faculty of Sciences & Techniques, Earth Sciences Department, Tangier, MOROCCO

Abstract: *Morocco is a major producer of phosphate, with an annual output of 19 million tons and reserves in excess of 35 billion cubic meters. This represents more than 75% of world reserves. Resistivity surveys have been successfully used in the Oulad Abdoun phosphate basin. A Schlumberger resistivity survey over an area of 50 hectares was carried out. A new field procedure based on analytic signal response of resistivity data was tested to deal with the presence of phosphate deposit disturbances. A resistivity map was expected to allow the electrical resistivity signal to be imaged in 2D. 2D wavelet is standard tool in the interpretation of geophysical potential field data. Wavelet transform is particulary suitable in denoising, filtering and analyzing geophysical data singularities. Wavelet transform tools is applied to analysis of a Moroccan phosphate deposit "disturbances". Wavelet approach applied to modeling surface phosphate "disturbances" was found to be consistently useful.*

Keywords: *resistivity, Schlumberger, phosphate, wavelet, Morocco*

INTRODUCTION

Resistivity is an excellent parameter and marker for distinguishing between different types and degree of alteration of rocks. Resistivity surveys have long been successfully used by geophysicists and engineering geologists and the procedures are well established. The study area is the Oulad Abdoun phosphate basin (figure 1) which contain the Sidi Chennane deposit.

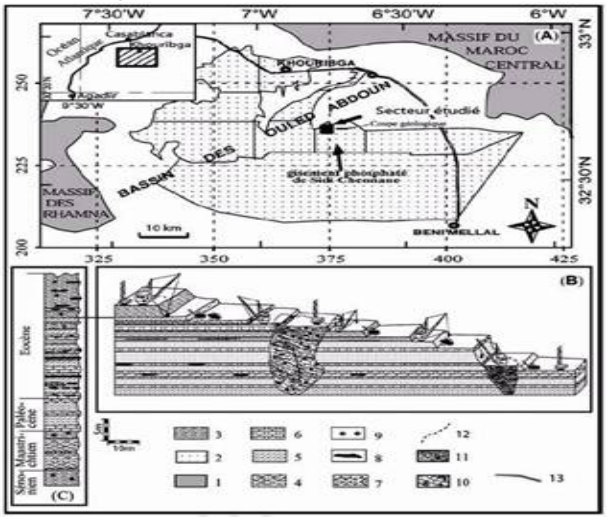

Figure 1. *(A) Location of the studied area in the sedimentary basin of Ouled Abdoun. (B) Section showing the disruption of the exploitation caused by disturbances. (C) Stratigraphical log of the phosphatic series of Sidi Chennane: (1) Hercynian massif; (2) phosphatic areas; (3) marls; (4) phosphatic; marls; (5) phosphatic layer; (6) limestones; (7) phosphatic limestone; (8) discontinuous silex bed; (9) silex nodule; (10) "disturbance" formed exclusively of silicified limestone; (11) "disturbance" constituted of a blend of limestone blocks, marls and clays; (12) "disturbance" limit; (13) roads.*

The Sidi Chennane deposit is sedimentary and contains several distinct phosphate-bearing layers. These layers are found in contact with alternating layers of calcareous and argillaceous hardpan. However, the new deposit contains many inclusions or lenses of extremely tough hardpan locally known as dérangements or disturbances (figure 2), found throughout the phosphate-bearing sequence.

Figure 2. *Example of "disturbance" affecting the phosphate strates*

The hardpan pockets are normally detected only at the time of drilling. Direct exploration methods such as well logging or surface geology are not particularly effective.

They interfere with field operations and introduce a severe bias in the estimates of phosphate reserves (figure 3) (KCHIKACH et al., 2002) (BAKKALI, 2005).

The study area was selected for its representativity and the resistivity profiles were designed to contain both disturbed and enriched areas. The sections were also calibrated by using vertical electrical soundings. High

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values of apparent resistivity were encountered due to the presence of near-vertical faulting between areas of contrasting resistivity, and fault zones which may contain more or less highly conducting fault gouge. The gouge may contain gravel pockets or alluvial material in a clay matrix (BAKKALI & BAHI, 2006) (BAKKALI, 2006). Such anomalous sections are also classified as disturbances. Apparent resistivity values in these profiles locally exceeded 200 Ω. □m.

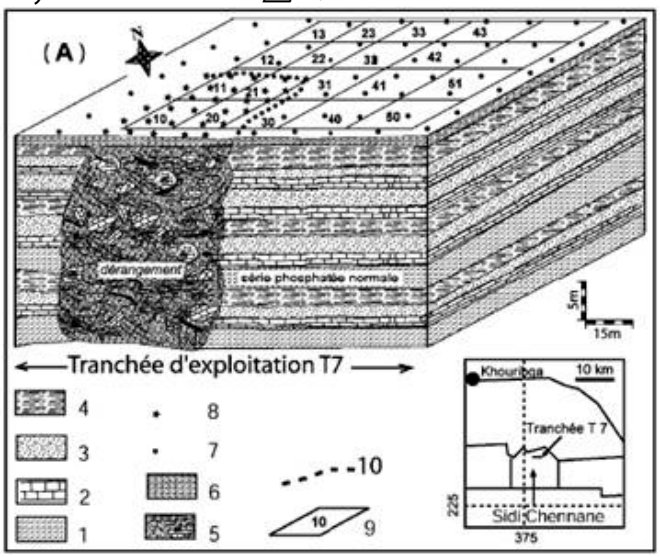

Figure 3. *(A) Geological section of the T7 exploitation trench showing a "disturbance" and position plan of the soundings tests. Apparent resistivity profiles positions while passing from the deranged zone to a normal phosphatic series : (1) phosphatic marls; (2) limestones; (3) phosphatic layer; (4) marls; (5) "disturbance" ; (6) Quaternary cover; (7) borehole crossing a normal phosphatic series; (8) borehole crossing a "disturbance"; (9) measures loop number 10; (10) "disturbance" limit.*

The lateral inhomogeneities of the ground can be investigated by means of the apparent resistivity obtained from the survey. As the surface extension of the layers is displayed we may infer the presence or absence of any disturbances as well as any facies variations. Our resistivity measurements were performed by means of a Syscal2 resistivity meter by BRGM Instruments using a rectangular array of 20 m x 5 m. In order to reach a mean depth of exploration of 40 m we carried out 51 traverses at a spacing of 20 m (figure 3). There were 101 stations at 5 m distance for every traverse, which makes 5151 stations all together in the survey. The apparent resistivity map (figure 4) which one obtains from such a survey is actually a map of discrete potentials on the free surface, and any major singularity in the apparent resistivities due to the presence of a perturbation will be due to the crossing from a "normal" into a "perturbed" area or vice versa.

In other words, the apparent resistivity map may be considered a map of scalar potential differences assumed to be harmonic everywhere except over the perturbed areas. Interpretation of resistivity anomalies is the process of extracting information on the position and composition of a target mineral body in the ground. In the present case the targets were essentially the inclusions called perturbations. The amplitude of an anomaly may be assumed to be proportional to the volume of a target body and to the resistivity contrast with the mother lode. If the body has the same resistivity as the mother lode no anomaly will be detected. Thus assumed in fact and in first approach that the resistivity anomalies would be representative of the local density contrast between the disturbances and the mother lode. Level disturbance of the anomalous zones is proportionnal to resistivity intensity (figure 5).

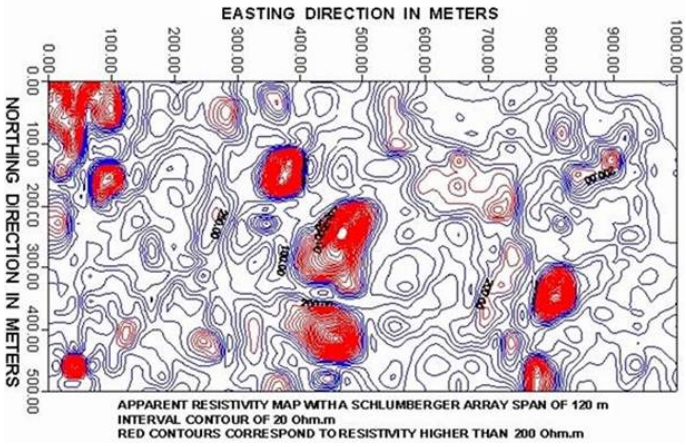

Figure 4 *. A map of resistivity anomalies for AB=120 m*

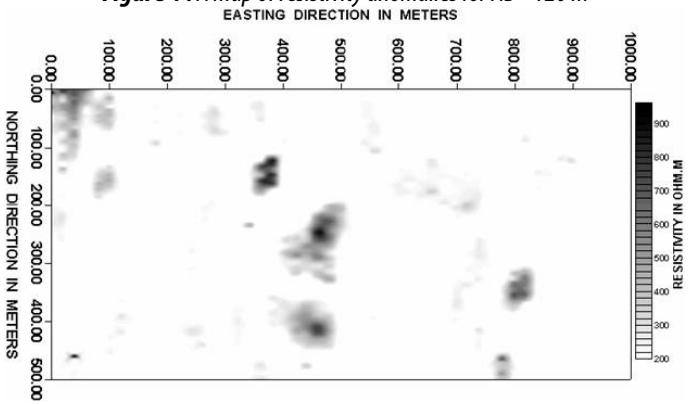

Figure 5. *A map of disturbed phosphate zones corresponding to Figure. 4*

2D WAVELET TRANSFORM & PROCESSING DATA

The wavelet transform is a time-frequency decomposition which links a time (or space) domain function to its time-scale wavelet domain representation. The concept of scale is broadly related to frequency. Small scales relate to short duration, high frequency features and correspondingly, large scales relate to long duration, low frequency features. Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or other function. In the signal analysis framework, the wavelet transform of the time (or space) varying signal depends on the scale that is related to frequency and time (or space) (RIDSDILL & DENDITH, 1999). The 2D wavelet method provides information on many more resolution than the former method. It is a powerfful tool particulary suitable in denoising, filtering and analyzing problems and potential singularities (SANZ et al., 1999). Moreover this property is crucial for performing an efficient linear denoising resistivity anomaly map of the moroccan phosphate deposit "disturbances". The wavelet transform of a 2D signal $f(x,y)$, where x and y represent respectively the easting and the northing directions, and f the apparent resistivity data □, is defined as:

$$\omega(X,Y,a,b)=\int\int \frac{1}{\sqrt{|XY|}} f(x,y)\psi\left(\frac{x-a}{X},\frac{y-b}{Y}\right)dxdy \qquad (1)$$

where $\frac{1}{\sqrt{|XY|}}\psi\left(\frac{x-a}{X},\frac{y-b}{Y}\right)$ is the wavelet coefficient associated to the scales X and Y at the point with coordinates a and b (TORRENCE & COMPO, 1998). The limits in the double integral are $-\infty$ and $+\infty$ for the two variables. ψ is the wavelet "mother" function that satisfies the constraints

$$\int\int dxdy\,\psi = 0 \quad (2)$$

and

$$\int\int dxdy\,\psi^2 = 0 \quad (3)$$

The 'admissibility' condition that allows to reconstruct the function f, i.e there exists the following integral :

$$C_\psi = (2\pi)^2 \int\int dk_1 dk_2 \frac{\left|\hat{\psi}(k_1,k_2)\right|^2}{|k_1 k_2|} \quad (4)$$

where $\hat{\psi}(k_1,k_2)$ represents the 2D Fourier transform of ψ and denotes the modulus of the complex number C_ψ. A reconstruction of the original geophysical signal corresponding to resitivity data can be achieved using the inversion formula expressed by :

$$f(x,y) = \frac{1}{C_\psi}\int\int \frac{dXdY}{|XY|^2} dadb\omega(X,Y,a,b)\frac{1}{\sqrt{|XY|}}\psi\left(\frac{x-a}{X},\frac{y-b}{Y}\right) \quad (5)$$

We have chosen in our study the Morlet wavelet "mother" (UCAN et al., 2000) (figure 6) defined in 1D by the following equation :

$$\psi_{Morlet}(x) = \frac{1}{\pi^4} e^{(j\alpha_0 x)} e^{\left(-x^2/2\right)} \quad (6)$$

where α_0 is an adjustable parameter (wavenumber). The adjustable parameter have been put to 6. This is the smallest wavenumber that allows for an accurate resistivity signal reconstruction.

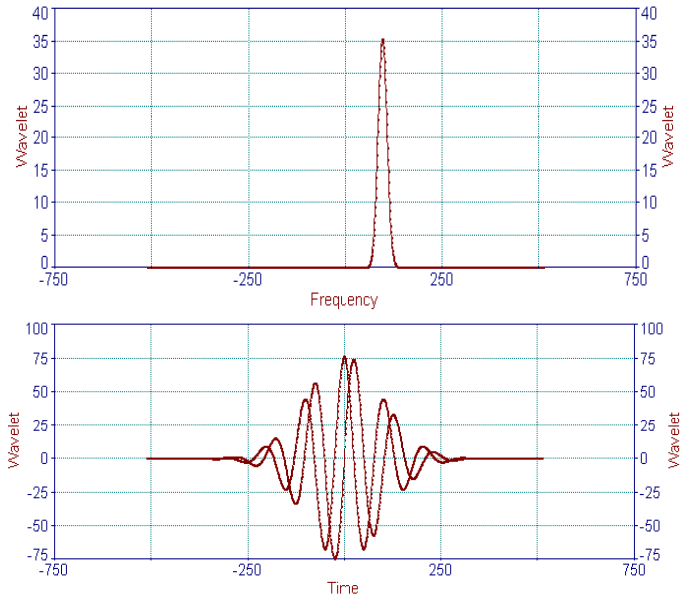

Figure 6. Time and frequency Morlet wavelet "mother" responses

The resistivity data base is a compilation of 51 traverses at a spacing of 20 m. There were 101 stations at 5 m distance for every traverse, which makes 5151 stations all together in the resistivity survey. We calculated the magnitude square of the wavelet transform coefficients using AutoSignal routine (SYSTAT, 2002) for each resistivity traverse (figure 7). Then we deferred all the results to built a 2D wavelet spectrum regular maps which represent in fact filtering and denoising map of the phosphate deposit "disturbances".

Since a major potential application of wavelets is in image processing, the 2D wavelet transform is a necessity to be applied as a detector and analyser of singularities like edges, contours or corners (TSIVOURAKI-PAPAFOTIOU et al., 2005).

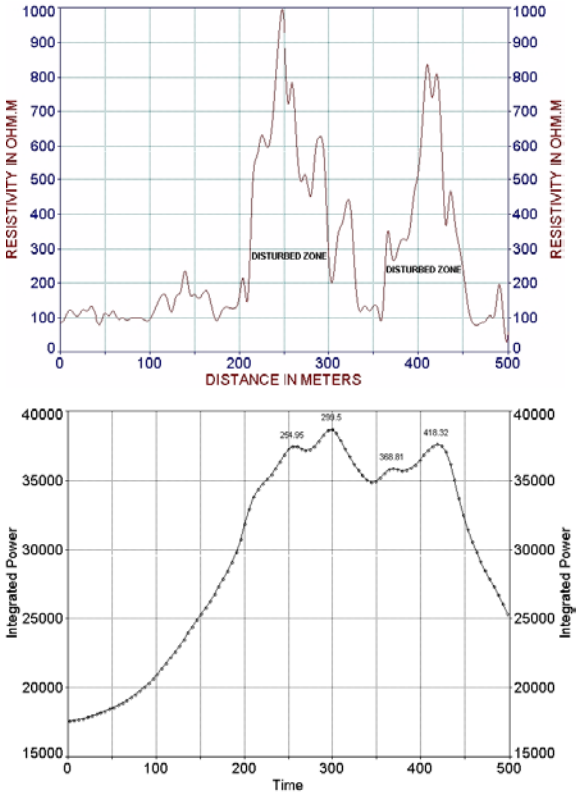

Figure 7. Example of real resistivity traverse data of the survey and the corresponding continous wavelet transform using Morlet "mother".

RESULTS & CONCLUSIONS

Figure 8 represents an indicator of the level of variation of the contrast of density between the disturbances and the normal phosphate-bearing rock. The surface modeling of resistivity anomalies is obtained by AutoSignal routine from our apparent resistivity survey.These procedure enables us to define the surface phosphate disturbed zones.

The continous wavelet analysis surface of phosphate deposit disturbance zones modeling as obtained by the above procedure in the study area provided a direct image for an interpretation of the resistivity survey. These method enable us to identify the anomalies area which turned out to be strongly correlated with the disturbances. The disturbances as detected from surface measurements were distributed apparently at random as confirmed by figure 8. These figure represents an effective indicator of the intensity level of "disturbance". The use of magnitude square of the continous wavelet transform represent an effective filtering method which makes it possible to attenuate considerably the noise represented by the minor dispersed and random disturbances. The overall effect is that of scanning and denoising the anomalous bodies. Comparatively to classical approaches used in filtering and denoising

geophysical data maps, the advantage of the 2D continous wavelet transform method is doesn't introduce significant distorsion to the shape of the original resistivity signal .

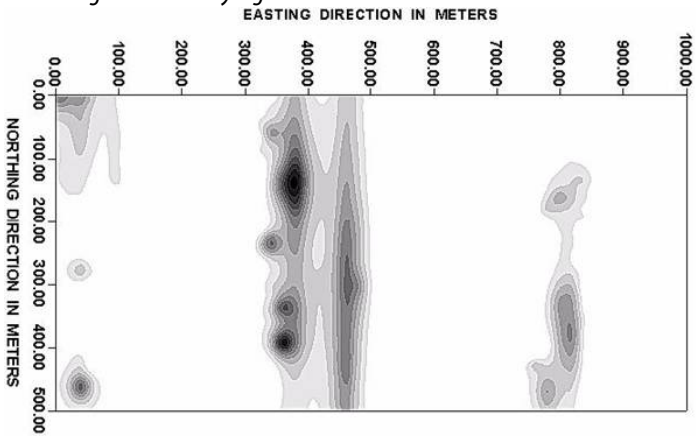

Figure 8. *Wavelet output of the phosphate deposit "disturbances" map given in Figure 6*

The wavelet output of the apparent resistivity which correspond to the wavelet output of the anomalous phoshate deposit map obtained from such a technical tool represent the crossing dominate area from a "normal" into a "perturbed" area or vice versa. Moreover the level of disturbance is very clearly shown.

The proposed filtering and denoising method using 2D continous wavelet transform tends to give a real estimation of the surface of the phosphate deposit "disturbances" zones with a significant suppression of the noise. The level disturbance resulting from such method is also more defined in all the disturbed zones.

We have described an analytical procedure to analyze the anomalies of a specific problem in the phosphate mining industry. The results proved satisfying. Data processing procedures as 2D wavelet transform of resistivity data map was found to be consistently useful and the corresponding map may be used as auxiliary tools for decision making under field conditions.

REFERENCES

[1.] Kchikach, A., Jaffal, M., Aifa, T. & L.Bahi, 2002. Cartographie de corps stériles sous couverture quaternaire par méthode de résistivités électriques dans le gisement phosphaté de Sidi Chennane (Maroc). Comptes Rendus Geosciences, 334, 379-386.

[2.] Bakkali, S., 2005. Analysis of phosphate deposit "disturbances" using the horizontal-gradient responses of resistivity data (Oulad Abdoun, Morocco), Earth Sci. Res. J. Vol.9, N°2, 123-131.

[3.] Bakkali, S. & Bahi, L., 2006. Cartographie des « dérangements » de séries phosphatées par mesures de résistivités électriques, Journal des Sciences Pour l'Ingénieur, J.S.P.I., 6, 1-10.

[4.] Bakkali, S., 2006. A resistivity survey of phosphate deposits containing hardpan pockets in Oulad Abdoun, Morocco, Geofisica Internacional, 45 (1), 73-82.

[5.] Ridsdill, T.A. & M.C.Dendith, M.C., 1999. The wavelet transform in aeromagnetic processing, Geophysics, Vol.64, 4, 1003-1013.

[6.] Sanz, J.L., Barreiro, R.B., Cayon, L., Martinez-Gonzalez, E., Ruiz, G.A., Diaz, F.J., Argüeso, F., Silk, J. & Tofolatti, L., 1999. Analysis of CMB maps with 2D wavelets, Astron. Astrophys. Suppl. Ser. 140, 99-105.

[7.] Torrence, C. & Compo, G.P., 1998. A practical guide to wavelet analysis, Bull. Am. Meteorol. Soc., 79, 61-78.

[8.] Systat ,2002. About AutoSignal V1.6 software, Copyrignt 2002 AISN Software Inc.

[9.] Ucan, O.N., Seker, S., Abora, A.M. & Ozmen, A., 2000. Separation of magnetic fields in geophysical studies using a 2-D multiresolution wavelet analysis approach. Journal. Balkan Geophysical Society, Vol 3, 3, 53-58.

[10.] Tsivouraki-Papafotiou, B., Tsokas, G.N. & Tsurlos, P., 2005. Wavelet denoising of magnetic prospecting data, Journal. Balkan Geophysical Society, Vol 8, 2, 28-36.

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BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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DEVELOPMENT OF PAPER PULP FILLED CEMENTITIOUS COMPOSITES FOR FURNITURE AND FITTINGS APPLICATIONS

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Abstract: The need for aesthetic, strong and environmentally beneficial composites for furniture and fittings was the thrust of this work. The research involves comparative study and analysis of the behavior of brown and white papers when they are mixed with different proportions of cement as binder. Waste papers from offices were sourced locally and were sorted into white and brown papers after which the papers were pulverized and made into slurry. The slurry obtained were compacted into flexural and compressive tests samples with the aid of compacting machine by applying a load of 20 KN for 5 minutes followed by drying at room temperature in the laboratory. Flexural, compressive and water absorption tests were carried out on the samples using universal testing machine and percentage weight different of immersed samples in water respectively. It was observed from the results that, white paper cement bonded samples possessed the best properties in all compared to brown paper cement bonded samples. The results showed that the mixture of 70 % white paper and 30 % cement possess the best combination of mechanical and physical properties and hence, the potential material for paper pulp composite in low cost furniture and fittings applications.

Keywords: waste paper, cement, paper pulp, composites, mechanical properties, water absorption

INTRODUCTION

In the topical age, research and development is been focused on the use of naturally available raw materials as well as waste materials for engineering application. This was the case because; they not only occur in luxurious abundance in many parts of the world, but can also lead directly to energy savings, conservation of the world's most scarce resources and also protect humans and his environment. Natural and vegetative plants have thus a unique irreplaceable role in the ecological cycle. Throughout history, technological innovations have helped humankind improve their standards of living through impressive rapid developments and research. However, some technology also creates negative environmental impact. Therefore efforts are invested in making use of natural based biodegradable and sustainable material that exist in nature rather than create a new material [3].

Composite materials generally have properties such as lighter weights, ability to be tailored for optimum strength and stiffness, improved fatigue life, corrosion resistance, and reduced assembly or manufacturing costs due to fewer detail in parts and fasteners. Due to the excellent mechanical properties of composite materials, they have been widely used throughout the last four decades [4]. Composites are designed to display combination of the best properties of each of its constituents. Properties of composite are strongly dependent on the properties of their constituent materials, their distributions, and the interaction among them [5]. The composite properties may be the volume fraction sum of the properties of the constituents or the constituents may interact in a synergistic way resulting in improved or better properties. Apart from the nature of the constituent materials, the geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent. The concentration, distribution, and orientation of the reinforcement in the matrix also affect the properties of the composite. The interface has characteristics that are not depicted by any of the component in isolation. The interface is a bounding surface or zone where a discontinuity occurs, whether physical, mechanical or chemical. To obtain desirable properties in a composite, the applied load should be effectively transferred from the matrix to the fibres via the interface [6]. This means that the interface must be large and exhibit strong adhesion between fibres and matrix. Failure at the interface (called de-bonding) may or may not be desirable [4].

Wood, which serves as a major raw material for the production of paper consists of lignin, hemicellulose, cellulose and extractives. The percentage of lignin in the composition of paper wood is about 20-30%. During pulping, about 50% of the whole wood material and about 95% of the lignin are removed [7]. Paper is a wood based product without which modern civilization would not have evolved, and would not have been sustained and advanced. But paper itself, is a major product of wood pulp; i.e. pulp gives birth to paper, also pulp can be used for diverse purposes such as in the preparation of cellulose derivatives e.g. cellulose nitrate, cellulose acetate, regenerated cellulose etc. [1].

White papers are produced when bleaching operation took place as a result of the removal of lignin in the pulp from the pulp mill Lignin is a

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complex chemical compound most commonly derived from wood, and an integral part of the secondary cell walls of plants. It is one of the most abundant organic polymers on earth, exceeded only by cellulose, employing 30% of non-fossil organic carbon [2] and constituting from a quarter to a third of the dry mass of wood.

Through bleaching, the brightness is increased as the remaining lignin and other coloured substances are removed from the pulp. Bleaching also removes impurities from the pulp and improves the printability of paper produced [8]. As a result of the bleaching process and removal of lignin, the crystallinity of the structure of the paper material improves, thus enhancing the strength properties of the white paper material.

In modern buildings, furniture and fittings such as light weight tables and stools, portraits, flower vases and many more for low cost applications are the focus of this work. The aim was to transform readily available biodegradable materials that are regarded as waste into useful applications by manipulating them to develop strong and light weight low cost furniture and fittings materials.

MATERIALS AND EQUIPMENT USED

In this research work, the following materials and equipment were used for the production of the paper boards.

Materials and Equipment

Waste office papers (white), waste newsprint papers (brown), Portland cement and water.

The following major equipment were used for the research; milling machine from Forestry and Wood Technology Department, compaction machine from Metallurgical and Materials Engineering Department both at Federal University of Technology Akure, Ondo State, Nigeria, Testometric universal machine from Federal Institute of Industrial Research Oshodi (FIIRO) Lagos State, Nigeria.

Methods

» **Preparation of Paper Particles**

The papers to be pulverized were soaked in water for two weeks so as to ensure smooth grinding and, thus reduce the pulverizing time. The wet paper which has been soaked was poured into the grinding milling machine as shown in Figure 1.

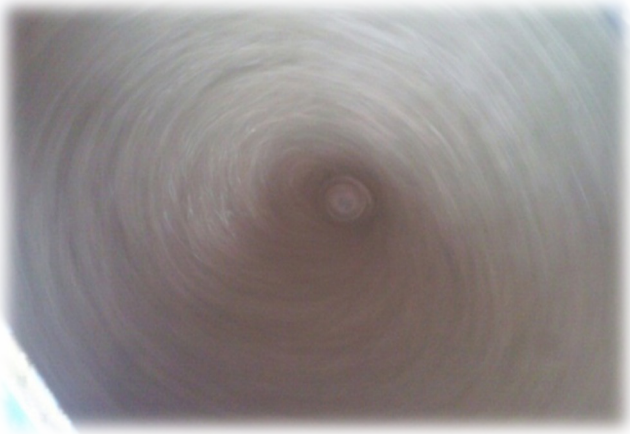

***Figure 1:** Paper pulp in slurry form during grinding operation*

During the grinding process, water was added to aid easy formation of slurry. The slurry allows even distribution of the papers that are being grinded within the machine. The pulverized paper was squeezed in order to remove the water and sun dried for 5 days to obtain particulate material.

» **Composites Development**

The composites were developed by forming the homogeneous pastes from the mixture of cement with white and brown papers slurry, respectively in predetermined proportions as shown in Table 1. Paper slurry was formed by blending 1 kg of the sun dried particulate paper with 8 litres of water followed by mixing in a bucket to form the slurry.

***Table 1:** Mixing proportions of cement with white and brown papers*

Compositions/ Samples	Control	A	B	C	D	E	F	G	H
Paper in slurry (%)	100	95	90	85	80	75	70	65	60
Cement (%)	-	05	10	15	20	25	30	35	40

Each representative samples were produced by pouring the homogenous paste into the flexural and compressive moulds. Compression moulding machine was used to press the samples inside the mould at room temperature with a load of 20 KN for 5 minutes. The samples were de-moulded after compaction and allow drying at room temperature in the laboratory for 28 days as shown in Figure 2.

***Figure 2:** Flexural and compressive samples of cement bonded white and brown paper boards*

Properties Test

» **Flexural Strength**

Flexural test was carried out by using Tensiometric Universal Testing Machine in accordance with ASTM D790. To carry out the test, the sample that has been shaped into the test piece dimensions of 150 × 50 × 30 mm was hooked on the grip, and the test commenced. As the specimen is stretched, the computer generates the required data and graphs. The test speed was 50.00 mm/min over a span of 100.00 mm.

» **Compressive Strength**

The compressive test was also carried out by using Tensiometric Universal Testing Machine in accordance with ASTM C 39

Cylindrical specimen was centered on the test machine and loaded to complete failure. Th loading rate on a hydraulic was maintained in a range of 20 to 50 psi/s (0.15 to 0.35 MP a/s). Afterwards, the type of break was recorded and the computer generates the required data and graph.

» ***Water Absorbtivity Test***

Water absorption test was carried out in accordance with ISO 175 using distilled water. This medium was chosen because the material is likely to encounter water in service. To carry out the test, clean plastic containers were procured into which 700 cm^3 of water was measured using measuring cylinder. The initial weight of each of the sample is taken using chemical weighing balance; FA2104A Model which is of high precision ± 0.0001 g accuracy before dropping inside the medium to be used and readings were taken every hour for seven hours. To take the readings, the samples were brought out, clean with white cloth and weighed. The data collected was used to determine the % water absorption using equation 1.

$$\%\ Water\ Absorption = \frac{Final\ Weight - Initial\ Weight}{Initial\ Weight} \times 100 \quad (1)$$

RESULTS AND DISCUSSION

Response of the materials to bending properties

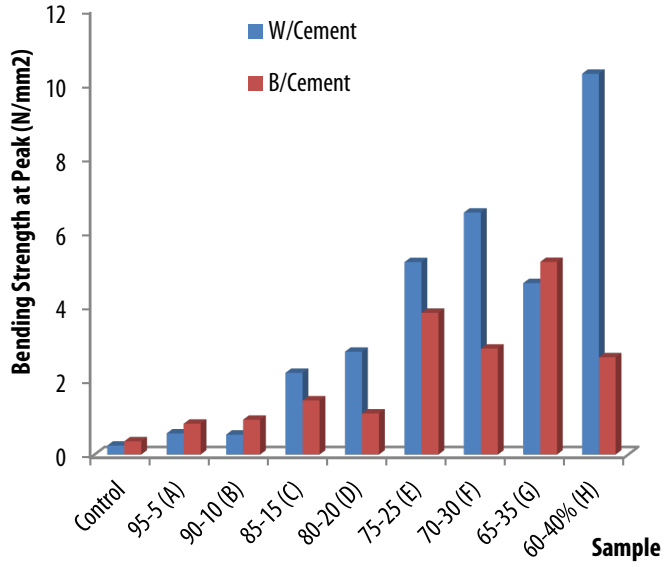

***Figure 3**: Plots of variation of Bending Strength at Peak with Samples*

The results of the variation of bending strength at peak were shown in Figure 3. From the results, it was observed that, the use of cement as binder for these paper pulps increases the bending strength of the developed composites more than the bonded paper without cement which serves as the control. Also, noticed was that, the strength of the developed composites tends to increase as the paper pulp content increases, particularly in the cement bonded white paper pulp composites.

The results revealed that white paper pulp bonded with cement gave the best output compared to brown paper pulp cement bonded. The best result was obtained when 60 wt % of the white paper pulp was blended with 40 wt % of cement with a bending strength value of 10.27 N/mm^2 followed by 70 wt % white paper pulp filled composite with values of 6.53 N/mm^2 and 65 wt % brown paper pulp filled cementitious composite with a value of 5.20 N/mm^2, respectively. Comparing these with the ordinarily bonded white and brown paper pulps strength with values of 0.24 and 0.36 N/mm^2, these has culminated to greater enhancement from both paper pulps, respectively. The improvement in the enhancement of the strength at peak for white paper pulp over brown ones which initially has better strength was due to the presence of lignin in the brown paper and the delignification that was achieved in white paper during bleaching. The presence of lignin in brown paper pulp prevents proper blending between the paper and cement during mixing, hence, the removal of lignin from the paper pulp through bleaching, the process for the production of white paper, aid proper blending of binders with the white paper pulp. This was possible because the binders will penetrate easily into the paper and thus the strength properties of the composite product made from white papers was greater than the ones made from brown papers.

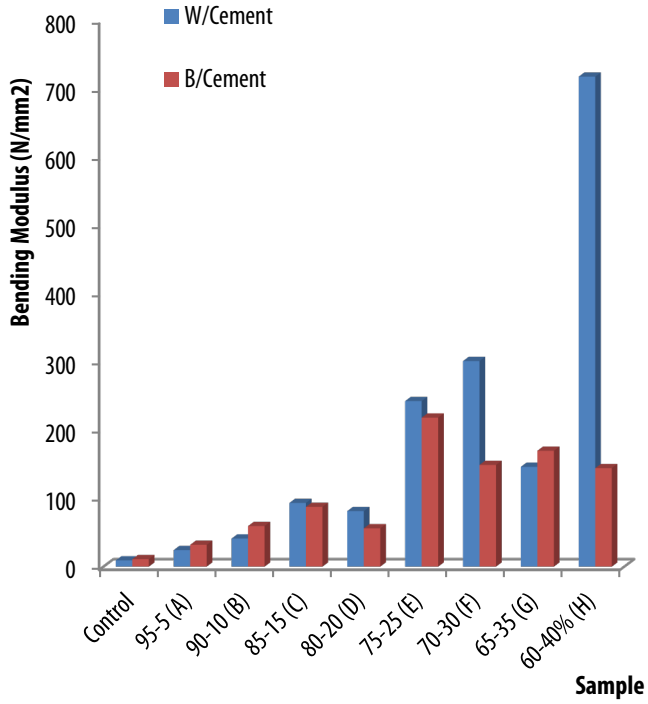

***Figure 4**: Plots of variation of Bending Modulus with Samples*

Figure 4 illustrates the response of the materials to bending modulus. From the results, similar trend to that of bending strength at peak was observed. At low weight fraction of between 5-20 wt % cement, bending modulus was observed to be low while at higher weight fraction of between 25-40 wt % cement content, bending modulus was observed to be high. It follows that the strength and stiffness of the developed composites were enhanced rapidly by cement content within the high weight fraction range. From the results, it was observed that, the modulus were better enhanced in cement bonded white paper pulp with 60, 70 and 75 wt % white paper pulp which has values of 717.75, 301.57 and 242.94 N/mm^2, respectively.

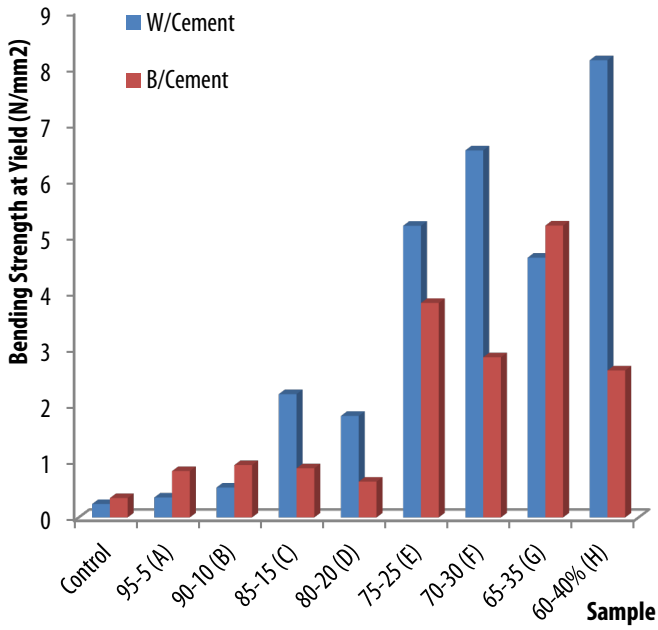

***Figure 5**: Plots of variation of Bending Strength at Yield with Samples*

The results of the bending strength at yield depicted in Figure 5 revealed similar pattern to that of bending strength at peak. Best results were obtained from 60, 70 wt % white paper pulp of cement bonded white paper pulp with values 8.13 and 6.53 N/mm^2 followed by 65 wt % brown paper pulp from cement bonded brown paper pulp with a value of 5.20 N/mm^2 . These values show brittle failure behavior because the yield strength coincided with the strength at peak values.

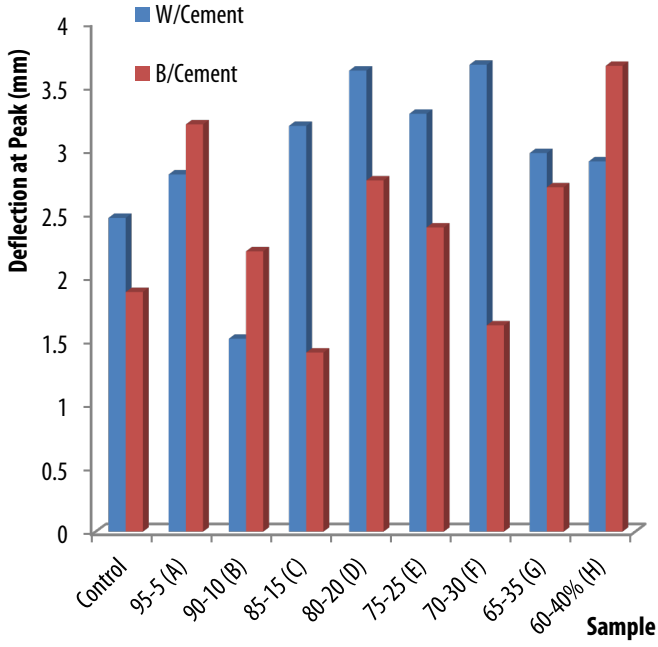

***Figure 6**: Plots of variation of deflection at Peak with Samples*

The responses of the deflection at peak show that all the samples possess comparatively good deflection response before failure. Both samples from low and high strength and stiffness possess good deflection response with values of about 3 mm compared to the control with values of 2.47 and 1.89 mm for white and brown paper pulp respectively. Cement bonded white paper pulp with 70 wt % white paper pulp has a value of 3.67 mm followed by cement bonded brown paper pulp with 60 wt % brown paper pulp having a value of 3.66 mm and cement bonded white paper pulp with 80 wt % white paper pulp of value 3.63 mm was next. All except cement bonded white paper pulp with 70 wt % white paper pulp exhibit weak strength and stiffness which is responsible for their high deflection at peak value. It follows from the results that composite material with good strength and stiffness as well as good deflection can be developed by using 70 wt % white paper pulp which is the average of the range of the weak and strong strength and stiffness for cement bonded white paper pulp composites.

Response of the materials to compressive properties.

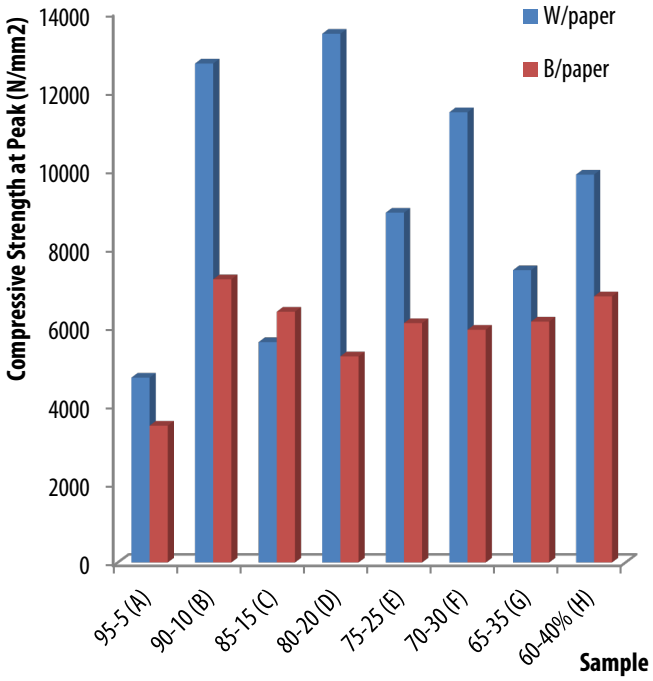

***Figure 7**: Plots of variation of Compressive Strength at Peak with Samples*

Figure 7 illustrates the behavior of the materials when subjected to compressive strength test. It was observed from the results that all except at 85 wt % white paper pulp cement bonded white paper pulp gave better enhancement in the compressive strength at peak than cement bonded brown paper pulp composites due to the reasons given in Figure 3. The best materials were composites with 80, 90 and 70 wt % white paper pulps with values 13454, 12700 and 11464 N/mm^2, respectively. The observed performance was the outcome of expected proper mixing proportion of cement and the white paper pulp. These show that there is mixing proportion for the materials that can give the best compressive strength at peak enhancement. It was noticed that the addition 70 wt % white paper pulp and 30 wt % cement has been the most suitable mixing proportions for the best combination of all the properties considered. Though not the outstanding best in most of the properties but has always appear as one of the best in most of the properties measured.

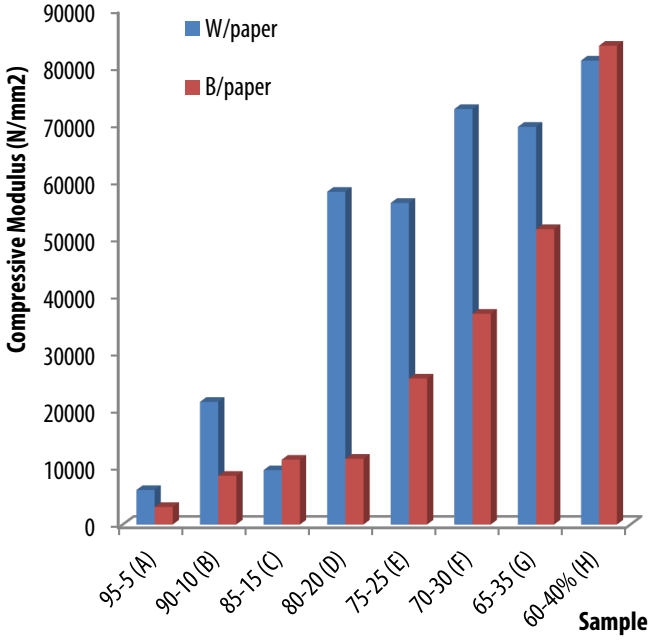

***Figure 8**: Plots of variation of Compressive Modulus with Samples*

The results of the compressive modulus were as shown in Figure 8. It was observed that the stiffness tends to increase as the paper pulp content increases. The trend seems to be contrary to the observed response in Figure 7. From the results, it was found that cement bonded brown paper pulp with 60 wt % brown paper pulp has the highest value of 83637 N/mm^2 followed by cement bonded white paper pulp with 60 and 70 wt % white paper pulp of values 81048 and 72619 N/mm^2, respectively.

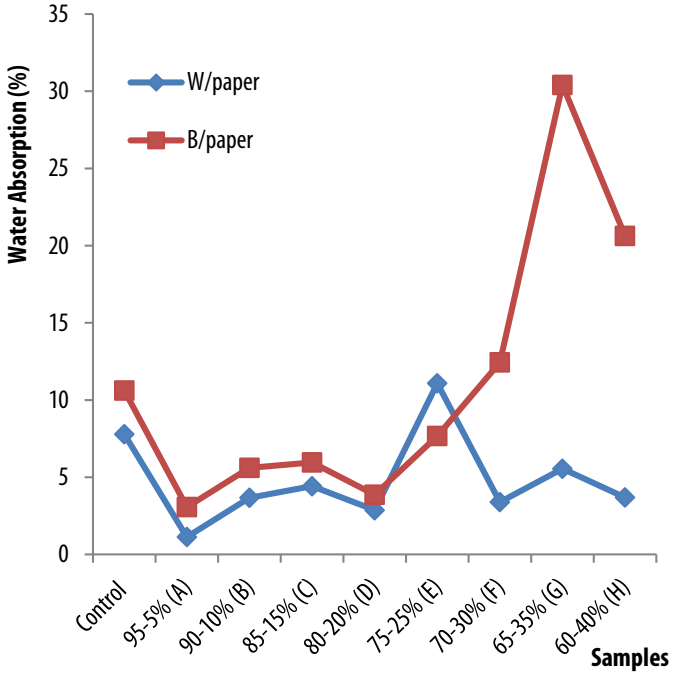

***Figure 9**: Plots of variation of Water Absorption with Samples*

Figure 9 shows the plots of the variation of water absorption properties with time for each of the samples for 7 hours. The results revealed that both white and brown paper board samples followed a similar trend. It was noticed that as the paper content increases, the rate of water absorption increases as a result of increase in the rate of diffusion of water molecule into the samples. This implies that, the addition of paper pulp tends to increase the pores present in the material. However, brown paper pulp reinforced samples absorbed much water than the white paper pulp samples. This may be due to the presence of lignin which tends to absorb much water in the brown paper. From the results, cement bonded white and brown paper pulps with 95 wt % white and brown paper pulps gave the best results with values 1.13 and 3.07 %, respectively. This was followed by cement bonded white paper pulp with 70 wt % white paper pulp content having a value of 3.39 %. This result further substantiates the superiority of 30-70 wt % cement bonded white paper pulp composites. The superb water resistance capability of the sample in addition to the excellent bending and compressive properties of the material has placed it above others.

CONCLUSION

This work has aided the necessity for paper sorting in the bid to use waste papers in a recycled form. These waste papers are readily available in offices and schools in Nigeria. They are usually burnt in most cases because they have not being put into economic use, thereby adding value to them. This work was carried out to shed more light into the use of these resources that are regarded as waste. The results showed that the properties of these two different sources of papers differ from one another and therefore, needed to be considered. From the results, the following deductions are made;

1. *White paper pulp gave better mechanical and physical performance than brown paper pulp when bonded with cement.*
2. *The best mixing ratio for excellent bending strength and stiffness was 60-40 wt % of white paper pulp to cement while 80-20 and 90-10 wt % white paper pulp to cement gave excellent compressive strength, on the other hand, 60-40 wt % brown and white paper pulps to cement gave the best compressive modulus.*
3. *The best mixing proportion was 70-30 wt % of white paper pulp to cement. At this mixing ratio, the best combination of both mechanical and physical properties were achieved.*
4. *The work confirms the prospect of the use of paper pulp filled cementitious composites developed from waste papers as potential structural engineering materials.*

References

[1.] *Akpabio, U. D, Effiong, I. E; and Akpakpan A. E. Preparation of pulp and cellulose acetate from nypa palm leaves. International Journal of Environment and Bioenergy. 1: 179. (2012).*

[2.] *Casey, J. P. Pulp and Paper Chemistry and Chemical Technology, 3rd Ed. Wiley Interscience, New York, pp. 152-156. (1980).*

[3.] *Hsie M., Tu C and Song P.S. Mechanical properties of polypropylene hybrid fiber-reinforced concrete, Material Science and Engineering A 494, 153-157. (2008).*

[4.] *Callister, Materials science, An Introduction: Fifth Edition, John Wiley and Sons Inc. New York, pp. 162-163,180-185, 511-17. (2001).*

[5.] *Sanjaya, Models of fiber debonding and pullout in composites, Baltimore U.S.A pp 23-24. (2011).*
[6.] *Kakani, S.L and Amit Kakani. Material science. First edition, New age international publishing limited, pp.22, 83. (2004).*
[7.] *Peter, W.H and Alan W.R, The bleaching of pulp, Fifth edition, Tappi press U.S.A, pp 10-13. (2012).*
[8.] *Metso Bleaching of chemical pulp, Metso corporation, Helsinki Finland, www.metso.com/MP/...nsf/.../MPS%20R%202034%20066-02.pdf, pp, 4-5. (2012).*

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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THE IRON CAST ROLLING MILLS ROLLS MANUFACTURING: METHODS, APPROACHES AND TENDENCIES FOR THE QUALITY ASSURANCE

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Abstract: *Our approaches the issue of quality assurance of the rolling mills rolls, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation. The experimented durability research, as well as the optimization of the manufacturing technology, allows the conclusion of direct results for the rolls. The beneficiaries of these results are the unit in which the rolls are manufactured, as well as the unit that exploits them. The technological manufacturing process of the rolling mills rolls, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation.*

Keywords: *rolling rolls, quality assurance, manufacturing, safety in exploitation, materials, MATLAB*

INTRODUCTORY NOTES

Rolls are the most important means of hot– and cold–forming bulk products in the ferrous industries. The concept and introduction of rolling mills made the forming of large quantities of metal economically feasible. Rolling mill construction and the art of rolling experienced a sharp growth when production of steel in molten form began and, along with improvements in roll materials, have remained closely connected with the development of the steel industry.

From the standpoint of materials, the above line–up of rolls for hot–rolling remained unchanged although advancing metallurgical and material developments improved the quality significantly. Roll producers learned how to improve the cast–steel rolls by suitable heat treatment and to adapt cast–iron rolls to specific applications by properly balanced charges and further advances in modeling techniques.

Alloying additions for cast–iron rolls probably first came into consideration for rolling sheet, where improvements in the surface of the hot–rolled product were especially necessary. Subsequently it was found possible to increase the performance of shape rolls also by alloying. The innovations in rolling mills placed unprecedented requirements on rolls and users demanded better surface quality on the rolled products, which were often high–strength and therefore difficultly workable steels. Thus, the rollers insisted on longer roll life. Further improvements in the existing types of rolls were made and new roll materials were developed. Today, the roller has available a number of roll types but it is not always simple to select the best one.

The rolls must present high exploitation qualities, which are determined from the hardness, resistance and high temperature stability. These qualities guarantee the high resistances at wear in the dried friction conditions and the unexpected temperature variation stability in the rolling operation. In addition, they assure the resistance at the thermal fatigue, (because the rolls are heated at the contact with the laminate), high resistance at the thermal shock stress, and the bending strain resistance. Also, the rolls must assure the clamping of materials, as well as the high quality of the laminate surface.

Quality of rolls is determined through hardness and through wear resistance, last index having a special importance for all modern rolling mills with a growth production. Of major importance for the rolls exploitation is not merely growth resistance, but also the ability to oppose to different types of wear. Thus, rolling mill rolls considerable influence the specific production and the qualitative level of laminates, reason for which they are given a special attention, in manufacturing, as well as in usage. These requirements cannot be completely fulfilled, compelling to the granting of priorities depending on the type of laminates, therefore to compromises. At large, the problem is reduced to the correct material choice, eased by the rich available experience in the current conditions of manufactured and burdened, in the same time, by the large diversity of material used.

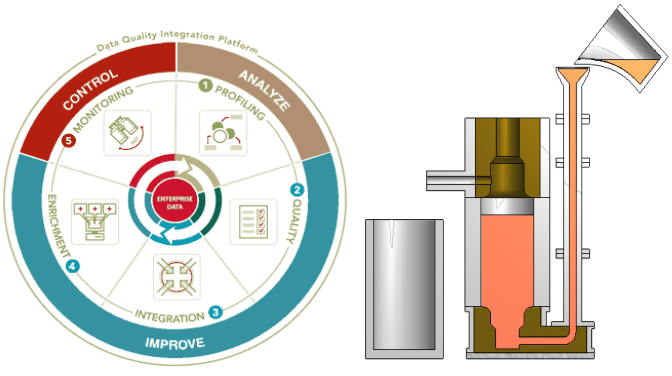

Figure 1*. The Quality control phases*

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Although the manufacture of rolls is in continuously perfecting, the requirements for superior quality rolls are not yet completely satisfied, in many cases, the absence of quality rolls preventing the realization of quality laminates or the realization of productivities of which rolling mills are capable.

To the selection of materials is considered the type of rolling mill, the sizes of rolls (in specially this diameter), the speeds of lamination, the stands from the train of lamination for which is achieved rolls, the working temperature in the lamination process, the module of cooling during work, the size caliber, the pressure on rolls, the rolled material hardness, etc.

The choice of material for rolls is the operation which takes into consideration the own solicitations of the lamination process afferent to the type of rolled products, and the features of different materials considerate optimum in the fabrication of different typo–dimensions of rolls.

METHODS, APPROACHES AND TENDENCIES

The technological manufacturing process of the rolling mills rolls, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation. Our proposal approaches the issue of quality assurance of the rolling mills rolls, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation.

In these sense, our researches propose, on aside, to analyze the durability in industrial exploitation of the iron cast rolling mills rolls (Figure 2) – analysis materialized from prism of the laboratory experiment (Figure 3), and on another side, the optimization of manufacturing technology of the cast rolls, especially those from cast–iron – using electronic calculus technique as the modeling phenomenon (Figure 4) and mathematical interpretation of the technological processes.

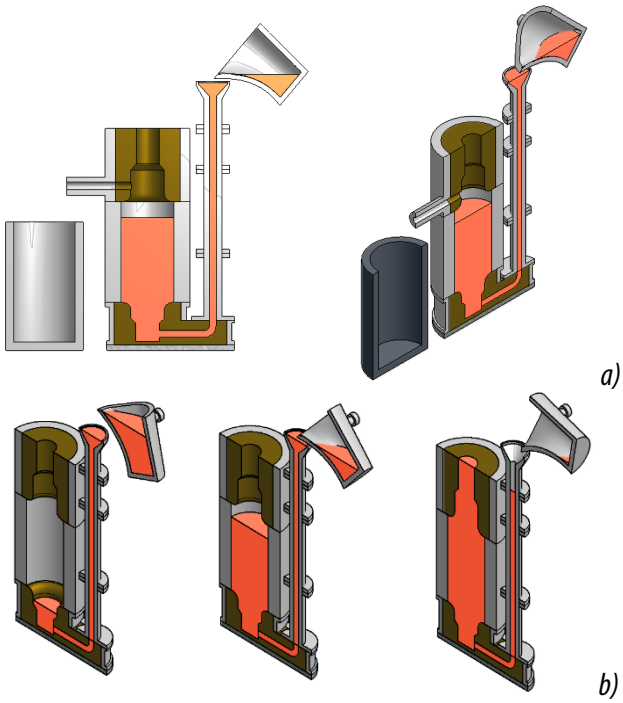

Figure 2. *The of the rolling mills rolls casting technology: a) the casting equipment; b) the casting phases*

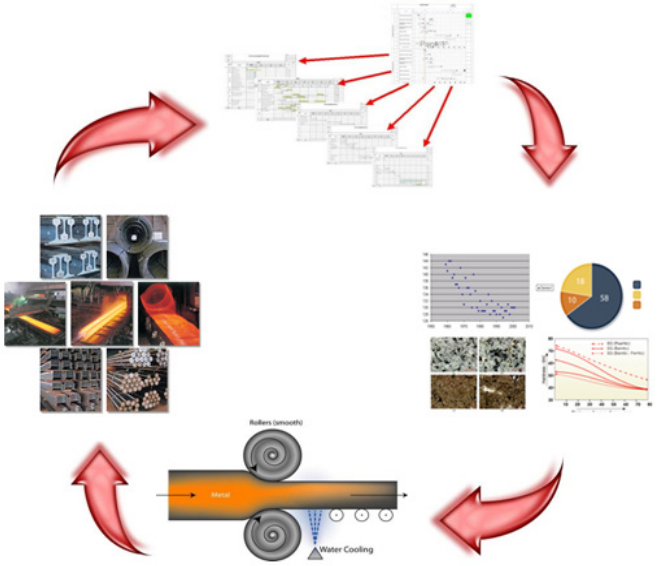

Figure 3*. Quality assurance of the rolling mills rolls through the laboratory experiment*

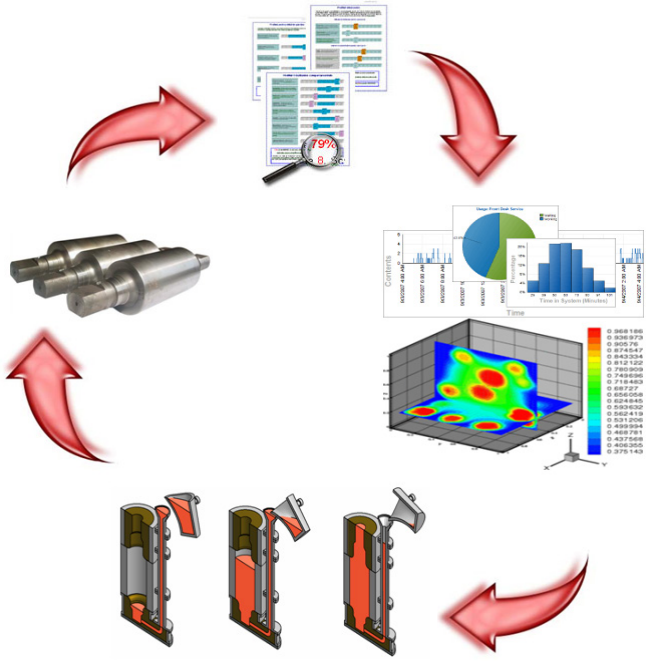

Figure 4*. Quality assurance of the rolling mills rolls through the modeling phenomenon*

The quality assurance research fields can be defined through the general research area, through the different experiments effectuated in the laboratories, and, also, through the modern calculation programs, optimization technologies and the better capitalization of the manufacturing data.

QUALITY OF ROLLS ASSURED BY THE LABORATORY EXPERIMENTS

The researches of durability in the exploitation of cast from cast–iron rolls, constitute a scientifically novelty, and experimentally define an important chapter from the thermal fatigue of the organs of machines in the movement of rotation, in variable temperature mediums. Hot rolling mills rolls work the in the variable compound solicitations, due to lamination process and which repeated to regular intervals of time.

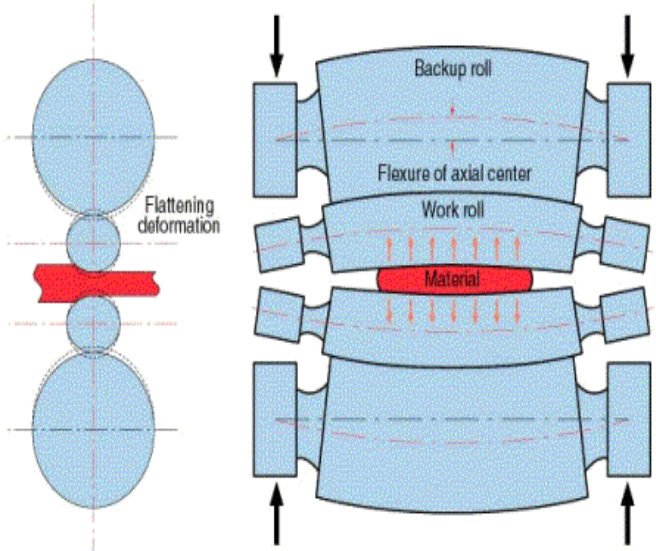

Figure 5. *Hot rolling mills rolls work the in the variable compound solicitations*

All these phenomena, which are more or less emphases depending on the type and typical of rolling mills, are not taking into consideration in the classic calculus of rolls. If the study of the rolls resistance is extended upon their durability, we must consider the whole complex of tensions with mechano–thermal influences. The research on durability in exploitation of hot rolling mills rolls assures relevant conditions for the appropriation of the research methods of the thermal regimes that are submitted the rolls or other organs of machines, that works in constant (symmetrical) or variables (asymmetrical) thermal solicitation conditions.

The recommendations for the increase of the duration of exploitation and remove of the damages through the accidental rupture of rolls from the stands of lamination, the attenuation of rolls thermal fatigue, the avoiding of thermal shock and their rational exploitation are actuality issues that must be continuously researched. In this trend is situated the research of the thermal fatigue phenomena, materialized in technical reports, whose beneficiary is the unit in which the rolls are exploited, as well as through scientific papers, that can develop the framework of scientific research. These researches results lead to direct conclusions about the cast–iron rolls, and permit their comparison with date about steel rolls, area studied thoroughly researched of specialists.

The work is of practical immediate utility, inscribing itself in the context of technical capitalization of the manufacturing technologies and of exploitation of cast–iron rolling mill rolls, for which exists an attentive preoccupation both from foundry sectors, as well as from lamination sectors, having as determinate aim the quality assurance and increase the durability in exploitation.

QUALITY OF ROLLS ASSURED BY THE MODELLING OF MANUFACTURING DATA

Starting from the principle of modeling process, used as necessary basic instrument, both in phase of conception, as well as in the industrial technologies analysis, is determined the optimum regimes of the cast rolls, from the view from chemical composition, as one as the most important parameters of disturbance of the manufacturing process.

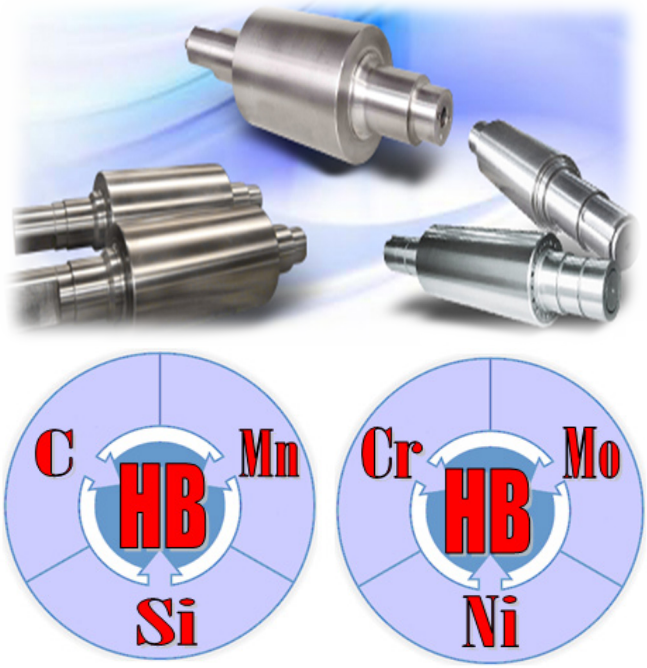

Figure 6. *The influence of the basic and the alloyed elements upon the Brinell hardness, in mathematical perspective*

The enunciation of some mathematically modeling results, described through a number of multi–component equations determined for the spaces with 3 and 4 dimensions, as well as the generation of some regression surfaces, of some curves of levels, of the volumes of variation, of the lines of outlines of the volumes of variation of surfaces and the areas of variation of these, can be represented and interpreted by technologists and can be considerate diagrams of correlation between the analyzed variables. From this point of view the research is inscribes in context of scientific capitalization of the process and the industrial technologies optimizations, on the way of the analysis and the mathematical experiment.

The MATLAB functions permit the graphical representations drawing in both planes, in 2D, which allows the display the reflector right and regression), as well as in 3D plane (which enable the plan of regression). The regression hyperplanes and the representations variation areas of the cast–irons chemical composition in the Figures 7-14 are presented.

In this way, using the regression analysis analytic by the calculation of statistical parameters could determine the regression equations. Areas of variation described by the regression equations, which can be realized that projections of the regression surfaces in the plan are used as the basis of a valuable called technologists who work in the manufacturing sectors.

The statistical calculations by MATLAB functions for the processing of data start with identification and determination of the highest and the lowest values, the calculation of the average, sorting items in ascending or descending order, the calculation of the regression equations, the calculation standard deviation, as well as the coefficient of correlation.

On the basis of the values determined in the statistical parameters, the MATLAB program allows the generation of the technological agreed areas, determined by the regression equations (degree 1.2 ... n), and,

also, the numerical equations that determine and describe the mathematical interpreted regression surfaces.

The regression equation surface described by an equation of degree 1 are described in Figures 7-8. Similarily, the regression equation surfaces described by an equation of degree 2, 3 and 4, are described in Figures 9-14, in some examples.

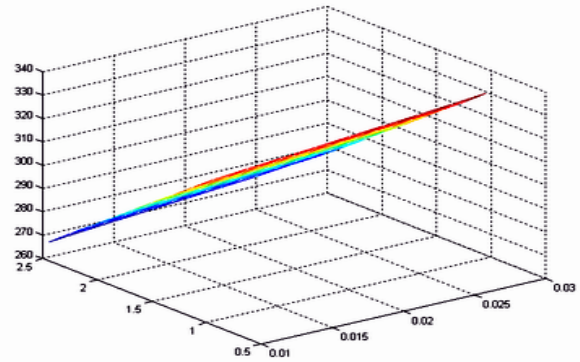

***Figure 7**. The regression surface, described by an equation of degree 1*

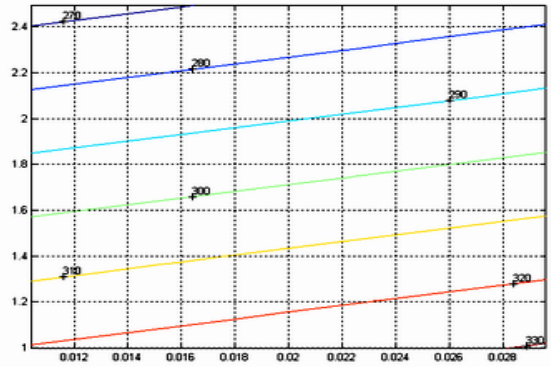

***Figure 8**. Areas of variation described by the equations of degree 1*

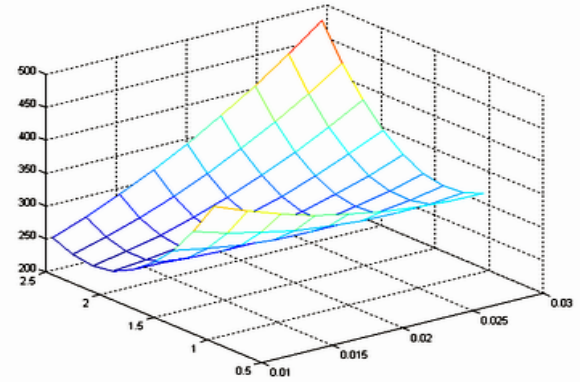

***Figure 9**. The regression surface, described by an equation of degree 2*

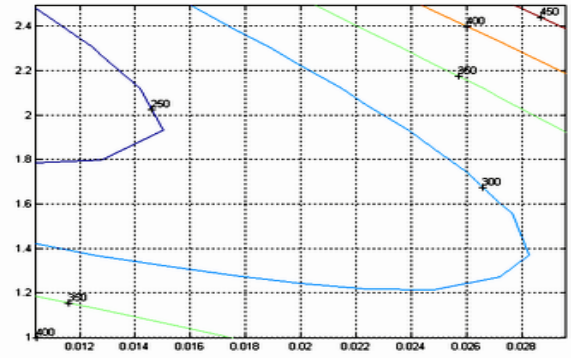

***Figure 10**. Areas of variation described by the equations of degree 2*

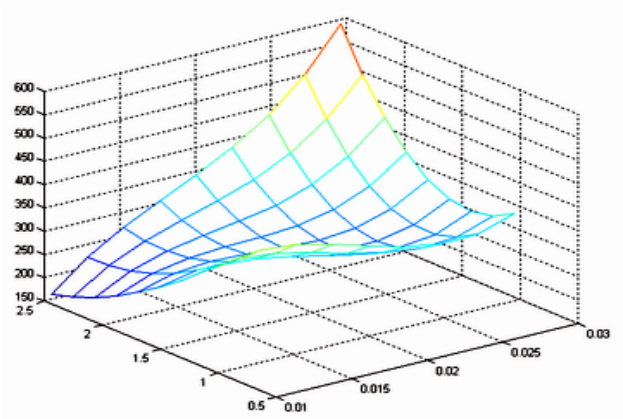

***Figure 11**. The regression surface, described by an equation of degree 3*

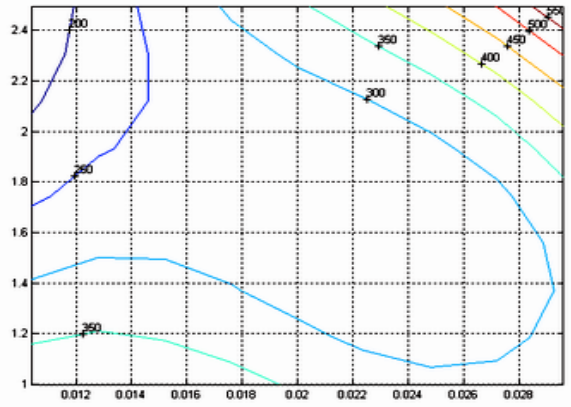

***Figure 12**. Areas of variation described by the equations of degree 3*

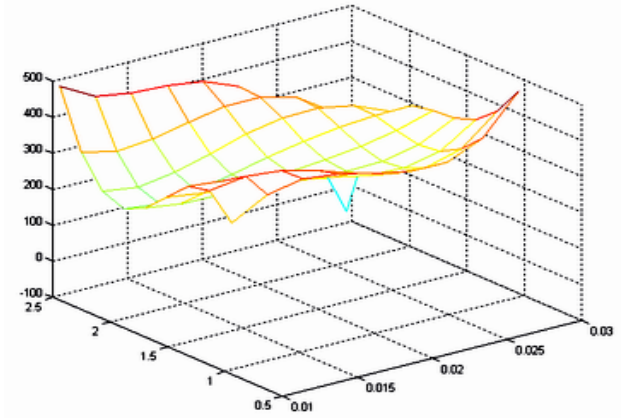

***Figure 13**. The regression surface, described by an equation of degree 4*

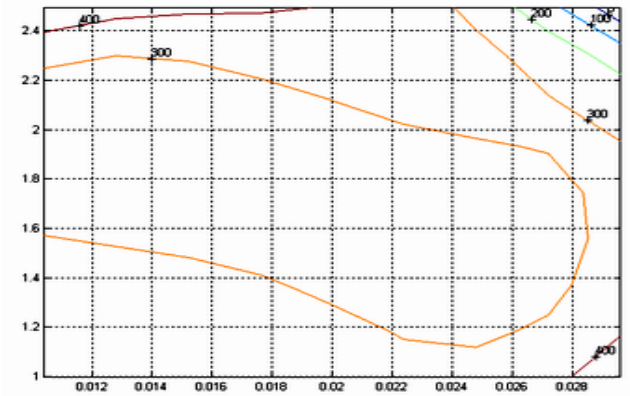

***Figure 14**. Areas of variation described by the equations of degree 4*

On the basis of the number variables (independent technology parameters) that are taken into consideration, regression analysis is a

simple regression analysis, when analysing influence a single independent variables "X" variable dependent on "Y": Y = f(X), or multiple regression analysis, when we analysing the cumulative influence of the several independent variables X1, X2, ... on the dependent variable "Y".

The character of the metallurgical processes optimization is influenced by the complex peculiarities of these, which take place into a great number of variables (parameters) that operates independently or cumulate.

For this reason, to analyze the metallurgical processes is used, mainly, the statistical fundamental methods that permit to draw conclusions, from the observed values, about the repartition of the frequencies of various parameters, about their interaction, about verification validity of certain premises, and about the research of the dependencies among different parameters. However, the statistical methods of the metallurgical process analyses do not solve a series of aspects regarding the mode of establish the decisions for the management of the process. Thereof, parallel with the statistical methods it was developed optimization methods.

The optimization of any technological process has, as a base, a mathematical model. The search for the best solution, for the truth, requests either to find, on the way of a study, definitive truths, or of relative valid truths, valid only in certain conditions, and which, in relation with the definitive truths, include implications and errors.

Areas of the technological variations, described by the regression equations, which can be realized that the plan projections of the regression surfaces (figure 8, 10, 12 and 14) are used as correlation diagrams by technologists who work in the sectors of production of the cast iron rolling rolls . These graphical representations as diagrams serve to determine the exact areas of variation of the variables the manufacturing processes of the cast irin rolling rolls.

CONCLUSIONS

The aim of these kind of research is to answer to as many questions possible regarding the general and peculiar quality of the rolling rolls. In this sense, durability in exploitation is extremely current, both for immediate practice, and for the scientific research attributed to the cast–iron. Also, the realization of optimum chemical compositions of the cast–iron can constitute a technical efficient way to assure the exploitation properties, the material from which the rolling mills rolls are manufactured having an important role in this sense.

The research on durability in exploitation of hot rolling mills rolls assures relevant conditions for the appropriation of the research methods of the thermal regimes that are submitted the rolls or other organs of machines, that works in constant (symmetrical) or variables (asymmetrical) thermal solicitation conditions. Also, it can be emphasized the thermal shock, phenomenon that constitutes a permanent danger, which leads to rupture, specific to rolling mills rolls.

On another hand, the realization of an optimal chemical composition can constitute a technical efficient mode to assure the exploitation properties, the material from which the rolling mills rolls are manufactured having an important role in this sense. From this point of view is applied the mathematical modeling, which is achieved starting from the differentiation on rolls component parts, taking into consideration the industrial data, as well as the national standards regulations, which recommends the hardness, for different chemical compositions.

Statistical calculations by MATLAB functions for the processing of data start with identification and determination of the highest values of the lowest values, the calculation of the average value, the calculation of the terms product regression, sorting items in ascending or descending order, the calculation standard deviation, as well as the coefficient of correlation.

The optimum solution is determined through some mathematical restrictions to the input values that the mathematical modeling is started. The realization of a mathematical model starting from industrial data, gathered at the rolls hardness measurement, and at the national standards regulations, which recommends the hardness, for different chemical compositions, also determines the degree of originality of the suggested project. The determination of the equations of regression hyperplanes, which describe the mathematical dependency between the chemical composition and the hardness, the determination of the multi–component relations and the realization of the graphic interfaces for the representations variation areas of the cast–irons chemical composition, completes this area of preoccupations within a processing mathematical of modeling and optimization. Through the original aimed elements mentioned above, the suggested research allows the enunciation of new approaches in the area afferent to the theme.

REFERENCES

[1.] Kiss, I. 2005, The quality of rolling mills cylinders cast by iron with nodular graphite, Mirton, Timisoara

[2.] Kiss, I., 2008, Rolling Rolls – Approaches of quality in the multidisciplinary research, Mirton Publishing House, Timisoara

[3.] Schroder, K. H.1988. Rolling conditions in hot strip mills and their influence on the performance of work rolls, Metallurgical Plant and Technology, no.4/88, 44–56, Dusseldorf

[4.] Schroder, K. H. 2000, Questions, answers, more questions – Twenty–five years of experience in discussing rolls and rolling technology, 42nd Mechanical Working and Steel Processing Conference Proceedings, Toronto

[5.] Pellizzari M., Molinari A., Straffelini G., 2005, Tribological behaviour of hot rolling rolls, Wear, Volume 259, Issues 7–12, 1281–1289

[6.] Kiss, I., 2012, Investigations upon the indefinite rolls quality assurance in multiple regression analysis, Revista De Metalurgia, CENIM, 85–96

[7.] Kiss, I., 2008, Research upon the quality assurance of the rolling–mill rolls and the variation boundaries of the chemical composition, Revista De Metalurgia, CENIM, 335–342

[8.] Kiss I., 2010, About the durability in exploitation of the cast iron hot rolling mill rolls in few experimental results, Acta Metallurgica Slovaca, 16 (1), Kosice, Slovakia, 35–41

[9.] Kiss, I., Heput, T., Cioata, V. G., 2010, Some interpretative research in the area of cast iron rolls quality assurance, Acta Metalurgica Slovaca, 16 (1), Kosice, Slovakia, 26-33

[10.] Kiss, I., Cioata, V.G., Alexa, V., 2010, Increasing the rolling–mill rolls quality – In some multidisciplinary research, Acta Technica Corviniensis – Bull. of Eng., Fascicule 2, 31–36
[11.] Kiss, Imre, Rațiu, S., Maksay, St., 2003, Triple correlation between the rolls hardness and the cast irons main alloyed elements. Annals of the Faculty of Engineering–Hunedoara – Int. J. of Engineering, 3
[12.] Kiss I., Alexa V., Cioata V.G., Ratiu S.A., 2011, Industrial and laboratory approaches for quality assurance in the rolling–mill rolls manufacturing, 1st Regional Conference – Mechatronics in Practice and Education MECH – CONF 2011, Subotica, Serbia
[13.] Kiss I., 2014, Laboratory researches upon the thermal fatigue of the organs of machines in movement of rotation, in variable temperature mediums, International Conference on Science and Technique based on Applied and Fundamental Research – ICoSTAF 2014, Szeged, Hungary
[14.] Nakamura, Shiro, Masahiro Fukuda, Akitoshi Okabayashi, 1983, Ductile cast iron roll and a manufacturing method thereof., U.S. Patent No. 4, 396-442
[15.] Goto, K., Matsuda, Y., Sakamoto, K., & Sugimoto, Y., 1992, Basic characteristics and microstructure of high-carbon high speed steel rolls for hot rolling mill, ISIJ international, 32(11), 1184-1189
[16.] Hashimoto, Mitsuo, Osamu Kubo, Yasuhiro Matsubara, 2004, Analysis of carbides in multi-component white cast iron for hot rolling mill rolls, ISIJ international, 44/2,372-380
[17.] Colás, R., Ramírez, J., Sandoval, I., Morales, J.C., Leduc, L.A., 1999, Damage in hot rolling work rolls, Wear, Volume 230, Issue 1, 56–60
[18.] Guerrero, M.P., Flores C. R., Pérez, A. , Colás, R., 1999, Modelling heat transfer in hot rolling work rolls, Journal of Materials Processing Technology, Volume 94, Issue 1, 52–59
[19.] Kudo, T., Kawashima, S., Kurahashi, R., 1992, Development of Monobloc Type High-carbon High-alloyed Rolls for Hot Rolling Mills. ISIJ International, 32(11), 1190-1193
[20.] Breyer, J. P., Walmag, G., 2002, Metallurgy of High Chromium-Molybdenum White Iron and Steel Rolls. Rolls for the Metalworking Industries, Warendale, Pittsburgh, 29-40
[21.] Kiss, I., Maksay, St., 2010, Bimetallic cast iron rolls–some approaches to assure the exploitation properties, Tehnički vjesnik, 17(2), 173-178
[22.] Kiss, I., Maksay, St., 2008, Technological correlations between the hardness and main alloyed elements in the area of cast iron half-hard rolls, Tehnički vjesnik, 15(1), 33-37
[23.] Belzunce, F. J., Ziadi, A., Rodriguez, C., 2004, Structural integrity of hot strip mill rolling rolls. Engineering Failure Analysis, 11(5), 789-797
[24.] Krawczyk, J., Pacyna, J., 2009, The influence of microstructure of mottled cast iron for mill rolls on its properties, 18th International Conference on Metallurgy and Materials Metal, 100-106

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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FACTORS INFLUENCING CONVEYING VELOCITY OF PRISMATIC PARTS ON A VIBRATORY FEEDER

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Abstract: Vibratory feeders are commonly used in industries for part feeding. There are several factors that affect the conveying velocity of parts on the vibratory feeder. Among these, the critical factors such as excitation frequency, amplitude of vibration, mass of part, co-efficient of friction and Length-to-width (L/W) ratio of the part were considered for experimental studies. The percentage of influence of each factor on conveying velocity was determined through ANOVA. Regression and Artificial Neural Network (ANN) models were developed to predict the velocity of prismatic parts on vibratory feeder. Comparison of results with experimental results revealed that ANN was able to predict closer than the regression model.
Keywords: Vibratory feeder, conveying velocity, regression, Artificial Neural Network

INTRODUCTION

Vibratory part feeders are commonly used in industries such as food processing, plastic component manufacturing, automobiles etc. Several literature focus on part motion in a vibratory feeder. Lim [1] performed a theoretical analysis of feeding on a track vibrating with simple harmonic motion. He considered excitation frequency, amplitude of vibration, co-efficient of friction and track angle as the factors affecting the conveying velocity of part on a vibratory feeder. He also developed a model to predict the conveying velocity based on the above said factors. Reznik et al [2] analyzed the part motion on a planar part feeder which had a longitudinally vibrating flat plate. They developed analytical expressions for feed rate. Ramalingam and Samuel [3] discussed the behavior of a linear vibratory feeder, used for conveying small parts. They considered barrel dimension, amplitude and angle of vibration, coefficient of friction and the operating frequency as the factors affecting the feed rate and conveying velocity of part the effect of these factors was determined experimentally. Udhayakumar et al [4] discussed the effect of excitation frequency, amplitude of vibration and trap inclination angle on conveying velocity of brakeliners on a vibratory feeder. The literature reported discussed the effect of factors individually on conveying velocity. Further, the literature on effect of Length-to-width (L/W) ratio of part on conveying velocity is very limited. In this paper, an attempt is made to determine the percentage of effect of factors such as excitation frequency, amplitude of vibration, mass of part, co-efficient of friction and Length-to-width (L/W) ratio of the part on conveying velocity on a vibratory feeder. Models to predict the conveying velocity of part was developed using Regression and Artificial Neural Network (ANN). The results predicted by the model were compared with the experimental results.

PARTS CONSIDERED

The factors considered were L/W ratio (Figure 1), mass (m), co-efficient of friction (μ), excitation frequency (f) and amplitude of vibration (A). The levels chosen for each factor is shown in Table 1. To vary the co-efficient of friction between the part and the feeder, four different materials made of steel, aluminium, brass and copper were chosen. The parts were fabricated according to the different L/W Ratio having different mass leading to 16 different parts as shown in Figure 2.

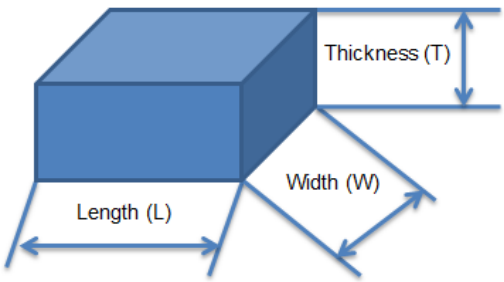

Figure 1. *Prismatic part indicating the Length (L) and Width (W)*

Table 1. *Factors and levels chosen*

S. No	Factors	Level-1	Level-2	Level-3	Level-4
1	L/W Ratio	1	1.5	2	2.5
2	Mass, M (g)	25	50	75	100
3	Co-efficient of friction, μ	0.37	0.39	0.41	0.45
4	Excitation Frequency, f(Hz)	28	30	32	34
5	Amplitude of vibration, A (mm)	0.5	0.6	0.7	0.8

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Figure 2. Parts of different material with different L/W Ratio and mass: a) copper; b) steel; c) aluminum; d) brass

EXPERIMENTAL SET-UP

A feeder tray made of acrylic material is fabricated and mounted on electro-dynamic shaker table, as shown in Figure 3. The specification of the electro-dynamic shaker system is shown in Table 2. The control unit of the shaker system has provisions for adjusting the frequency and amplitude of vibration of the shaker. When a part is put on the feeder tray and the shaker system is switched on, the part moves forward due to the vibratory motion caused by the shaker.

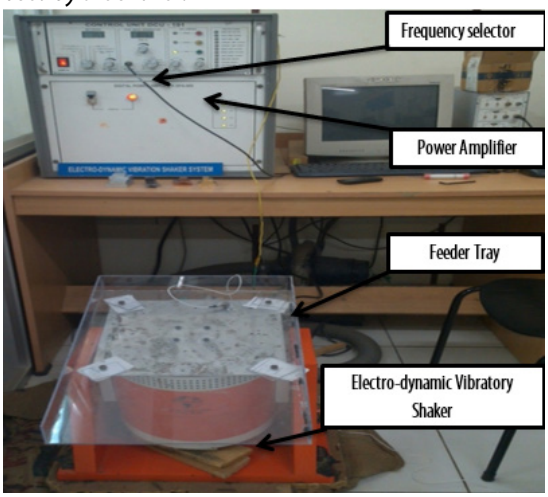

Figure 3. Experimental set-up

Table 2. Specification of electro-dynamic shaker

Armature diameter	100 mm
Mass of the armature	0.8 kg
Frequency range	Up to 4 KHz
Maximum displacement	12 mm (peak to peak)
Velocity	1.5 m/s
Shaker rotation	(±900)
Cooling	Air cooling

TAGUCHI'S DESIGN OF EXPERIMENTS

Robust design of experiments could be achieved by Taguchi method, wherein variation in a process is reduced. The Taguchi method was developed by Dr. Genichi Taguchi of Japan who maintained that variation. He developed a method for designing experiments to investigate how different factors affect the mean and variance of a process performance characteristic that defines how well the process is functioning. The experimental design involves using orthogonal arrays to organize the factors affecting the process and the levels at which they should be varied. Instead of full factorial design, the Taguchi method tests only certain combinations. This allows for the collection of the necessary data to determine which factors most affect product quality with a minimum amount of experimentation, thus saving time and resources. Since 5 factors were chosen at four levels, Taguchi's L16 (Table 3) orthogonal array was chosen for the experimentation.

Table 3. Taguchi's L16 Array

Experiment	P1	P2	P3	P4	P5
1	1	1	1	1	1
2	1	2	2	2	2
3	1	3	3	3	3
4	1	4	4	4	4
5	2	1	2	3	4
6	2	2	1	4	3
7	2	3	4	1	2
8	2	4	3	2	1
9	3	1	3	4	2
10	3	2	4	3	1
11	3	3	1	2	4
12	3	4	2	1	3
13	4	1	4	2	3
14	4	2	3	1	4
15	4	3	2	4	1
16	4	4	1	3	2

Based on the L16 orthogonal array, the experiments were conducted to determine the conveying velocity as the response. Each experiment was conducted five times and the mean conveying velocity was considered for further calculations.

ANALYSIS OF VARIANCE (ANOVA)

Analysis of variance (ANOVA), developed by R.A.Fisher, is a collection of statistical models used to analyze the differences between group means and their associated procedures (such as "variation" among and between groups). In its simplest form, ANOVA provides a statistical test of whether or not the means of several groups are equal. The experimental data was fed as input to Minitab 17 software and based on ANOVA, the influence of each factor on response was determined. The percentage of influence of each factor on conveying velocity of part on a vibratory feeder is given in Table 4.

Table 4. Percentage of influence of each factor on conveying velocity

Input parameter	% of influence
L/W Ratio	0.989
M (g)	26.02
μ	6.33
f (Hz)	42.39
A (mm)	24.25

From Table 4, it can be observed that the frequency of vibration is the most influencing parameter followed by amplitude of vibration, mass of part and co-efficient of friction. The L/W ratio has no significant effect on conveying velocity.

REGRESSION ANALYSIS

Regression is another statistical tool for measuring relationship between variables [5]. Regression is used to predict the output values with the set of input parameters. It creates an equation in terms of input variables to find the desired output. In this paper, the dependent variable is conveying velocity (V) and the independent variables are L/W Ratio, Mass (M), co-efficient of friction (μ), excitation frequency (f) and amplitude of vibration (A), With the help of the experiment results the regression model was generated using the Minitab 17 Statistical software, which is given by Equation (1).

$$v = -26.9155 - 1.99932\,L/W - 0.205103\,M - 95.6271\,\mu + 3.2722\,f + 49.5078\,A \quad (1)$$

where: v is Conveying Velocity (mm/s); L/W is Length/Thickness Ratio; M is Mass (g) ; μ is Co-efficient of friction between feeder tray and part; f is Excitation frequency (Hz); A is Amplitude of vibration (mm)

ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks (ANN) have been used for the structure and functionality of biological natural of human brain [6].Therefore, ANN is found to be more flexible and suitable than other modelling methods. Neural network is an information processing system in which the process is carried out by means of elements called neurons that are interconnected by link. The concept is based on ideal neuron which is assumed to be responding optimally to applied inputs. ANN model was developed using MATLAB 2013 based on the experimental results. The parameters chosen for developing the model is shown in Table 5.

Table 5. *Parameters for developing ANN Model*

Structure	Feed Forward
Algorithm	Back propagation
Type of Training	Trainlm
Network structure	15,h and l
Transfer function	TANSIG
Number of iterations	1000(max epoch)
Performance function	MSE = 0.00001
Data division	Random
Learning rate	0.01
Momentum	0.95

To determine the number of neurons in the hidden layer, trial and error method was employed [7]. 'R' value represented the correlation between outputs and targets. The hidden neurons were initially varied from 10 in increments of 100(i.e., 10, 20, 30 . . . etc.) From that maximum R value is chosen which means the input values are closer to fit the line. The overall 'R' value obtained by varying the hidden neurons is shown in Figure 4.

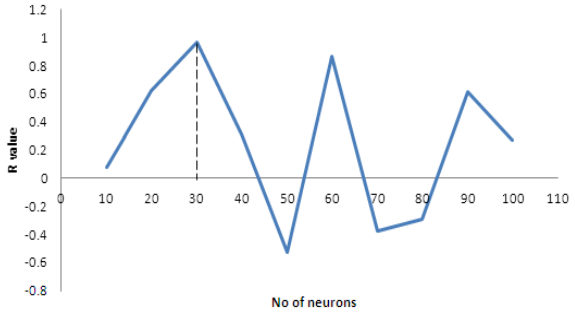

Figure 4. *Overall 'R' Vs no. of neurons in hidden layer*

From Figure 4, it could be inferred that hidden neuron size of 30 had the maximum 'R' value (shown in dashed line) and hence 30 was chosen as the appropriate number of hidden neuron. On increasing the neurons in hidden layer beyond 30, the 'R' value was found to decrease and hence the test was stopped at neuron size of 100.Using this, the ANN network was again created and trained. An ANN model capable of predicting the conveying velocity based on input parameters is available now.

COMPARISON OF RESULTS

Three different prismatic parts were chosen for validating the above two models. The comparison of regression and ANN model results with the experimental results is shown in Figure 5. From the results, it could be observed that ANN model was able to predict the results much closer to the experimental values than the regression model. This is in agreement with Abounoori and Bagherpour [8], who also concluded that ANN could predict results much better than regression models. ANN could make rules without any implicit formula and hence were able to predict the results much accurately than the regression equations. These models will help the industries to predict the conveying velocity of parts on a vibratory feeder based on their input parameters.

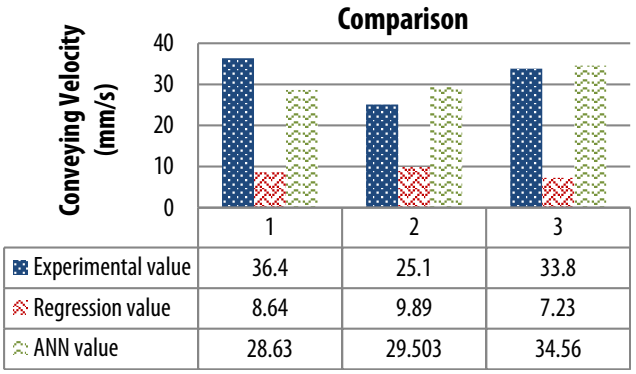

Figure 5. *Comparison of Regression & ANN with Experimental results*

CONCLUSIONS

An attempt was made to determine the influence of factors such as excitation frequency, amplitude of vibration, mass of part, co-efficient of friction and Length-to-width (L/W) ratio of the part, on conveying velocity of part on a vibratory feeder. Based on experimental results and ANOVA, the excitation frequency was found to be the most influencing factor followed by amplitude of vibration. The L/W ratio has no significant effect on conveying velocity. Regression and ANN models were developed to predict the conveying velocity of part on vibratory feeder. On comparing the results predicted by the models with the experimental results, it was observed that ANN model was much accurate than regression model. This model will aid the industries in predicting the conveying velocity of part on a vibratory feeder.

REFERENCES

[1] *Lim, G.H : On the conveying velocity of a vibratory feeder, Computers & Structures, 62(1),197-203, 1997*

[2] *Reznik, D., Canny, J. and Goldberg, K : Analysis of part motion on longitudinally vibrating plate, Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), vol. 1, 421-427, 1997*

[3] *Ramalingam, M. and Samuel, G.L : Investigation on the conveying velocity of a linear vibratory feeder while handling bulk-sized small parts, Int J Adv Manuf Technol, vol. 44, 372-382, 2009.*

[4] *Udhayakumar, S., Mohanram, P.V., Keerthi Anand, P and Srinivasan, R : Trap based part feeding system for stacking sector shaped parts, Journal of the Brazilian Society of Mechanical Sciences and Engineering, 36 (2), 421-431, 2014.*

[5] *Al-Khatib, I.A., Abu-Hassan, H.M and Abaza, K.A: Development of empirical regression-based models for predicting mean velocities in asymmetric compound channels, Flow Measurement and Instrumentation, vol. 33, 77-87, 2013.*

[6] *Arulmozhi, K.T and Sheelarani, R : Application of artificial neural network technique to predict ultrasonic velocities in binary oxide glasses, Advances in Applied Science Research, 2(4), 147-155, 2011*

[7] *Ricca, R.N., Jami, M.S and Alam, M.Z : The potential of artificial neural network (ANN) in optimizing media constituents of citric acid production by solid state bioconversion, International Food Research Journal, 19 (2), 491-497, 2012.*

[8] *Abounoori, E and Bagherpour, M: Estimation of industrial production costs, using regression analysis, neural networks or hybrid neural-regression method, Journal of Interdisciplinary Mathematics, 10(2), 59-167, 2007.*

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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DECISION-MAKING SUPPORT SOFTWARE APPLICATION OPTION FOR CRITICAL INFORMATIONAL INFRASTRUCTURES

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Abstract: *There can be practical question in connection with the networks: Do the malfunctions of devices, eruptions of social conflicts, devastations of biological or chemical disasters happen accidentally? The segments of the network can be paralysed by a series of chance events or a well-organized, targeted attack. If we know our system and lead a safety-conscious life we can avoid unpleasant events, system down. The Critical Information Infrastructures has become a complex network. Consequently the items of the system, their mutual effects and links and the map of the network have to be known properly. We have to realize that everything is linked with each other and the physical and logistical networks have mutual effects on each other as well. It is obvious, that the problem of mapping the complexity is very important. One of the most important part of the cognition is the obtainment and sorting of information.*
Keywords: *network, future IT warfare, structure of networks, Critical Infrastructures, Critical Information Infrastructures*

INTRODUCTION

We can ask a practical question regarding the networks: does the malfunctioning of technical devices, eruption of social conflicts, biological or chemical disasters happen accidentally?

Segments of the networks could be disabled by incidental events or well-organized and planned interventions as well. In 2013 the 91 % of business ventures suffered from cyber-attacks from which 9% were targeted. Considering the permanently increasing numbers and threat of these attacks and the growing tendency of cyber espionage backed by professional organizations, the situation is graver than ever. However from the point of view of network theory it is worth mentioning that the 13 % of business espionage was committed by humans and not technical devices.[1]

The goal of present essay is to emphasize the importance of system thinking and the complexity of informatics systems. I also intend to introduce briefly the elements of the IT systems and highlight the lack of software supporting the monitoring of the complex systems and decision making processes and the deficiency of the relating legislation and standards.

A research of Symantec – conducted between the July of 2012 and the June of 2013 – has been already dealt with the energy sector as one of the fields of the Critical Infrastructure. During the aforementioned timespan the average number of detected daily attacks was 74, of which 9 were launched against the energy sector. The vitally critical systems were attacked by 16 % of all targeted attempts, which made them the second most endangered networks. Fortunately the attacks did not cause serious loss of data (at least the researchers did not know about them) but by the continuously increasing number of them the attacks could exceed the statistical limit of harmful attempts.[2] The analysis of the attacks revealed the growing number of weaknesses as well by which the threats arriving from external sources mean greater risks. Nowadays the 10 % of the business ventures are under permanent attacks and pressure. The success of the dangerous targeted attacks is enhanced by the significant sources provided by different organizations, business ventures, even public administrations. Generally the victim does not even notice the attack and the detection of weaknesses and their solutions could take years. The recognition of the violation is even more difficult in the lack of information on its source, the main client, the coder, the attacker and so an. The malicious codes usually exploits the unique human and technical weaknesses of the systems and these sophisticated "tools" can cause more damage to a country or a facility of vital importance than a traditional military strike. For example the IT warfare and its new field, the IT operations can ruin the financial sector or political structure of a certain country, which could influence the course of events in the affected area on a long term and relatively on a low cost.

Other risk endangering the IT infrastructure is the inner threat originating from the planning and coordination faults of working processes or other procedures and the drawbacks of the human nature, which could pose the greatest threat by the misconduct of IT systems, data and information. Many times CEOs working in different fields propose different solutions in connection with the same IT matter, which should be avoided by exact regulations, audited organizations, education and training, safety-conscious working attitude, sufficient human and financial resources.

The third aspect of the subject is the availability of the system, which includes the failed setting up, risks of operation, amortization,

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technological or operational defect of technical devices. A sustainable and highly available system can be provided by reliable producers, proper technology and redundancy and operational environment satisfying the goals of the system.

The critical infrastructure, which includes the critical informational infrastructure, has to be operated within the framework of the aforementioned environment.

Our system must be run by the common interpretation of the three fields (external effects, internal effects, structure of the system). In my opinion the existing defence mechanism is not sufficient and other mechanisms should be invented. From this aspect the setting up of the multilevel protection is inevitable and a particular software capable to map up the different networks, find their inherency and draw up the necessary conclusions is highly needed. If we know our system and run it on a safety-conscious way, we may not encounter with service interruptions or loss of data. So, it is important to know the items of our system, their effects on each other, their links with each other and the map of the network properly. We also have to be aware of the fact that everything relates with each other such like the physical and logical networks. That is obvious that extremely important to map up their complexity, which – as the most important step of it - must include the gathering of data and organizing it into databases.

According to the definition the IT system or facility of vital importance (known also as critical informational infrastructure) is: "the network-like physical or virtual systems of the society, which by the necessity of providing continuously information or the availability of the informatics environment are vital items of the system or they are essential for the running of other identified vital system elements."[3]

From the viewpoint of the critical informational systems the system thinking approach is very important. It is supported by the proper knowledge of our system, the preparation of an exact data asset inventory, which includes the working processes, system elements, their links, environment variables and many other things. After the survey and the accurate documentation, the system can be modelled by certain aspects. The next step of modelling is the systematization of data and the demonstration of elements and their links by graphs. Then the graphs are organized in matrixes, which can be processed by computers more easily.

For the sufficient operation the system should have a well-prepared programme plan including the whole life cycle of the system. This programme plan can be controlled by a software application, which has to be able to permanently receive inputs and send signals and alerts regarding dangerous events occurring during the operation. Based on the stored data it has to be able to recognise such kind of relations, which can't be found out of the knowledge of subsystems exclusively or they are originating from the complexity of the system. Using artificial intelligence the software has to continuously develop its knowledge base on the relations and links of the system's items and it has to propose in connection with the necessary maintenances and upgrades. Initially the modular software has to support the risk analysis and risk management as well. The risk analysis must be carried out with respect of confidentiality, integrity and availability. The system may not affect processes in case of temporarily working or shutting down for a longer time, but confidentiality has to be considered as an important demand in these cases as well.

The examination of a system of complex network elements can be carried out by the assistance of network theory, or from another approach using the graph theory. The graphs are the mathematical descriptions of networks by which the interactions, navigations and behaviours can be introduced on a mathematical way. The "models" of different systems can be similar to each other, which can indicate the existence of rules.

Following the preparation of graphs simplifications can be carried out and on other way unseen but harmful relations can be identified in the network. In case of more loops or surplus redundancies the normal operation of the system could switch to emergency status quite soon. Apart from the known events introduced in the risk analysis many tiny irrelevant events can also alter the system. Moreover, according to my approach, the different networks can be considered as one dimension of IT, human, infrastructural, traffic etc. Networks, which are not independent from each other but they are linked and form up a complex system of a multidimensional network. In these networks two points or two separated IT systems may not have relations with each other but there could be other edges or network nodes, which link them up. The graphs can be converted into matrixes by a method introduced later on and by the matrixes the calculations, revealing the relations, can be done more easily.

The simplest matrix calculations to analyse the links are as follows: The method of matrix creation is based on the number taking place in the columns' and rows' cross section. In this case the columns and rows mean the nodes of the network.

i row; j column

NEIGHBOURHOOD MATRIX

The neighbourhood matrix indicates the number of edges between two nodes.

It can be interesting from more points of view. On one hand the redundancy can be planned by them, while the surplus links, causing incalculableness and instability in our network, can also be found.

a_{ij} *indicates the number of edges linking* p_i *and* p_j *nodes*

$$\boldsymbol{A} = [\boldsymbol{a_{ij}}]$$

In case of undirected graphs:

$$a_{ij} = \begin{cases} 1, & \text{if } p_i \text{ and } p_j \text{ are linked directly, edge} \\ 0, & \text{in every other case} \end{cases}$$

In case of directed graphs:

$$a_{ij} = \begin{cases} 1, \text{if there is an edge from } p_i \text{ to } p_j \\ 0, \text{in every other case} \end{cases}$$

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix};$$

for instance: $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 2 \\ 0 & 3 & 0 \end{bmatrix}$

Edge matrix

Edge matrixes indicate the links between edges and vertices.

Marking:

$$B = [b_{ij}]$$

In case of undirected graphs:

$$b_{ij} = \begin{cases} 1, & \text{if } e_j \text{ is not loop edge and it interlocks with } p_i \\ 0, & \text{in every other case} \end{cases}$$

$$B = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

In case of directed graphs:

$$b_{ij} = \begin{cases} 1, \text{if } e_j \text{ is not a loop edge and its starting point is } p_i \\ 0, \text{if } e_j \text{ is loop edge and it does not interlock with } p_i \\ -1, \text{if } e_j \text{ is not edge loop and its starting point is } p_i \end{cases}$$

$$B = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

Availability matrix, power matrix

If the neighbourhood matrix is multiplied with itself the result is the availability matrix, consequently the power of the neighbourhood matrix gives the availability matrix.

This matrix determines the number of different ways leading from one point to another. The way taken is indicated by the difference of the vertices' sequence, which means that there can be only one way between two neighbouring points with disregard the real number of the linking edges.

Marking:

$$A^k = a_{ij}^{[k]};\ A^2 = a_{ij}^{[2]} = \sum_{s=1}^{m} a_{is} * a_{sj}$$

Sum matrix

The sum of the availability matrixes gives the sum matrix.

The sum matrix indicates the number of maximum k steps and other different ways, which are needed to get from one point to another.

If we would like to know whether one point can be available from another at least via one k step then the signum matrix have to be used.

Marking:

$$H_k = h_{ij}^{[k]} = \sum_{n=1}^{k} A^n$$

$$H_2 = A^1 + A^2,$$

$$H_3 = A^1 + A^2 + A^3 = H_2 + A^3$$

Signum matrix

If we want to know whether one given point can be available from another at least via one k step then the signum matrix have to be used.

Marking:

$$s_{ij}^{[k]} = \begin{cases} 1, & \text{if from } p_i \text{ node we can get to } p_j \text{ via } k \text{ step} \\ 0, & \text{via } k \text{ step it can't be reached} \end{cases}$$

Availability matrix

If we only want to know whether a certain point can be reached from another one via optional number of steps, then the:

*Z_(m*m)*

availability matrix has to be used. The signum and availability matrixes can be used in many ways for IT risk analysis, but in case of risk analysis the effects of elements to each other and the reduction of them by the increase of the number of links can be also examined.

Marking:

$$Z = sign \sum_{n=1}^{m} A^n$$

During the modelling we can use deterministic, stochastic and fuzzy methods. For the development of the software different mathematical algorithms have to be used, which exist in other systems, only to mention the rapidly improving firewalls. Since the human factor is very significant regarding the behaviour of the system, a team of psychologist has to formulate the details and the know-how of the system in order to achieve success. Naturally the existing knowledge, such as standards elaborated by experts, has to be used as well.

In our opinion the accurate preparation, the careful selection of the junctions, the documentation and the reliability of the system are very important too. The planning and operation are static and dynamic at the same time. Regarding one certain process the direction and dynamics of the alteration can be also interesting. During the analysis of the systems and inputs, the systems of the multinational business ventures can cause problems as well. These problems can emerge from the affiliates, their parent companies and their other subordinations or the data centres, which are located at great distances from each other in order to establish geo-redundancy. In case of disaster prevention activity the informatics networks stretching through countries can also encounter obstacles. Due to the complexity of the environmental effects and relations, the simple running of the software can result in wrong outputs deriving from the simplification attempt of the aforementioned systems. Because of the globalisation and the improvement of IT communication systems everything is in connection with each other, which influences our system on an unpredictable way. But by the means of risk analysis, based on statistical and probability calculations, a relatively stable and reliable system can be established.

The determination of the exact amount of input needed for the modelling process is quite difficult, but it is not so much to make the necessary time boundless. The best instances of it the weather forecast, when the process of weather data can't last longer than the exact date of the forecast. On one hand, as much information has to be obtained as possible, which enables the system to make more and more accurate calculations resulting in more detailed outputs. At the same time more data can slow down the process extremely and in case of a very complex system the chance of malfunctions is more probable as well. Considering the aforementioned facts a plenty of sensors have to be used and much more calculations have to be done, while the weaknesses, threats, characteristics of assets and other basic information must be mapped up. This information can be obtained from producers or by sensors, experiences etc. but the optimization itself can't be neglected.

The software can be operated by a management info-communication network, which has to be independent from the "target" system, while

the operation system should be based on the RAID data storages. The system would run on three or more operation systems, which would be coordinated by a lower layer continuously monitoring its operation, alteration of the code and intervene, if it is necessary. In this case the achievements of artificial intelligence and system analysis can be installed in the software as well. Regarding the system, the existence of an unlock suitable for human intervention and the override of decisions or restoration to an earlier version is essential. Another fact is that only the systems built up by the principles of system analysis are protected against the incidental malfunctions and not the randomly created ones. In case of the scale-free networks the direct attacks are more dangerous. By the protection of the controlled and reduced edge interfaces and external connection points, the risks of attacks can be eliminated. The vast amount of data or the input of unexpected information arriving through the input points can also cause hazards endangering the running of the software. In order to minimize the impact of the butterfly effect the number of random events has to be reduced. It can be achieved by the strict regulation and maintenance of stability and the correction of abnormal processes, which can influence each other and result in chaos. The normal status of the system can be determined as follows:

The software can manage 7 statuses:

- *Planning phase*
- *Setting up phase*
- *Normal working phase*
- *Readiness phase*
- *Disaster phase*
- *Restoration phase*
- *System withdrawal phase*

Planning phase

The risk analysis is usually initiated in the framework of the planning phase by the input of initial values, modelling of system operation and the improvement of the final implementation plans. The software is adjusted to the environment, it is modelled, the locations of sensors are planned and the amount of the input data is optimised.

Setting Up phase

The software is adjusted to the system. Practically it is an initial, "tutorial" status, when a database of the vast amount of elementary data is created and the data links are instructing the system by the support of the artificial intelligence.

Normal working phase

The critical system element is working in a normal status, the software does not detect any unusual event and no threats, pre-identified by the risk analysis, are in effect.

Readiness phase

The software detects a pre-identified threat but it is not influencing the operation of the system. The risk is acceptable, manageable but its alteration has to be closely monitored. In case of numerous unexpected events, minor but separately manageable threats, the software sends alert messages and the restoration of normal operation has to be launched. The system can remain in this status forced by such an external impact against which we can't or don't intend to apply countermeasures. We can also anticipate regularly returning effects as well.

Disaster phase

The software detects a pre-identified serious threat, which can cause the malfunctioning or shut down of the system or other grave consequences. The software sends alert messages and attempts to maintain the reduced operation, while alarming the external cooperative organizations as well.

Restoration phase

Following the disaster phase the system is in a stable status (e.g. the default configuration of servers had been done) but its normal working status has to be restored. The external threat causing the disaster situation had been eliminated and the software supports the recovering of normal data trying to prevent the "oscillation". The restoration sequence has to be determined by priorities, which take into consideration the need of urgent recovery of the critical elements' stable status, but do not neglect the technological and logical aspects as well. Unfortunately most of the business ventures and even the critical facilities do not have incident management plan, which has to be included into the software too.

System withdrawal phase

In order to provide the permanent working of the business or fulfil the demands of legislation the withdrawal and replacement of the system must respect the principles of availability, intactness and privacy. At this stage the software does not supervise certain data, because the operation of each system elements is not assured any more but it warns if the sequence of the process could lead to disaster.[5]

The software continuously calculates the probability of switching into another status. The software also has to be prepared to isolated running, when some of the elements of the critical infrastructure has been already shut down. On one hand the software is the part of the critical informational infrastructure, because they supervise and control the critical system elements jointly, but one isolated part of it is independent and it controls the informational infrastructure. Such activities are the monitoring of the servers, the network infrastructure, the protection of the endpoints and the system against intrusions etc. and the processing of the information received from the aforementioned sources.

From the viewpoint of the system management the robust systems, which change their status slowly, can be handled relatively easily. In their case the system operators have enough time to intervene, but on the other hand the shutting down of processes and the restoration can take longer time as well.[6]

SUMMARY

I am convinced that the present fast improvement of IT technology can't be sustained for so long. Such as every processes of the real human life it will also be slowed down or suddenly come to a halt by the self-regulation. This kind of development has resulted in such sudden and fundamental changes in our life that can't be compared to anything in history.

Unfortunately the dynamic improvement has been not followed by the evolution of regulations and safety properly. The main goal of my essay is the raising of awareness. The IT revolution opened up previously closed doors and the free information flow connects everything together. This vast freedom is basically welcomed but if it is leading to anarchy that could cause problems as well. There are some fields where the establishment of uncontrolled and freely established network connections can't be allowed. Apart from the concerning regulations a specific tool – a software may be – is needed, which is capable to apply the rules in practice. In fact the recent struggle (firewalls, antivirus applications etc.) is moving on a spiral way, earning a lot of money for some actors of the business segment, but it does not solve the real problem. The creation of the software supervising the critical informational infrastructure takes a long time though some elements of it already exist. As the first step a framework has to be created in which the support of decision making can be based and launched. The other parts of it will be added gradually. The input points have to be prepared to accept the devices and software already in use. As the critical system elements are working in a complex environment, which has an impact on us, we also have to invite the experts of different professional fields and integrate their achievements into the software. [7,8,9]

IT experts, mathematicians, psychologists, mechanic and electrician engineers will be highly welcomed to participate. The aforementioned idea of the software may not solve the problem and perhaps another completely different theory will be the final solution, but the processes speeding along a spiral line has to be moved anyway. Perhaps biologists, physicians or sociologists will find the answers for the questions of network analysis based on their results achieved in their unique discipline. As a matter of fact the societies and biological systems already regulate themselves and they usually encounter problems caused by the impacts of external effects.

References:

[1.] Kaspersky Lab ZAO source : http://report.Kaspersky.com/#corporate-threats [Online] 2014. [Download date: 18/10/2014]

[2.] Symantec Corporation, source: http://www.symantec.com/content/en/us/enterprise/media/security_response/whitepapers/targeted_attacks_against_the_energy_sector.pdf [Online] 13/01/2014. [Download date: 18/10/2014]

[3.] 65/2013. (III. 8.) Korm. Rendelet a létfontosságú rendszerek és létesítmények azonosításáról, kijelö-léséről és védelméről szóló 2012. évi CLXVI. törvény végrehajtásáról. 08/03/2013.

[4.] Pokorádi László: Rendszerek és folyamatok modellezése. Debrecen: Campus Kiadó, 2008. ISBN 978-963-9822-06-1

[5.] MAVIR Magyar Villamosenergia-ipari Átviteli Rendszerirányító Zártkörűen Működő Részvénytársaság (MAVIR ZRt.), source: http://mavir.hu/documents/10258/20774/policy5_final+version_H.pdf/8fe133d9-cda2-4581-9703-ff69226a41c2 [Online] 27/01/2012. [Download date: 18/10/2014]

[6.] F. Szlivka, I. Molnar: Measured and non-free vortex design results of axial flow fans, Journal of Mechanical Science and Technology 22:(10) pp. 1902-1907, 2008

[7.] Molnár I, Dr Szlivka F: Conclusions of the measurement data of the velocity- and pressure distribution of an axial flow fan, HUNGARIAN AGRICULTURAL ENGINEERING 19: pp. 41-42. (2006)

[8.] Rajnai Zoltán, Fregan Beatrix: Un portrait militaire au reflet de l'insurrection hongroise, ORIENTS 2013: (10) pp. 93-96.

[9.] Gyula Mester, "Sensor Based Control of Autonomous Wheeled Mobile Robots", The Ipsi BgD Transactions on Internet Research, TIR, Volume 6, Number 2, pp. 29-34, ISSN 1820-4503, New York, Frankfurt, Tokio, Belgrade, Source: http://internetjournals.net/journals/tir/2010/July/Paper%2004.pdf , 2010

[10.] Rajnai Zoltán-Bleier Attila: Technical problems in the IP comunication systems of the Hungarian Army, Academic and Applied Research in Military Science (ISSN: 1588-8789) (eISSN: 1788-0017) 9: (1) pp. 15-23. (2010)

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ISSN:2067-3809

ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 1 [JANUARY–MARCH]
ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 2 [APRIL–JUNE]
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ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 4 [OCTOBER–DECEMBER]

fascicule 4
[October - December]
tome VII [2015]
ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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COMPARATIVE STUDY OF WATER LILY (Nymphaeaceae) EXTRACTS ON CORROSION OF LOW AND MEDIUM CARBON STEEL IN A MILD ENVIRONMENT

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Abstract: Fluid extract from the leave of water lily (Nymphaeaceae) was tested as corrosion inhibitor for mild steel in tetraoxosulphate (VI) acid solution. Weight loss and determination of the potential difference (Pd) of the steel samples were measured. The effect of concentration on the inhibitor performance of the extract was studied. The results obtained shown that the leave extract functioned as effective corrosion inhibitor. The fitting of the experimental data to the corrosion rate, potential difference and inhibitor efficiency equations revealed that the organic constituents of the extract were physically adsorbed on the corroding mild steel surface. The findings provide ready friendly application for the problematic fresh water weed water lily.
Keywords: corrosion inhibitors, potential difference, water lily plant, leave extract

INTRODUCTION

The corrosion of metallic materials, especially ferrous alloy (low and medium) carbon steel in water saturated with H_2SO_4 is a complex phenomenon which implies a general attacks as well as localized attacks, pitting corrosion, crevice corrosion stress corrosion cracking and other forms of corrosion. The rate of corrosion depend upon many environmental factors such as; pH and presence of aggressive ions particularly oxides of sulphur and chlorides.

Low and medium carbon steel corrode in most atmospheric environment when the relative humidity exceeds 60%. Once a moisture films has formed on the metal substrate the metal is sets to corrode. It has been found that low and medium carbon steel has higher affinity for corrosion rate in mild environment. Mild steel is extensively used in industries and as a result corrodes when exposed to industrial environments and conditions.

The application of inhibitors has been said to be among the most practicable ways for protection of metals against corrosion, especially in acidic media [1, 2]. The inhibitive reactivity of inhibitors is fundamentally affected by the molecular structure of the inhibiting molecules [3, 4]. Most prominent corrosion inhibitors are organic compound containing nitrogen, sulphur, oxygen, phosphorous in their functional groups [4].

The use of natural products of plant origin as corrosion inhibitors has being widely reported by several authors [5,6]. Such interest derived from their inexpensive and friendly natures, ease availability and wide variety. Also the use of these biomass products were justified by the photochemical compound present therein with molecular and electronic structure bearing close similarity to convectional organic inhibitor.

Water lily (an aquatic herb of genus Nymphaea, family Nymphaeaceae), a precious perennial aquatic flower plant, isdivided into two ecological groups, namely Tropical and Hardywater lily [7]. Water lily is noted as one of the most important and noxious freshwater weed, ranked 8th in the list of the world ten most serious weed. Water lily is a native of tropical America. It is believed that water lily originated from Brazil and found its way into Nigeria coastal areas; water lily is known to be cheap and environmental safe as corrosion inhibitors in acidic environment [8,9].Organic heterogeneous compounds have been reported to be efficient corrosion inhibitors [10,11]. These compounds contain Nitrogen, oxygen, sulphur and aromatic ring in their molecular structure and function via adsorption of the molecules on the metal surface creating a barrier to corrosion attack.

The yields of this compound as well as the corrosion inhibitor ability vary widely depending on the part of the plant and its geographical location. Despite its long list of harmful effect on the water ways and ponds, in recent years it has been found useful in animal feeds, compost, paper energy (from biogas), biological waste water treatment and heavy metal uptake. [12].

In recent time, studies have been carried out to identify more useful application of this abundant noxious weed and certain active compound with antioxidant activates such as carotenoids, phenols, alkaloids, and terpenoids have been successfully obtained from water lily and Crassipes extract [10]. The antioxidant showed corrosion inhibition efficiency on magnesium alloy in saline environmentand it may be due to the presence of a great number to double bonds, amine and hydroxyl groups [10]. However, the water lily extract has not be been studies for corrosion inhibitor ability on low and medium carbon steel. The present study

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investigate the inhibitive effect of leave and root extract of water lily on mild steel and medium carbon steel in H_2SO_4 solution using weight lost and potential difference methods.

MATERIALS AND METHOD

Materials

The materials used in this study are low and medium carbon steel gotten from Pulpit Steel Company Ikorodu, Lagos, Nigeria.The elemental composition of each material in weight percent (wt%) wasobtained by the use of optical emission spectrographic (Model: Maxx LMF04, Part No: 76004134). Water lily plant was collected from Ipoti- Ekiti in Ekiti-State, Nigeria. The results for the elemental composition of the materials used are in Tables 1- 3.

***Table 1**. Elemental composition of medium carbon steel*

Element	C	Si	Mn	F
Wt %	0.382	0.243	0.654	0.0176
Element	S	Cr	Mo	Ni
Wt %	0.0409	0.0105	0.0212	0.0788
Element	Al	Co	Cu	Nb
Wt %	0.0016	0.0112	0.192	<0.0010
Element	Ti	V	W	Pb
Wt %	0.00037	0.0047	<0.0050	<0.0010
Element	Sn	As	Zr	Bi
Wt %	0.0226	0.0091	0.0016	0.0037
Element	Ca	Ce	Sb	Te
Wt %	0.0018	0.0030	<0.0010	0.0016
Element	Se	Ta	B	Zn
Wt %	<0.0020	<0.0070	0.0026	0.0049
Element	La	N	Fe	
Wt %	<0.00030	0.0118	98.17	

***Table 2**. Elemental compositions (wt%) of the procured mild steel pipe.*

Elements / Wt %						
	C	Si	Mn	P	S	
	0.133	0.307	0.82	0.0061	0.0081	
	Cr	Ni	Mo	Al	Sn	
	0.080	0.102	0.038	0.0036	0.0063	
	Cu	Co	Ti	Nb	V	
	0.178	0.0085	0.0003	0.0054	0.0016	
	W	Pb	B	Zr	La	
	<0.0001	<0.0001	0.0007	0.0006	<0.0001	
	Zn	As	Bi	Ca	Ce	Fe
	0.0042	0.0005	0.0010	0.0010	0.0023	98.30

***Table 3**. Mineral analysis of elemental composition of water lily*

Sample Code	Fe (ppm)	Mg (ppm)	Ca (ppm)	Cu (ppm)	K (ppm)
WL	32.80	7.00	61.50	0.09	233.00
Sample Code	Mn (ppm)	Na (ppm)	P (ppm)	Nitrogen %	
WL	0.66	69.90	4215.00	2.60	

EXPERIMENTAL PROCEDURE

Samples Preparation

The low and medium carbon steels were cut into rectangular pieces numbering thirty six, eighteen from each sample, and all with length of 20 mm by 20 mm breath. The surfaces of each sample were polished to remove rust using emery papers of different grit sizes (ranging from P60 up toP2200) in a single-deck polishing machine-DC motor (Motor capacity: ½ HP DC) and the samples were kept inside desiccators to prevent corrosion before immersion. The total surface area and weight of each sample were taken using LCD digital vernier (Range: 0-150 mm, Resolution: 0.01mm/0.0005 in) and analytical weighing balance (ranging from 0.001 mg up to 100 tones) and kept in a desiccators, ready for immersion for corrosion investigation.

Preparation of Inhibitor from Water lily Extract

The leaves of the water lily plant were plucked and placed inside an oven for drying at atemperature of 70°C for 5 hours. The dried leaves were then pulverized to very fine particles using a mechanical grinding machine. The water lily leaves were pulverized (dried and ground to powder) to give room for large surface area for extraction of higher concentration of active ingredients responsible for corrosion inhibition [13]. The 20g, 40g, and 60g each of the pulverized leaves (Nymphaeaceae) were measured and poured into different beaker containing 1000 ml of distilled water. The resultant solution was kept for 24 hours to allow it to soak properly thereafter, filtered and stored. From the stock solution, 20g/L, 40g/L and 60g/L were concentrated to 100ml filtratein water bath (DKZ Series, shaking water bath) at a temperature of 100°C for 5 hours. Finally, from each stock solution 5ml, 10ml. 15ml, 20ml, 25ml, and 30ml of solution were prepared as inhibitors for each sample. Total samples of eighteen were prepared for low and medium carbon steel.

Experimental Method

A sample each from low and medium carbon steel respectively was immersed in a plasticcontainercontaining 0.5M $H_2SO_4$with no inhibitor added to it to serve as the control sample. Another sample from each material was also immersed in a plastic container containing 0.5MH_2SO_4 in a closed environment with no inhibitors added to it, which also served as second control experiment.

The prepared concentration of extract from 20g of the water lily leave extract were poured at avolume of 5 ml, 10 ml, 15 ml, 20 ml, 25 ml and 30ml into plastic containers containing 0.5MH_2SO_4 as the corrosive medium and each of the steel sample was immersed in the mixture of the container. The procedure was carried out for the prepared 20g, 40g and 60g of inhibitor respectively.

Measurement of Electrode Potentials and Corrosion Rates from Weight loss

The electrode potential between the samples and dilute 0.5MH_2SO_4 environment were taken at aninterval of three times daily for 30 days. The electrode potential was measured using DT8300D digital multi-meter with zinc rod as reference electrode. The reference electrode was immersed in the medium when readings were to be taken and removed after each measurement. The electrode potential values were converted into standard calomel electrode using the relation below:

$$Electrode\ potential\ mV\ (SCE) = Ezn - 1030mV [12, 13] \quad (1)$$

where E_{zn} is Electrode potential reading obtained using the zinc rod. SCE is standard calomel electrode. E_{zn}

The weight loss measurements were taken by removing each of the samples from the corrosive medium at intervals of three days (72 hrs) for thirty days, clean and dry beforeweighing using analytical digital weighing balance. The pH values of the solution were also recorded. The weight losses were recorded and the cumulative weight loss was calculated. The corrosion rate was determined using the relation below:

$$R = W/DA(T/365) \quad (2)$$

where:R = corrosion rate (mg/mm^2/year), W= weight loss, A= surface area of specimens (mm^2), D = density of the specimen and T/365 = exposure time in days extrapolated to year.

RESULTS AND DISCUSSIONS

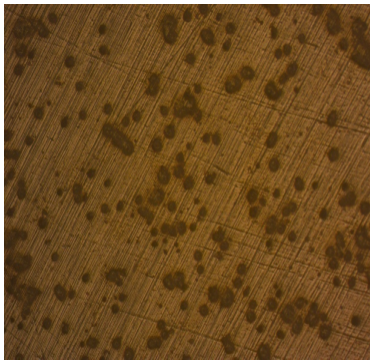

***Figure1a**: micrograph of medium carbon steelafter corrosion*

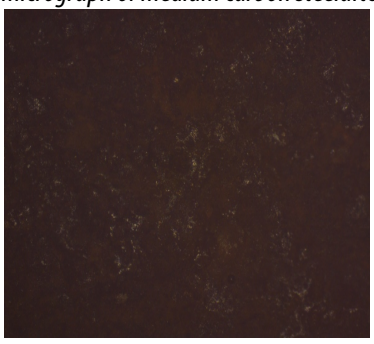

***Figure1b**: micrograph of medium before corrosion*

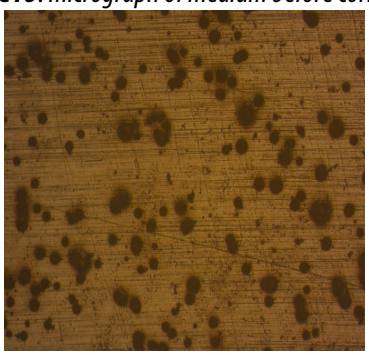

***Figure 1c**: micrograph of low carbon steel after corrosion*

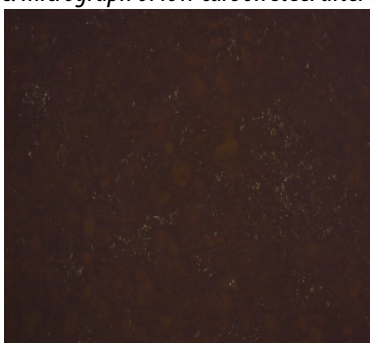

***Figure 1d**: micrograph of low carbon steel before corrosion*

Elemental composition of Inhibitor

Table 4 shows the elemental composition of the inhibitor, which contains metals and non-metals. The main constituents of water lily leaves extract which are also metal constituents are iron, copper, manganese, sodium, potassium, phosphorus, calcium and magnesium which formed high proportion of the total amount at 99.99% and the non-metal is nitrogen which formed very minor proportion of the total amount at 0.0000001%. The inhibitive action of water lilly (Nymphaeaceae) leaves extract towards the corrosion of low and medium carbon steel can be attributed to the neutralization of nitrogen by the metals by a direct chemical reaction of the metals and non-metals to form hygroscopic salt which likely prevents corrosion of the sample in the mild corrosion environment [14].

***Table 4**. Mineral analysis of elemental composition of water lily*

Elements	Fe	Mg	Ca	Cu	K
ppm	32.80	7.00	61.50	0.09	233.00
Elements	Mn	Na	P	N	
ppm	0.66	69.90	4215.00	2.60	

Corrosion rate of low and medium carbon steel exposed to mild environment with various concentration of water lily leave extracts

The corrosion rate of low and medium carbon steel was found to reduce progressively as the amount of the extract increases from 20g to 60g in a mild environment. In Figure 2 to 7, corrosion rate decreases, it was probably due to the formation of the protective film on surface of the corrosive samples as a result of increase in adsorption of the compound of water lily extract on the carbon steel surface [5]. More so, the corrosion rate was also found to decrease as the exposure day increases to 42thdays. In the Figure 2 to 4, the corrosion rate of medium carbon steel in a mild environment without an inhibitor was merged with the corrosion rate of medium carbon steel with different concentration of inhibitor in a mild environment, and this was as a result of ability of the steels to develop protective films as mention above against corrosion despite the fact that the percentage by weight in Table 1 of chromium (0.0105) and nickel (0.0788) of medium carbon steel was low to function as corrosion resistance. Meanwhile in Figure 5 to 7, the corrosion rate of low carbon steel was diverge since the chemical composition of low carbon steel used in Table 2 contains very low value of chromium (0.080) and nickel (0.102) in chemical composition of steel which may catered for corrosion resistance[14]. Generally it can be said that, the main factors in the corrosion experiment in a mild environment and in an open condition with different concentration of water lily leave extract are the protectiveness of corrosion by films produced and decrease the rate of oxygen diffusion. The degree of film protection is largely determine by the pH of the solution directly adjacent to the corroding sample, but this film requires considerable time to develop its full protectiveness, and is not readily destroy when the alkalinity of the solution is within pH 7.1 – 8.7 under the same condition of the experiment above, the steels showed corrosion inhibition by developing protective film [15]. Therefore the corrosion rate of each of the sample in inhibited media was merged in a good proportion as compared to sample

in water lily extract inhibition which shown that the water lily leaves extract can function better as corrosion inhibition.

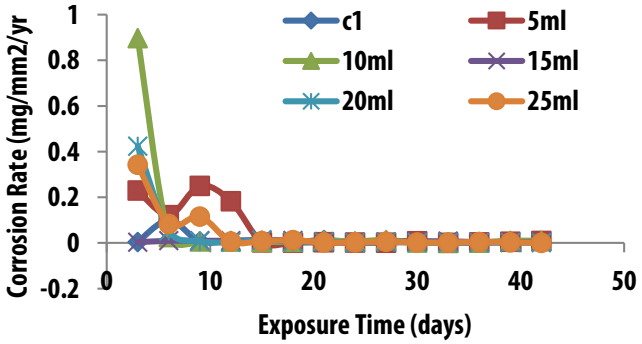

***Figure 2**: Corrosion Rate for 20g inhibitor for Medium Carbon Steel immersed in 0.5M H_2SO_4 at differentconcentrations of inhibitor*

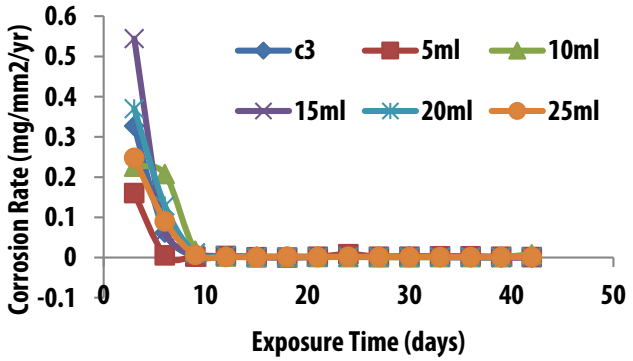

***Figure 3**: Corrosion Rate for 40g inhibitor forMedium Carbon Steel immersed in 0.5M H_2SO_4 at different concentrations of inhibitor*

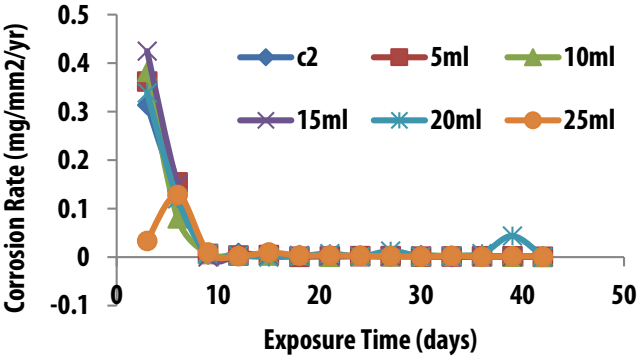

***Figure 4**: corrosion rate of 60g inhibitors forMedium Carbon Steel immersed in 0.5M H_2SO_4 at different concentration*

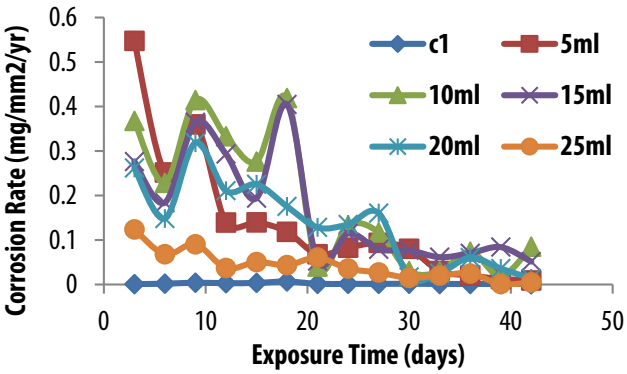

***Figure 5**: Corrosion Rate for 20g inhibitor for Low Carbon Steel immersed in 0.5M H_2SO_4 at different concentrations of inhibitor*

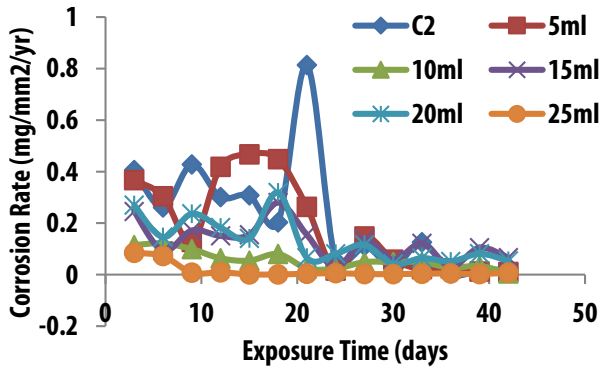

***Figure 6**: Corrosion Rate for 40g inhibitor for Low Carbon Steel immersed in 0.5M H_2SO_4 at different concentrations of inhibitor*

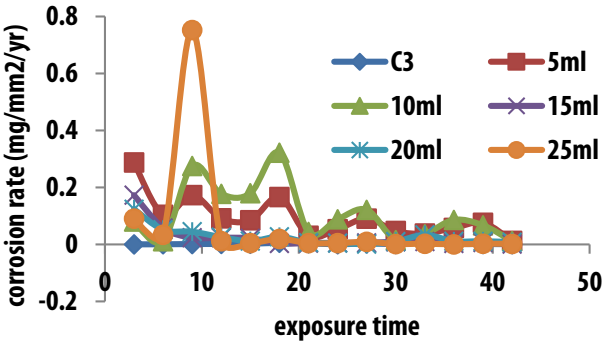

***Figure 7**: Corrosion Rate for 60g inhibitor forLow Carbon Steel immersed in 0.5M H_2SO_4 at different concentrations of inhibitor*

Effect of Inhibitor Concentration on Inhibitor efficiency

The effect of inhibitor concentration on inhibition efficiency of water lily leaves extract on low and medium carbon steel were represented in Figure 8 to 13. For low carbon steel, the extract showed maximum inhibition efficiency of 100% at concentration of 5ml of 20g of water lily per 100ml distilled water at 39th day exposure period in Figure 8 as compared to the inhibition efficiency of extract on medium carbon steel with the maximum inhibition efficiency of 95.0 % at concentration of 10ml of 20g of water lily per 100ml distilled water at 12days exposure period, and further increase in extract to 15ml, 20ml, and 25ml and 60 ml of water lily per 100 ml distilled water does not cause any significant change in the performance of the extract in Figure 11.

In low carbon steel, the extract showed maximum inhibition efficiency of 99.71% at concentration of 25ml of 40g of water lily per 100 ml distilled water at 6th day of exposure period in Figure 8 and compared to the inhibitors efficiency of extract on medium carbon steel with the maximum inhibition efficiency of 95.1% at concentration of 10ml at 18th day of exposure period, further increase or decrease in extract concentration of water lily per 100ml distilled water does not also cause any significant change in performance of the extract Figure 12.

The extract showed maximum inhibition efficiency of 98.85% for low carbon steel at concentration of 20ml of 60g of water lily per 100ml of distilled water at 24th day of exposure period in Figure 10 as also compared to inhibition efficiency of extract on medium carbon steel with the maximum inhibitor of 93.02% at concentration of 10ml at 24th day of exposure period; and further increase in extract concentration from

25ml per 60g of water lily per 100 ml distilled water does not cause any significant change in performance of the extract in Figure 13.
It was therefore observed that inhibition efficiency was consistent with the extract concentration and exposure time in Figure 8 to 13and more so the water lily leaves extract can function better for the corrosion inhibition for low carbon and medium carbon steel, but function more efficiently in low carbon steel[16].

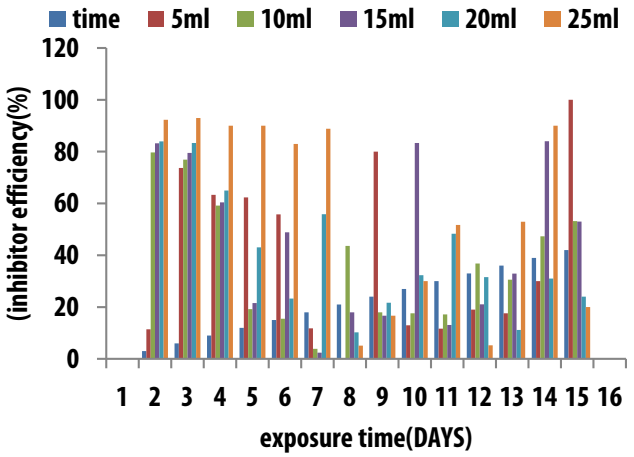

***Figure 8**: The plot of inhibitor efficiency against time for Low Carbon Steel at 20g inhibitor in 0.5M H_2SO_4concentration*

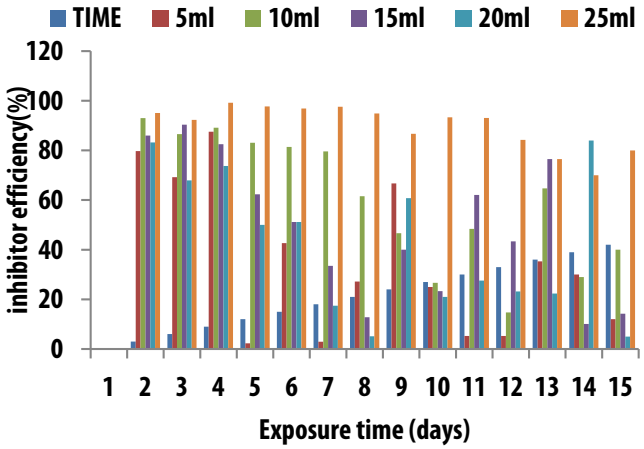

***Figure 9**: The plot of inhibitor efficiency against time for Low Carbon Steel at 40g inhibitor in 0.5M H_2SO_4 concentration*

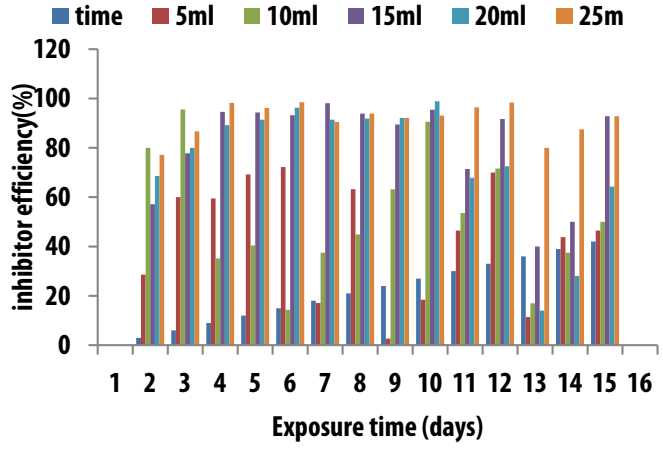

***Figure 10**: The plot of inhibitor efficiency against time Low Carbon Steel for at 60g of inhibitor in 0.5M H_2SO_4concentration.*

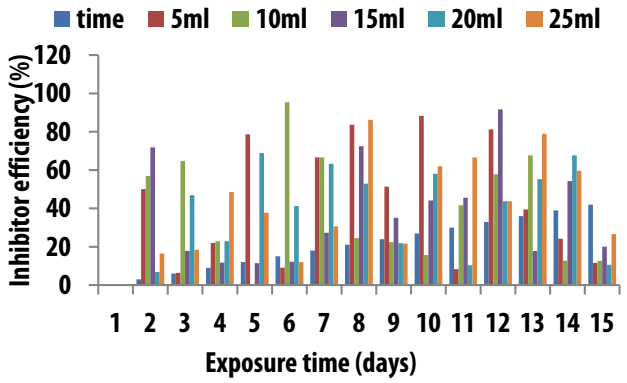

***Figure 11**: The plot of inhibitor efficiency against time for Medium Carbon Steel at 20g inhibitor in 0.5M H_2SO_4 concentration*

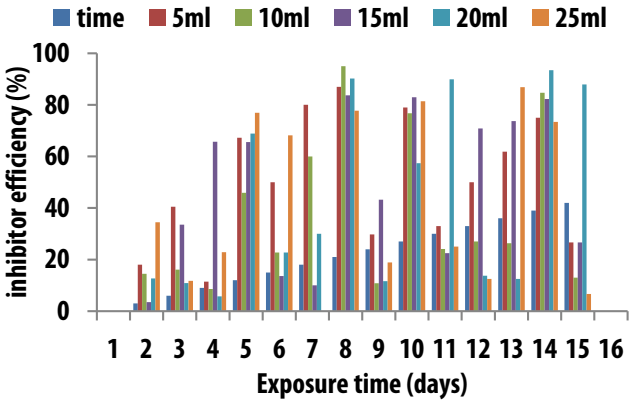

***Figure 12**: The plot of inhibitor efficiency against time forMedium Carbon Steel at 40g of inhibitor in 0.5M H_2SO_4concentration.*

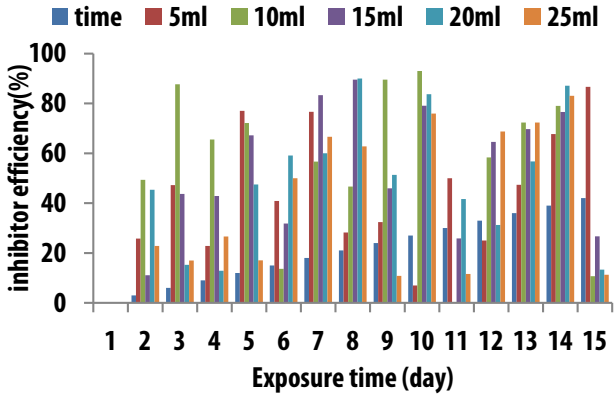

***Figure 13**: The plot of inhibitor efficiency against time for Medium Carbon Steel at 60g of inhibitor in 0.5M H_2SO_4 concentration.*

Potential Difference

The observation made in the variation of electrode potential with exposure time for the low and medium carbon steel in a mild environment with various concentration of inhibitor in Figure 13 to 18 showed different behaviours in corrosion media. In low carbon steel, the corrosion potentials were within -720mV SCE to -523 mV SCE throughout the exposure period and most especially the sample without inhibitor had the corrosion potential within the range of -770 mV SCE to -591 mV SCE which indicate more susceptibility to corrosion as the electrode potential value moved towards positive (-591 mV SCE) and this was as a result of ability of low carbon steel to form protective films to prevent corrosion in Figure 13 to 15. The corrosion potentials in medium carbon

steel range from -876 mV SCE to -232 mV SCE throughout the exposure period and that of low steel was within the range of -776 mV SCE to -350 mV SCE, but in the absence of inhibitor, the potential difference rage from -826mV SCE to -601Mv SCE which indicate less susceptibility to corrosion. But at 20 ml of 60 g water lily per 100 ml distilled water, the extract inhibitor helped in reducing susceptibility to corrosion rate as electrode potential moved toward positive (-523 mV SCE) the same behaviour was observed in medium steel at 5ml of 20g water lily per 100 ml distilled water which also helped reducing susceptibility to corrosion rate as electrode potential move towards positive (-232mV SCE) as shown in Figure 16 to 18 [17].

CONCLUSIONS

This work had gone through series of examination and analysis to investigate the efficiency of water lily leaves extract as inhibitor on low and medium carbon steel, and to compare the inhibitor efficiency on the steels samples in a mild environment respectively, and the following conclusion were drawn:

- *The inhibitive action of water lily leaves extract towards the corrosion of the samples can be attributed to the neutralization of nitrogen by metals by a direct chemical reaction of the samples in a mild environment.*
- *Finally, the inhibition efficiency of water lily leaves extract as compared as an inhibitor for low and medium carbon steel in a mild environment is very effective and function better in low carbon steel than medium carbon.*

Reference

[1.] *Desia P.S and Kaporara S.M.: Inhibiting effect of anisidines on corrosion of aluminium in hydrochloric acid, Indian journal of chemical technology, vol 16, pp 486 – 491, 2009.*

[2.] *Ramananda M, Singh. 2008, "The inhibitory effect of dicthanolamine on corrosion of mild steel in O.S.M sulpuric medium", Portugaliae Electrochemical Acta, vol. 26, pp. 479 -492*

[3.] *Fonda A.S., Elewandy G.Y, and El-Haddad M.N., "Corrosion inhibition of carbon, steel in acidic solution using some azodyes", Canadian journal on specific and industrimistral research, vol 2, no. 1, pp 1-18, 2011.*

[4.] *Sachin H.P., M.H.M. Khan and N.S. Rhujangaiah: Surface modification of mild steel by orthophenylendiamine and its corrosion study, International Journal of Electrochemical Science, vol. 4, no. 1, pp 134 – 143, 2009*

[5.] *Saedah R. Al Mhyawi,: Inhibition of mild steel corrosion using juniperus plants as green inhibitor, African journal of pure and applied chemistry, vol. 8,(1) pp. 9-12, 2014*

[6.] *Uwah I.E, Okafor P.C and Ebiekpe V.E,: Inhibitive action of ethanol extracts from Nauclealatifolia on the corrosion of mild steel in H_2SO_4 solutions and their adsorption characteristics, Arabian journal of chemistry, vol. 6 issue 3, pp. 285-293,2013.*

[7.] *Huang G.Z., Deng H.Q, Li Z.X, Li G.: Water lily. Beijing: China Forestry Publishing House. 3 p, 2009.*

[8.] *Ofoegbu S.U and Ofoegbu P.U.: Corrosion inhibition of mild steel in 0.1M hydrochloric acid media by chloroquinediaphosphate" ARPN journal of Engineering and Applid science. Vol.7, no.3, pp 272-279,2012*

[9.] *Hari S., Kummar and Karthikeyan S.,: Inhibition of mild steel corrosion in hydrochloric acid solution by cloxocillin drug" journal of Material and Enviromental science vol. 3, no. 5, pp 925-934,2004*

[10.] *Ulaeto S.B, Ekpe U.J, Chidiebere M.A and Oguzie E.E,:Corrosion Inhibition of Mild Steel in Hydrochloric Acid by Acid Extracts of EichhorniaCrassipes, International journal of materials and chemistry, vol.2 issue 4, pp 158-164,2012.*

[11.] *Obot I.B, Ebenso E.E, GasemZ.M,:Eco-friendly Corrosion Inhibitors: Adsorption and Inhibitive Action of Ethanol Extracts of ChlomolaenaOdorata L. for the Corrosion of Mild Steel in H_2SO_4 Solutions, International journal of electrochemical science, vol. 7, pp.1997-2008,2012*

[12.] *Oloruntoba, D. T, Abbas, J. A and Olusegun, S.J.:Water hyacinth (eichhorniacrassipes) leaves extract as corrosion inhibitor for AISI 1030 steel in sea water In: Laryea, S., Agyepong, S.A., Leiringer, R. and Hughes, W. (Eds) Procs 4th WestAfrica BuiltEnvironment Research (WABER) Conference,24 - 26 July 2012, Abuja, Nigeria. pp. 1131- 1140,2012*

[13.] *Oladele I. O, Omotoyinbo J.A, Akinwekomi A. D.: The Effect of Weld Geometry and Post-Weld Heat Treatment on the Corrosion Behaviour of Austenitic Stainless Steel Immersed in 1.0 M NaCl Solution, journal of material research, vol. 13,issue 1, pp. 21-24,,2009*

[14.] *Dorbrzanski L. A., SitekW,:Designing of the Chemical Composition of Construction Alloy Steels, journal of Materials Processing Technology, Singapore. Vol. 89 - 90, pp. 467 – 472, 1999.*

[15.] *Fouda A.S and BadrHamdy,: Aqueous extract of propolis as corrosion inhibitor for carbon steel in aqueous solutions, African journal pure and applied chemistry, Vol.7 (10),pp 350-359,2013*

[16.] *Dadgarinezhad A. and Baghaei F : The Inhibition Mild Steel Corrosion in phosphoric acid solutions by 2- phenyl-1-hydrazine carboxamide, journal of the Chilean chemical society, vol.45, No3, pp 208-211,2009.*

[17.] *Mater J: Electrode potential Evaluation of Effect of Inhibitors on the Electro chemical Corrosion behaviour of Mild steel reinforcement in concrete in H2SO4. Environmental Science 3, ISSN: 2028 – 2508. pp. 195 - 205, 2011*

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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CHANGE THEORIES DRIFT CONVENTIONAL TOURISM INTO ECOTOURISM

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Abstract: *The extension of the conventional tourism practices along with fast development in tourism industry (TI) brings considerable benefits to regional economics. there are also negative interferences of some diverge vectors opposing the application of any renovated theories to reach the conventional tourism to Ecotourism i.e. the accessibility of drinking water and the availability of agricultural soil, water consumption, solid waste (SW) disposal and their transfer facility, and tourists transportation. In this regard, this study is the first study put theories with reliable tools for benchmarking the environmental performance (EP) via the assessment of the aforementioned impacts and their Touristic Ecological Footprint (TEF) and the Tourism Ecological Balance (TEB) in a civilized community.*

Keywords: *regional economics, Solid Waste, Ecological Balance*

INTRODUCTION

In some locations, uncontrolled conventional tourism has been accused of failing to integrate its structures with the natural features and indigenous architecture of the destination. Large dominating resorts can look out of place in any natural environment and may clash with the indigenous structural design (Gun, 2008). By the hand, hotels are large consumers of water. A tourist staying in a hotel uses an average 1/3 more water per day than a local inhabitant and the energy consumption per m^2 per year by a one star hotel is 157 kWh (380 kWh in a four star hotel) (EEA, 2003). However, most of the time the infrastructure is not designed to cope with peak periods. Tourism especially nature tourism, is closely linked to biodiversity and attractions and it may generate positive impacts (economic growth, social well-being and environmental preservation) Rabbany, Afrin, Rahman, Islam, and Hoque (2013). On the other hand, it is both vulnerable to climate change impacts and contributes to climate change by its high levels of GHG emissions. In addition, tourism creates great pressure on local resources such as energy, food, land and water that may already be in short supply producing negative impacts i.e. environmental degradation caused by the architectural pollution; issues regarding collection, waste disposal and treatment of sewage; noise and air pollution; and erosion ensuing from sports practice in tourist destinations (Wray et al., 2010). The growing number of tourists visiting sensitive natural areas may also jeopardize nature conservation (McKercher and Robbins, 1998). Some conflicts may also arise between tourism development and other sectors such as agriculture and forestry Sancho, Green, and Pintado (2007). Traditional and conventional tourism industry generally overuses water resources for hotels, swimming pools, golf courses and personal use of water by tourists, and in-house irrigation for gardening (UNEP, 2007). This can result water shortages and degradation of water supplies, as well as generate a greater volume of wastewater. Forests often suffer negative effects of tourism in the form of deforestation caused by fuel wood collection and land clearing (Gasparri and Grau, 2007). This is the case in many valuable coastal areas like in the Mediterranean countries where the forests were cleared for the construction of summer houses and hotels during the last three decades (Palahi, 2007). The island of Mykonos (Greece) is a well known international tourist resort, which has experienced rapid touristic development during the last 30 years. Parallel to the expansion of the TI (accommodation, bars, etc.) the island's population has also increased in size, in contrast to other Greek islands that have lost population over the last decades (EC, 2002). This growth was followed by the expansion of the infrastructure (enlargement of the port, improvement of the road network, construction of a surface dam, etc.). These investments have further boosted the island's capacity to accommodate tourists and other visitors. Problems and some signs of saturation have already appeared: congestion, lack of parking space, higher crime rate, severe water and soil pollution, and loss of flora and fauna especially during the peak summer season. A large proportion of the island's extremely limited land surface has either been absorbed by intensive housing construction. Tourism development and its accompanying infrastructure were left unused for future speculation, causing widespread loss of agricultural land. These traditional malpractices in TI in the island together with other newly developed villages on which the TI was based mainly during the first phase of development have already been transformed in scale, volume of built-up areas, character and environmental quality as a result of uncontrolled and rapid development of tourism (Coccossis and Parpairis, 1996). As a result of the rapid urbanization that alters the socio-economic structure and local culture, tourism now accounts for energy production emissions and more than 60% of air travel. Therefore is responsible for an important share of air emissions such as carbon

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dioxide (CO_2). These emissions are linked to acid rain, global warming and severe local air pollution (Coccossis and Parpairis, 1996).

Therefore, this newborn work aims to adopt certain theories to measure TEF and TEB in order to define biologically productive lands fit tourists activities and capacitate their footprints in their destinations.

LITERATURE REVIEW

Few researches were found working on the development of this industry. Through the available literature reviews, Wackernagel and Rees (1996) and Gössling, Borgström-Hansoon, Horstmeier, and Saggel (2002a) had devised TEF method appraises the environmental impact of tourism and by turn discriminates the bio-productive, built and fossil energy lands but they failed twice: (1) to cover the estimation of the TEF as a result of some environmental aspects i.e. water consumption and SW generation in hotels, and fossil fuels from marine transports, (2) to involve the estimation of the ecological balance, as well as the consequent ecological deficit or surplus.

Besides, in 2012, Gössling et al. recommended implementing water resources category in alike studies in both water shortage and the relatively abundant water resource areas (Gössling et al., 2002b).

METHODOLOGY

In the system of this work, choosing some definitive categories of tourists consumptions regarding expected environmental impacts had facilitated the formulation of the equations involve transportation, quarters of lodging (i.e. hotels, dormitories, and other accommodation facilities), touristic activities, and food and garment consumptions. These equations calculate the ecological footprints, TEF, TEB, and the Bio-capacity of the area.

Measurement System Analysis (MSA)

TEF measurements in built lands: EF (BL. Air Transport)

The measurement is taken in order as follows:

1) Estimate the total number of tourist's leisure throughout the destination in a year;

2) Define the transport infrastructure area (ha) used by tourists (airports, ports, airfields, parking lots, highways, and railways);

3) Take the sum of all areas;

4) Divide the total area by the number of tourists.

TEF measurements for transport expressed as fossil fuel energy: EF (T. FFE. Transport)

Those measurements are divided into two parts A. air transport and B. marine transport

A. *The measurement is attributed to air transport and is taken in order as follows: EF (FFE. Air Transport)*

1) Estimate the total number of passengers per flight;

2) Estimate the distance traveled per flight;

3) Determine the total distance flown in passenger-kilometer (pkm), by multiplying the flown distance (km) by the total number of passengers;

4) Multiply the total distance flown (pkm) by the energy intensity factor (2MJ/pkm) to obtain the energy consumption of the flight;

5) Convert the result found on item "4" into GJ., considering 1 GJ = 1,000 MJ;

6) Divide the Biomass energy consumption of the flight (GJ) by the total passengers to identify the per capita biomass energy consumption (GJ cap^{-1});

7) Divide the per capita biomass energy consumption by 73 GJ ha^{-1} yr^{-1}, where yr means year, to determine the amount of per capita fossil fuel energy required (ha cap^{-1});

8) Estimate again the fossil fuel energy land required per passenger, by multiplying the quotient of item "7" by the elevation correction factor.

B. *The measurement is attributed to marine transport and is taken in order as follows: EF (M. Transport)*

1) Estimate the total number of tourists per ship;

2) Estimate the quantity of liters of fuel required by a ship in one round trip;

3) Identify how many ships (which transport tourists) at the dock island port during one year;

4) Multiply the total liters of fuel consumed by a ship by the number of ships arriving the port in a year; 5) Convert the fuel consumption in liters into giving off tons of CO_2 assuming that 1 liter of diesel emits 0.00315 metric tons of CO_2;

6) Divide the total amount of CO_2 found in previous item by one, since one metric ton of CO_2 is absorbed by one hectare of land;

7) Divide the amount found in the prior item by the total number of passengers who arrive at the port; 8) Estimate again the required fossil fuel energy land per passenger, by multiplying the quotient of the previous item by 1.37, value corresponding to the global productivity of land.

TEF measurements for water consumption: EF (Water)

The measurement is taken in order as follows:

1) Estimate water consumption in (m^3) for one tourist, considering that the consumption average is 120 liters/guest/day and 1 liter equals 0.001 m^3;

2) Calculate the total amount emitted of CO_2, considering that 0.37 metric tons of CO_2 are emitted per each liter of water used during the process of treatment, plumbing and distribution;

3) Estimate the total number of beds occupied in hotel in one year;

4) Multiply tourist's water consumption by the total number of beds in the lodging.

TEF measurements for Solid waste (SW): EF (SW)

1) Estimate the daily amount produced of SW in kg by one tourist;

2) Estimate the average residence period (days) of the tourist in the destination;

3) Find the product of step 1 and step 2;

4) Convert the product in the last step into tons of CO_2 taking into account that 0.00135 tons of SW is equivalent to 0.00045 metric tons of CO_2;

5) Multiply the result found in the 4rd step by "two", since 1 ton of CO_2 and 1 ton CH_4 are generated;

6) Estimate the number of tourists who pay visit the destination in one year;

7) Find the product of the estimated values in the 5th and 6th steps.

TEF measurements for Lodging: EF (T. Lodging)

These measurements are divided into two parts C. Built lands and D. Fossil energy

C. *The measurement is attributed to Built lands and is taken in order as follows: EF (BL. Lodging)*

1) Estimate the required area per bed, taking into account that the requisite amount of built lands per bed is 60 m^2; the required area for a luxury inn is 200 m^2, 100 m^2 for (1 and 2- star hotels), 300 m^2 for (3 and 4-star hotels), 2,000 m^2 for (5-star hotels), 300 m^2 for apartment, 50 m^2 for private houses, 15 m^2 for boats (including the port area);

2) Estimate the total number of beds from the hotel infrastructure list;

3) Multiply the required land area per bed by the total number of beds that the lodging has.

D. *The measurement is attributed to Fossil Fuel energy and is taken in order as follows: EF (FFE. Lodging)*

1) *Estimate the energy consumption for one bed, considering that the average consumption is 50 MJ/bed/night in rural lodgings and 130MJ/bed/nights for lodgings in traditional hotels;*
2) *Estimate the electricity consumption (MWh) employing in the tourist activity in one year;*
3) *Convert the result found in the last stage into GJ, considering that 1MWh is equivalent to 3.6 GJ;*
4) *From hotels infrastructure - Estimate the total number of beds occupied in one year;*
5) *Multiply the electricity consumption for 1 bed by the total number of beds in the lodging.*

TEF measurements for Leisure activities: EF (Leisure Activities)

In 2002, Gossling et al. took into account only the areas in the golf courses (Gössling et al., 2002a), but in this study the measurements cover all the leisure activities.

The measurement is attributed to Built lands and is scheduled in order as follows:

1) The total number of leisure is estimated for a year;

2) Total area (ha) of the leisure place in certain destination is estimated;

3) The total occupied area in last step is divided by the number of tourists in the destination.

TEF measurements for Bio-productive (food and garment) consumption: EF (Bp. Food and Garment)

In order to accomplish the calculation of the food and garment category, Gossling et al.(2002a) took into account that tourists in their destinations buy the same foodstuff and garment available in their home countries. The annual average consumption of each individual is available in the living planet report (WWF). Considerably, in this study the measurements are scheduled downward in a proper and useful way:

1) Identify the nationalities of tourists who visit the destination that will be researched;

2) Identify the annual consumption quantity of each criterion food and garment in their hometowns;

3) Add up all the annual consumption quantities of food and garment;

4) Work out the tourist' annual average consumption;

5) Dividing the value found in item "4" by 365 or 366 (leap year);

6) Multiply the value found in item "5" by the average period stay of a tourist in a year.

RESULTING EQUATIONS

All the measurements in the Methodology are participated in the following equations as follows:

$$EF(T.\ FFE.\ Transport) = EF(FFE.\ Air\ Transport) + EF(M.\ Transport) \quad (1)$$

$$EF(Fossil\ Energy) = EF(T.\ FFE.\ Transport) + EF(FFE.\ Lodging) + EF(Water) + EF(SW) \quad (2)$$

$$EF(Built\ Lands) = EF(BL.\ Air\ Transport) + EF(BL.\ Lodging) + EF(Leisure\ Activities) \quad (3)$$

$$TEF = EF(Fossil\ Energy) * 1.8 + EF(Built\ Lands) * 3.2 + EF(Bp.\ Food\ and\ Garment) \quad (4)$$

After identifying the TEF, the next step concerns the calculation of tourism ecological balance (TEB), as a way to express the ecological deficits or surpluses (Ecological Deficit > Bio-capacity > Ecological Surplus):

$$TEB\ (ha) = TEF\ (ha) - Bio\text{-}capacity\ of\ the\ area\ (ha) \quad (5)$$

where,

$$Bio\text{-}capacity\ of\ the\ area\ (ha) = Actual\ Physical\ Area\ (ha) * Yield\ Factor * Equivalence\ Factor \quad (6)$$

CONCLUSIONS

As a result of the adopted theories-based range in the measurements of TEF (for the following categories: built lands, transport, water consumption, SW, Lodging, Leisure activities, Bio-productive (food and garment) consumption) and TEB, it's expected that will bring future rapid dynamical changes in the culture of TI and also will contribute to the mitigation and if possible the elimination of negative impacts of TI.

References

[1.] *Coccossis, H., and Parpairis, A.: The Challenge of Tourism Carrying Capacity Assessment: Theory and Practice. Aldershot, UK, Ashgate, 1996.*

[2.] *Council of the European Union (EC).: Council Directive 2002/53/EC of 13 June 2002 on the common catalogue of varieties of agricultural plant species. Off J. Eur Comm, 2002; 193: 1-11.*

[3.] *European Environmental Agency (EEA).: Assessment and reporting on soil erosion, EEA (Technical Report No. 94). Copenhagen, European Environmental Agency, 2003.*

[4.] *Gasparri, N.I., and Grau, H.R.: Deforestation and fragmentation of Chaco dry forest in MW Argentina (1972-2007). Forest Ecol Manag, 2009; 258: 913-921.*

[5.] *Gössling, S., Borgström-Hansoon, C., Horstmeier, O., and Saggel, S.: (2002a). Ecological footprint analysis as a tool to assess tourism sustainability. J. Ecol Econ, 2002a; 43(2-3): 199-211.*

[6.] *Gössling, S., Peeters, P., Hall, M.C., Ceron, J.P., Dubois, G., Lehmann, L.V., and Scott, D.: Tourism water use: Supply, demand, and security. An international review. J. Tourism Manage, 2021b; 33: 1-15.*

[7.] *Gun, C. A.: Tourism planning, Washington, DC, Taylor and Francis.*

[8.] *McKercher, B., and Robbins, B.: Business development issues affecting nature-based tourism operators in Australia. J. Sustain Tourism, 1998; 6: 173–188.*

[9.] *Palahi, M.: Mediterranean Forest Fires- An unsolvable problem? European Forest Institute News (No. 2, Vol. 8), Joensuu, Finland: EFI, 2002.*
[10.] *Rabbany, G.Md., Afrin, S., Rahman, A., Islam, F., and Hoque, F.: Environmental effects of tourism. American journal of environmental, energy and power research, 2013; 1: 117-130.*
[11.] *Sancho, L.G.T., Green, G.A., and Pintado, A.: Slowest to fastest: extreme range in lichen growth rates supports their use as an indicator of climate change in Antarctica. Flora, 2007; 202: 667-673.*
[12.] *United Nations Environmental Programme (UNEP): Awards for improving the coastal environment: The blue flag example (Joint project with World Tourism Organization and Foundation for Environmental Education in Europe), Madrid, Spain, UNEP, 1996.*
[13.] *Wackernagel, M., and Rees W. E.: Our Ecological Footprint: Reducing Human Impact on the Earth. CT, New Society, 1996.*
[14.] *Wray, M., Dredge, D., Cox, C., Buultjens, J., Hollick, M., Lee, D., Pearlman, M., and Lacroix, C.: Sustainable regional tourism destinations: Best practice for management, development and marketing. Technical Report, Gold Coast, Australia, Sustainable Tourism Cooperative Research Centre (STCRC), 2010.*

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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PLASTIC DEFORMATION AND YIELD CRITERIA IN FORMING– AN OVERVIEW

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Abstract: *Forming is an important component in modern industry. As plastic deformities are important to processes, the present paper presents v arious issues of plastic deformities. Under forming, classification of processes, properties of the materials used in the process and the criteria of yield are described. For convenience, the forming processes are classified based on other parameters of the processes, namely, stress, raw material, temperature and induction of force. In addition, yield theories namely, van Mises-Henckyor Distortion energy criterion and maximum shear stress or Tressa criterion are delineated.*
Keywords: *Forming, Plastic deformation, Yield criterion, Metallurgy*

INTRODUCTION

Forming plays a very important role in modern manufacturing industry, and itself is a major industry. It is generally a huge producer of semi-finished and finished goods and this is the reason that it is feasible to undertake large scale research and developmental projects [3].

In forming process, the product shapes are produced by plastic deformation, so it is important to know the plastic flow properties of the material for optimization of the output [2]. These depend upon the intensity and the conditions of plastic deformation during forming process. Many forming processes produce raw materials for other process which in turn produce semi-finished /finished products. Considering billets produced by steel plants are re-rolled in mills to give products like angles, channels, bars, etc. Bars may be used for manufacturing forging, wires and machined products. Similarly, wires are used further for the manufacturing of rivets, bolts and screws by the manufacturers and process them further. Plastic deformation of a material under forming process must specify the yield criteria for the analysis of stress and strain of a material loaded beyond the elastic limits and the specify the working loads up to which the material processed can withstand [4]. To describe the forming of material, it is important to know the structure of the material which may be modified by alloying elements, by heat treatment or plastic deformation.

FORMING

Forming processes are manufacturing processes which uses stresses to cause plastic deformation of material to produce required shapes without deterioration of their properties. In order to attain plastic deformation in a metal, a force must exceed the yield strength of a material [5,7].

During forming no material is removed, i.e., they are deformed and displaced. Some of the examples are sheet metal forming, extrusion, forging, rolling, thread rolling, explosive forming, electromagnetic forming, etc. It includes many manufacturing processes. Forming process can classified as followed.

Classification of forming processes

Classification of forming process is mainly based on :

(i) state of stress,

(ii) type of raw material,

(iii) forming temperature and (iv)methods of induction of forces into the work piece.

According to state of stress, it is subdivided into:

(i) Direct compression type processes, here in compression force is applied in the normal direction of the metal flow. Some of the examples are forging, rolling, etc.

(ii) Tension type processes, here applied force is tensile in nature, and deformation takes place along the axis. Example stretching, bulge forming, expanding etc.

(iii) Indirect compression type processes, the metal flow is under the combined stress state. The primary force is tensile, with indirect compression force developed due to the reaction of work piece. Examples are extrusion, wire drawing, tube drawing, etc.

(iv) Shearing processes, the applied force involves shearing forces along the surface of the metal with sufficient magnitude to rupture the metal in the plane shear i.e., shear displacement, twisting etc.

(v) Bending processes, here bending moments are induced in the sheet due to the applied forces. Examples are bending with linear/rotary tool motion. These processes, which are classified based on the state of stress, are illustrated in Figure 1.

According to the type of raw material, it is divided into two types. They are:

(i) Sheet forming, the parts produced have a 3D form with approximately constant wall thickness, and

(ii) Bulk forming, the parts produced are 3D form but has very different wall thickness or cross-section [5].

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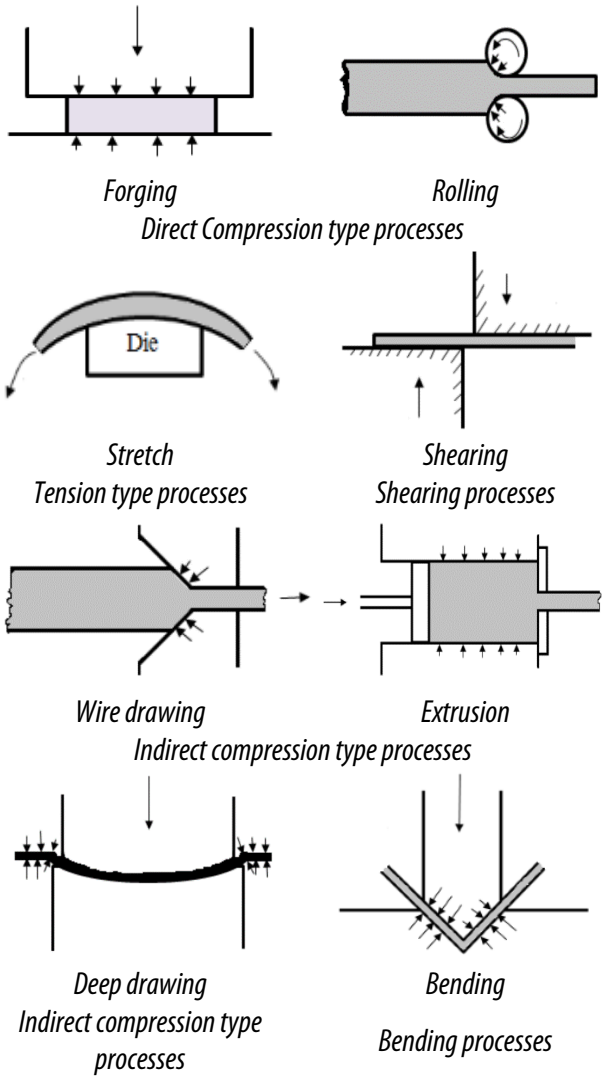

***Figure 1**: Different processes of forming based on the state of stress*

According to the forming temperature, it is subcategorized as:

(i) Hot forming, occurs at temperatures of 60% or above of the melting temperature of the metal on an absolute scale. At high temperatures, the metal decreases in its strength, hence small forces needed for deformation. Recrystallization occurs readily, causing new grains to form continuously during deformation. This continuous formation of new grains causes the ductility of the metal to remain high, allowing large amounts of deformation to be imparted without fracture. Control of final dimensions is more difficult in a hot-worked metal.

(ii) Cold forming occurs at temperatures about 30% or less of its melting temperature on an absolute temperature scale. During cold work, the metal experiences an increased number of dislocations and entanglement of these dislocations, causing strain hardening. With strain hardening, the strength of the metal increases with deformation. To recrystallize the metal, a thermal treatment, called anneal, is needed. During annealing, the strength of the metal can be reduced with a significant increase in ductility. The increase in ductility allows further deformation to occur before fracture. The final surface finish and dimensional tolerances can be well controlled in this process.

(iii) Warm forming, occurs between hot working and cold working. It occurs in the approximate temperature range of 30-60% of the melting temperature of the metal on an absolute scale. The forces required to deform metal in the warm working regime are higher than during hot working. The final finish and dimensional tolerances are better than hot working but not nearly as good as a cold working process. Although warm work seems to have drawbacks, the primary driver for warm working is economic. If the working temperature is lowered, there can be major cost savings in the process.

According to induction of forces into the work piece, the process is categorized as:

(i) Indirect force application, the force applied to metal is indirect. Some medium is acting between the force and the material. i.e., deep drawing, and

(ii) Direct force application, force is directly applied to the metal as in the case of upsetting (Figure 2).

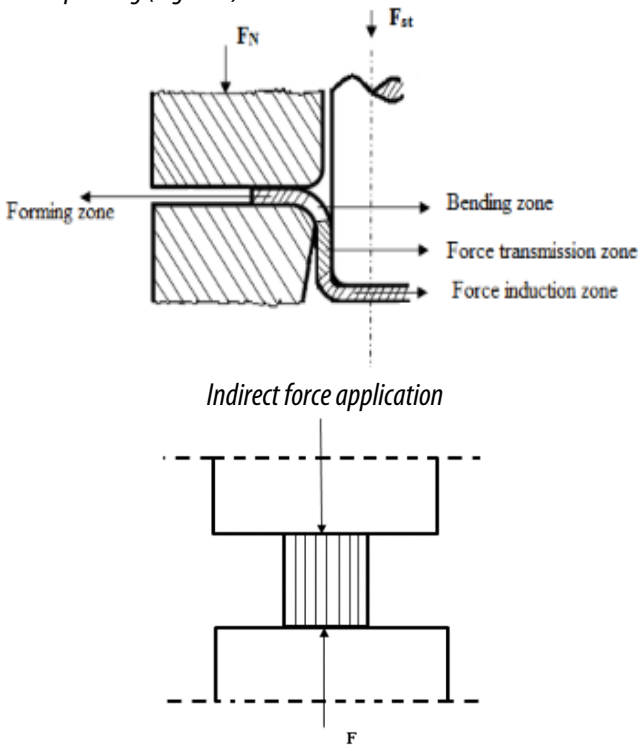

***Figure 2**: Indirect and direct force application in forming*

Properties of the material during forming processes

During forming processes properties of the materials are considered for optimal working of the product to the required standards. In deep drawing of sheet metal, one of the requirements is that the material should be ductile. But other properties should also be considered. For example, lead is quite ductile at room temperature but lead sheet is not that suitable for drawing into cups in the way steel cups are drawn.

When a force is subjected on a material, it may results in deformation or translation/rotation of that material. The ability of material to withstand the subjected force without having any deformation is expressed in two ways, strength and hardness. We can say permanent deformation which is also known as plastic deformation, occurs where deformation cannot be recovered even if applied forces are removed. In temporary deformation also known as elastic deformation, where deformation recovers after applied forces are removed. When force is applied on the

material it undergoes elastic deformation and then followed by plastic deformation. Degree of elastic and plastic deformations will mainly depends on the temperatures surrounded, load application, kind of material, and many other conditions. Changes occur from elastic deformation state to plastic deformation state is given by the yield strength (σ_0) of the material.

Deformation can be defined as percentage change in length by unit length in three different directions. Engineering stress(s) which is defined as force per area on where force is subjected on the material. Engineering strain(e) is defined as change in length by original length. An average change in length at a particular direction is defined by engineering strain. According to definitions, 's' and 'e' are as follows:

Engineering stress $(s) = P/A_0$; Engineering strain $(e) = \frac{L-L_0}{L_0}$, where P is the load applied over area A_0, L, the final length, L_0 original length. Because material dimensions changes continuously under application of the load, these values are may not be the true indication of material deformation characteristics but specifies approximate values. Thus, Ludwik first proposed the concept of, true strain or natural strain (ε) is given by sum of all incremental strains as follows: $\varepsilon = \sum[(L_1 - L_0)/L_0 + (L_2 - L_1)/L_1 + (L_3 - L_2 + \dots]$, assume material volume to be constant that is $A_0 L_0 = AL$, therefore, $\varepsilon = \int_{L_0}^{L} \frac{dL}{L} = ln\frac{L}{L_0}$. The expression for true strain may also be written as, $ln\frac{L}{L_0} = ln(1 + \frac{dL}{L_0}) = ln(1 + e)$, where e = engineering strain [6].

True stress(σ) is defined as load per cross-sectional area on which force is acting at a particular time.

$$\sigma = \frac{P}{A} = \frac{P}{A_0}\frac{A_0}{A} = s(e + 1)$$

Up to the elastic limit of the material, engineering stress/strain is equal to true stress/strain of the material and two values differ from each other after thebeginning of plastic deformation. The engineering and true stress-strain equations above are valid only up to the uniform deformation limit, at which necking starts under tension test because the relationships are generated by assuming constant volume and homogeneous distribution of strain of the specimen along the length which is in applied tension direction. Deformation can be determined by stress-strain relationships and the relations usually obtained from different experimental tests. The tests include tension test, compression test, torsion test, plain strain compression test, etc.

The tension test is commonly used, in which specimen is subjected to a continuously increasing uni-axial tensile load and measures the stress and strain simultaneously. A typical plot of stress-strain curve is shown as Figure 3.

As shown above, initial stages stress is proportional to strain up to elastic limit, after that it increases to maximum uniform deformation, and then decreases by necking i.e., non-uniform plastic deformation until fracture of the specimen happens. In the curve along the line segment ab, as defined by Hooke's law engineering stress is directly proportional to engineering strain, so point b is defined as proportionality limit. Young modulus of elasticity of the material is given by the slope of the line ab. Further increment in stress to point c, material can still be in elastic nature, so it is known as elastic limit. We can't define a point exactly where material plastically deformation starts. Otherwise point c may also call as yield point. Therefore yield strength (σ_0) can be assumed to be the stress value at 0.2% offset of strain, at point-e. Thereafter from the point e (yield point) the stress increments along strain and reaches the maximum value at point f, known as tensile strength (σ_f) up to here uniform plastic deformation takes place in the direction of length of the specimen and then after the point of stress reduces with non-uniform plastic deformation up to fracture of the specimen at point g, known as facture limit, due to the starting of necking. The parameters like tensile strength and yield strength describes the material's strength and indication of the ductility of the material which defines as the maximum deformation of the material can be withstand by the material when subjected to the applied force before fracture occurs is obtained by reduction in cross sectional area and percentage elongation in length.

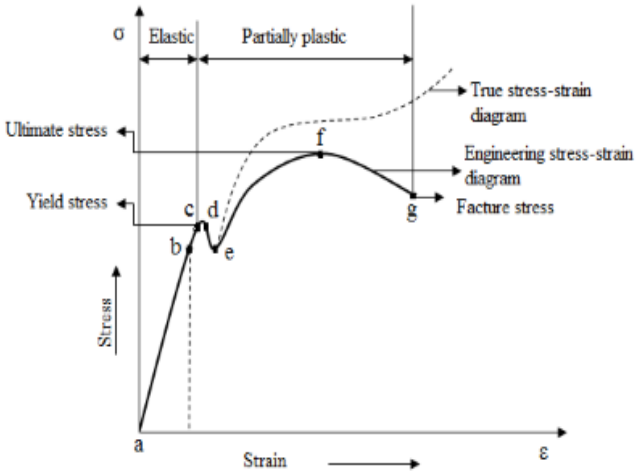

Figure 3: Genaral stress–strain curve

To understand the effect of strain hardening let us again consider the tension test curve as shown in Figure 4. In this figure the test piece is loaded beyond the yield point up to a point D. The test piece is then unloaded. The elastic deformation recovers via the unloading curve DP which is more or less parallel to AB. It is generally taken that there is no change in Young's modulus during plastic deformation. The line DP depicts elastic recovery. Out of the total strain AP corresponding to the point D, the part PR is the elastic recovery. The part AP which is not recovered is the plastic strain suffered by the test specimen. Now if we reload the same test piece, it nearly follows the line PD. There is, however, some deviation due to hysteresis which is very small, and the yielding now occurs at the point D. Further loading of the test piece beyond D gives the same stress-strain curve as we would have obtained if there were no unloading. This shows that after suffering a plastic strain represented by AP, the yield strength of metal has increased from point C to point D (or σ_{01} to σ_{02}). This is known strain hardening or work hardening. $\sigma = K\varepsilon^n$, where σ is true stress, ε is true strain, K is constant, n is work hardening exponent is valid from the beginning of plastic to the maximum load at which the specimen begins to neck down.

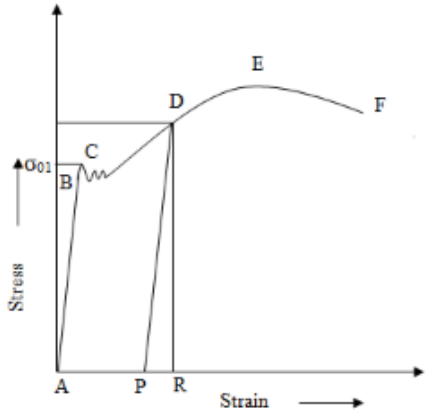

***Figure 4**: Strain hardening*

During forming process, it is significant to know the force which will be needed to execute the necessary deformation. The flow stress is used to analyze what is happening at any point in forming process. In order to determine the maximum flow stress, the force needed for the maximum strain of the material must have been calculated. For different forming processes, the flow stress analysis may vary. The maximum flow stress value will be very important in forging like processes, whereas processes like extrusion, the mean flow stress value is determined in which the metal is deformed continuously. Another factor that increases load on forming equipment is the rate at which the forming process is carried out, known as strain rate [9]. At higher rates of strain the flow stress of material increases leading to higher loads on the equipment. The effect of strain rate on yield strength for an alloy is illustrated (Figure 5).

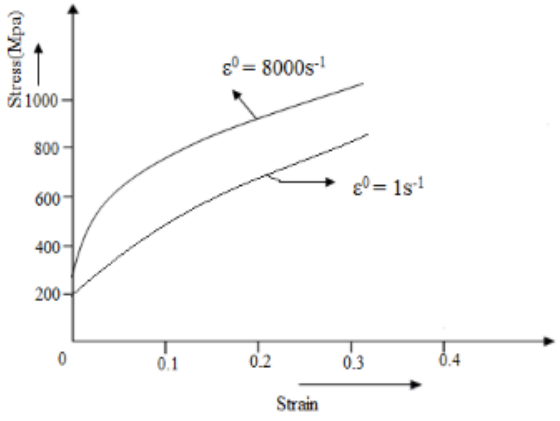

***Figure 5**: Effect of strain rate on yield strength*

If a forming process is carried out at a temperature less than the re-crystallization temperature and at a slow rate, such a case may be taken as an isothermal process, i.e. the effect of temperature change during the process may be neglected and we may consider only the effect of strain hardening. When a forming process is carried out in hot state the re-crystallization is also present along with strain hardening and strain rate effect. The strain hardening may be nullified by recrystallization. Therefore, in hot working we may only consider the effect of temperature and strain rate on the yield strength of metal. The effect of strain rate may be written as given as $\sigma_f = \sigma_0(\dot{\varepsilon})^m$, *where* σ_f *is the flow stress,* $\dot{\varepsilon}$ *is the plastic strain rate, m is strain rate sensitivityand* σ_0 *are material parameter [9].*

At hot working temperatures, flow stress also depends on strain rate (Figure 6). As strain rate increases, resistance to deformation increases, this effect is known as strain-rate sensitivity. At low strain rates the flow stress increases with increase in strain rate. At higher strain rates it still increases but at a slower rate because of the softening effect due to temperature rise in the material [9].

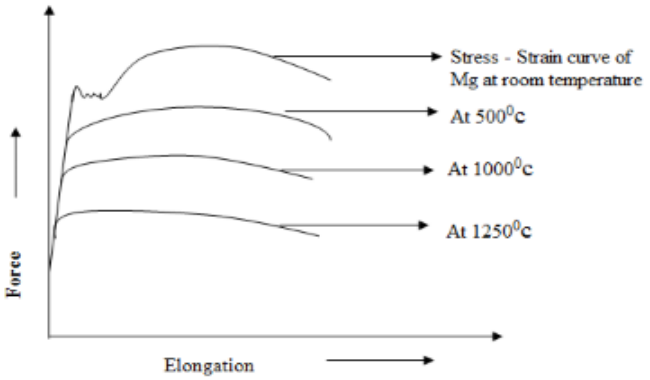

***Figure 6**: Effect of temperature on the yield strength*

Stout and Follanshee [8] have determined the following expression for strain rate sensitivity in stainless steel 304L at strain rates of the order of $10^3 S^{-1}$ *and above. So,* $\sigma_f = \sigma_b + \beta_{\dot{\varepsilon}}$, *where* $\sigma_b = 668\ MPa\ and\ \beta = 0.0066 \pm 0.0025\ MP_{a-s}$.

***Recovery and Re-crystallization,** is very important in forming process, because the grain structure in material may undergo different stages during process. The flow of deformation of grain structure is shown in Figure 7.*

The material gets strain hardened, i.e. its yield strength, UTM and hardness increase while ductility decreases. The strain hardening occurs because the dislocation density increases due to cold deformation. With increase in temperature the movement of dislocations gets easier and they readjust due to stresses locked in the lattice. Some dislocations having opposite sign may annihilate each other. This is called recovery process in which the residual stresses are reduced, however, the enhanced properties due to cold working are only little affected.

*Now if the compressed metal piece is heated to certain higher temperature (0.4 to 0.6*T_{melt}*), new grains will start emerging at the boundaries of old grains and at sites of other defects. If this temperature is maintained for some time the new grains will grow to cover the entire structure. This is called primary re-crystallization. Re-crystallization removes the strain hardening effect and hence reduces strength but increases ductility. However, the process does not stop there. Some grains start growing at the expense of other grains till the complete structure is covered by bigger grains. This is called secondary re-crystallization and grain growth. The mechanical properties like yield strength depend upon the grain size. The relationship between grain size and flow stress is given by the Hall-Petch formula,* $\sigma_f = \sigma_0 + \lambda d^{-\frac{1}{2}}$, *where* σ_f *is the flow stress of material, d is the average grain size and* σ_0 *and* λ *are material parameters.*

The parameters σ_0 *and* λ *are not absolute constants but are functions of strain, strain rate and temperature. During hot working the processes of*

strain hardening and subsequent stress relieving/recovery and re-crystallization may occur depending upon the temperature and strain. Bonnavand, Bramley and Mynores [1] have employed the following formulation for the effect of these for yield strength, which includes the effect of strain, strain rate, temperature, grain size and re-crystallization for calculations related to backward extrusion process $\sigma = \frac{2}{\sqrt{3(1-m)}} K\varepsilon^n(\dot{\varepsilon})^m exp(-\beta T)$, *where K is material constant in stress units,* ε = *equivalent strain, n = strain hardening exponent, m = strain-rate-effect exponent, T = temperature (Kelvin) and* β = *material parameter.*

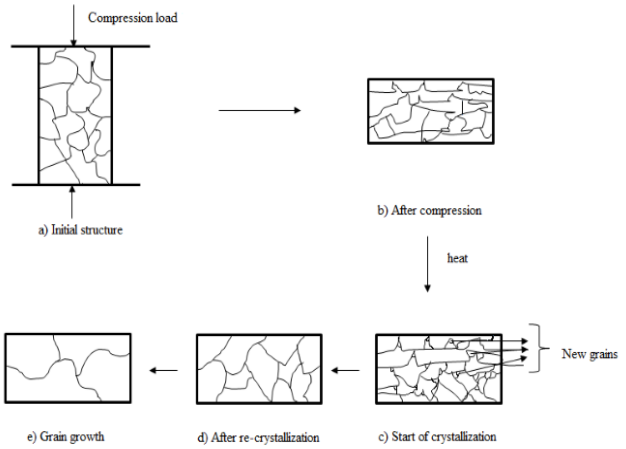

Figure 7*: Recovery and recrystallization in forming process; A-Initial structure, B-After compression, C-Start of crystallization, D-After recrystallization, E-Grain growth*

YIELD CRITERIA

Yield criteria are also called theories of yielding. A number of yield criteria have been developed for ductile and brittle materials. Yield criteria is the relationship between the stress state and the strength of the material, when the criteria met, then plastic deformation occurs. In uni-axial tensile tests, yield occurs that is at yield stress (σ_0*) where macroscopic plastic flow starts [2]. There are two accepted theories which are used in anticipating the yielding distribution in ductile material are:*

(i) von Mises-Hencky or Distortion-energy criterion, and

(ii) Maximum-shear-stress or Tresca criterion.

von Mises-HenckyorDistortion-energy criterion:

It states that when the second invariant of stress deviator J_2 *over comes the critical value then yield occurs. It is calculated as*

$$J_2 = k^2,$$

where $J_2 = \frac{1}{6}[(\sigma_1-\sigma_2)^2 + (\sigma_2-\sigma_3)^2 + (\sigma_3-\sigma_1)^2]$; *σ1, σ2 and σ3 are principal stresses. Criterion is independent of hydrostatic stress due to the presence of differences of normal stresses. Distortion energy is defined as total strain energy divided by unit volume, which changes its shape to obstruct the change in volume.*

To determinek, let's consider the yield in unidirectional tension test$(\sigma_1 = \sigma_0, \sigma_2 = \sigma_3 = 0)$. *Thus ,*$\frac{1}{6}(\sigma_0-\sigma_0)^2 = k^2;\ \sigma_0 = \sqrt{3}k = \frac{1}{\sqrt{2}}[(\sigma_1-\sigma_2)^2 + (\sigma_2-\sigma_3)^2 + (\sigma_3-\sigma_1)^2]^{\frac{1}{2}}$.

To identify the constant k, by defining the stress state in pure shear$[\sigma_1 = -\sigma_3 = T, \sigma_2 = 0.\quad \frac{1}{6}(\sigma_1^2 + \sigma_1^2 + 4\sigma_1^2) = k^2;\ \sigma_1 = k$, *where, k is the yield stress under pure shear condition, whereas* σ_0 *represents the yield stress under unidirectional tension. These two stresses can be related as* $k = \frac{1}{\sqrt{3}}\sigma_0 = 0.577\sigma_0$.

For design purposes it is convenient to include a chosen ***safety factor N*** *in the calculations so that the stress state will be safely inside the failure-stress ellipse.* $N = \frac{S_y}{\sigma'}$, *where* σ' *is effective stress,* S_y *is tensile yield strength*

Maximum-shear-stress or Tresca criterion:

It was first proposed by coulomb and later described by Tresca. It states that yielding occurs when the maximum shear stress in a system exceeds the shear stress in a tensile test. The principal stresses σ_1, σ_2 *and* σ_3 *are arranged in a descending order. Maximum shear stress,* $T_{max} = \frac{\sigma_1-\sigma_3}{2}$.

This criterion may be easy than the von Mises-Hencky criterion, however it is necessary to know the minimum and maximum principal stresses from the system before. Under uni-axial tension test $(\sigma_1 = \sigma_0, \sigma_2 = \sigma_3 = 0)$, $T_{max} = \frac{\sigma_1-\sigma_3}{2} = {}^{\sigma_0}/_{2}$, *therefore* $\sigma_1 - \sigma_3 = \sigma_0$. *Under pure shear stress conditions* $\sigma_1 = -\sigma_3 = \sigma_0 = 0, k = \frac{\sigma_1-\sigma_3}{2} = \frac{1}{2}\sigma_0$. *The safety factor for the maximum shear-stress theory is given by* $N = \frac{S_{ys}}{\tau_{max}} = \frac{S_y}{(\sigma_1-\sigma_3)}$, *where* S_{ys} *is the shear yield strength (Figure 8).*

The yield locus of the maximum shear stress criterion falls inside of the distortion-energy yield ellipse. The two yielding criteria anticipate the same yield stress for uni-axial stress conditions. The greatest deviation between the two yield theories occurs for pure shear stress $(\sigma_1 = -\sigma_3)$ *where yield stress from distortion-energy criterion* $(\frac{1}{\sqrt{3}}\sigma_0)$ *is 15.5% greater than the yield stress from maximum shear stress criterion* $(\frac{1}{2}\sigma_0)$.

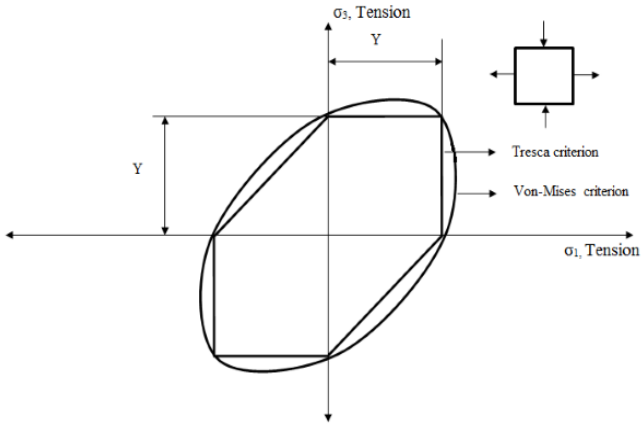

Figure 8*: Yield loci for the two yield criteria in plane stress*

Once the necking started, non-uniform plastic deformation is initiated in the material, then unidirectional state of stress turns into multi-directional/tri-axial sate of stress. A mild notch effect is present in the necked region. Because of the tri-axial state of stress, the uni-axial yield

stress(σ_0) is less than the tri-axial yield stress, because of the presence of tri-axial stresses it is more difficult to spread the yield zone. Therefore, at the neck average true stress is greater than the state of stress which would cause flow in tension be more. Under tri-axial stress state, the true stress state from calculated stress in axial direction can be measured by mathematical analysis by Bridgman. Following assumptions are considered during his analysis, they are: (a) Necked region cross-section remains circular; (b) Necking cross-section is approximated by arc of the circle; (c) Distortion-energy yield theory is applicable; (d) Over the cross-section area, strains are constant.

For the flow curve, from the point E that is the onset of necking Bridgman's correction is applicable. Corrected yield stress in tri-axial stress state is $\sigma = \frac{(\sigma_x)_{avg}}{\left(1+\frac{2R}{a}\right)[ln(1+\frac{a}{2R})]}$, *where,* σ_x *– average measured stress in the axial direction, a - smallest radius in the neck region, R – radius of the curvature of neck(Figure 9).*

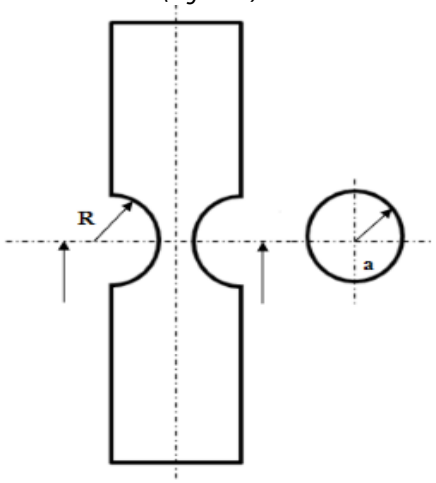

***Figure 9**: Necked region in the specimen*

CONCLUSION

Thus the forming is an important component in modern industry, as it uses stresses to cause plastic deformation of material without deteriorating their properties. And the present paper presents various issues of forming and plastic deformities. The properties of materials are to be considered as important issue for the production at the required standards. A theory of yielding is also important issue to be understood in the industry, as it is related to the stress state and strength of the material.

References

[1] *Bonnavand, F., Bramley, A.N., Mynors, D.J., A fast new numerical tool for designing pre-stressed dies for backward extrusion, part 2-numerical analysis. Proceedings of Institute of Mechanical Engineers, 215 (B), 181-193 (2001).*

[2] *Bridgeman, P.W., Studies in large plastic flow and fracture with special emphasis on the effects of hydrostatic pressure. New York, McGraw-Hill (1952).*

[3] *Callister, W.D. Jr., Materials science and engineering, Seventh Edition. New York, John Wiley & Sons, Inc. (2004).*

[4] *Dieter, G.E., Mechanical metallurgy, Third edition. New York, McGraw-Hill (1986).*

[5] *Jones, D.R.H. and Ashby, M.F., Engineering materials 1, Second Edition. Woburn, UK, Butterworth-Heinemann (1996).*

[6] *Ludwik, P. Element der Technologischen Mechanic. Berlin, Springer Verlagoltlt (1909).*

[7] *Rowe, G.W., Principles of industrial metal forming processes; London, Edward Arnold (1977).*

[8] *Stout, M.G. and Follanshee, P.S., Strain sensitivity and yield behavior of 304L stainless steel. Transactions of ASME, 108, 344 (1986).*

[9] *Wulf, G.L., The high strain rate compression of 1023 and 4130 steels. International Journal of Mechanical Sciences, 20 (12), 843-848 (1978).*

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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COMBINED PRE-TREATMENT FOR SACCHARIFICATION

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Abstract: *Tobacco plants (Nicotiana rustica, Nicotiana tabacum) produce abundant biomass in more than 100 countries and could be used to produce abundant biofuels since about one quarter of the tobacco plant is cellulosic material [1]. This biomass appears attractive for conversion to ethanol because it contains very low amounts of the hard-to-convert woody material lignin [1]. Microwave (MW) irradiation has a good potential to increase the ability of organic matter for biological degradation so we connected the enzymatic hydrolysis of the cellulose type material of the tobacco plant and the microwave pretreatment. Our results show that microwave pre-treatments was suitable to enhance the biodegradability of tobacco plant and this way the MW pre-treatment was suitable for enhancing the sugar yield. The saccharification time was shortened by the alkali pre-treatment so the combination of alkali pH and MW could be the better solution. The objective of our work was to investigate how to affect the MW pre-treatment on the enzymatic hydrolysis.*
Keywords: *microwave; saccharification; tobacco; bio-fuel, by-product*

INTRODUCTION

Tobacco plants (Nicotiana rustica, Nicotiana tabacum) is an ideal crop for bio-based products it is a perennial herbaceous plant. It is found only in cultivation where it is the most commonly grown of all plants in the Nicotiana genus and its leaves are commercially grown in many countries to be processed into tobacco. It grows to heights between 1 to 2 meters [1]. Tobacco is sensitive to temperature, air, ground humidity and type of land. Temperatures of 20-30 °C are best for adequate growth, an atmospheric humidity of 80 to 85% and soil without a high level of nitrogen are also optimal [1]. Tobacco has potent oil biosynthesis machinery, which produces up to 40% oil per seed dry weight [2]. Recently, tobacco seed oil has been successfully tested for its potential as a fuel for diesel engines [3]. Tobacco leaves contain 1.7%–4% oil per dry weight [4], which is extractable as fatty acid esters, the major component of biofuel oil [5]. Cultivation of tobacco for biomass is very different from conventional tobacco. While conventional tobacco production is labor-intensive, biomass tobacco is largely mechanized. Thus, production costs are substantially reduced. The plants are grown much more closely together and for biomass tobacco it is possible to obtain multiple harvests in a single season from a single crop of tobacco, the plants will re-grow following a harvest [5]. Tobacco produces more biomass than virtually any other agricultural crop. Tobacco naturally produces large volumes of starches and sugars [6].

Lignocellulose-containing waste is very common for example in tobacco industry. The main problem with the lignocellulose is the necessity of hydrolysis before fermentation since it cannot be transformed directly into bioethanol. First it should be transformed (with hydrolysis) into glucose and after the glucose should be fermented into ethanol [7]. It is also possible to do these two processes in the same time: it is called Simultaneous Saccharification and Fermentation (SSF) [8]. Different ways had been tested to make the cellulose more accessible for fermentation. Pre-treatment greatly affect the efficiency of saccharification and the ethanol production cost as well. Over the years, a number of different methods such as steam explosion [9], thermal methods [10], acid and alkaline hydrolysis pre-treatment has been developed to enhance the cellulose degradation, remove hemicellulose and lignin and alter the structure of them. Microwave heating is based on the ability of a particular substance such as a solvent or substrate to absorb microwave energy and effectively convert the electromagnetic energy to heat. Molecules with a dipole moment attempt to align themselves with the oscillating electric field of the microwave irradiation, leading to rotation. In liquid and solid phase, this rotation produces friction which results in an increase of the temperature. It is possible to achieve rapid and uniform heating of relatively thick materials. When microwave are directed towards a material, part of the energy is reflected, part is transmitted through the surface and of this latter quantity, and part of it is absorbed [11].

Although the use of microwave for cooking is widespread, the application of this technology to the processing materials is relatively new development. As many researchers have already stated in numerous published papers microwave irradiation (usually at the ISM –Industrial Scientific and Medical – frequency of 2.45 GHz) produces efficient internal heating for most chemical reactions, delivering energy exactly where it is needed, even under exothermic conditions. Another valuable advantage of using controlled microwave dielectric heating for chemical synthesis is the dramatic reduction in reaction times: from days and hours to minutes and seconds. These two properties are sufficient

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motivation to promote the use of microwaves in "greener chemical processes." [12].

The aim of this study is to examine the effect of MW pre-treatment on the enzymatic hydrolysis of cellulose, to optimize the process parameter of MW pre-treatment and to investigate the efficiency of simultaneous saccharification and fermentation (SSF).

MATERIAL AND METHODS

Raw material

"Experimental" and "By-products" tobacco samples were get from Hungarian tobacco plant cultivation. The "experimental" (EX) samples were the whole plant, the stem and leaves at all. Meanwhile the "by-product" (BY) consisted mainly on the stem, the part of plant after tobacco-processing. The samples were cut and frozen after harvesting immediately and were keeping in deep frozen until hydrolysis. One part of the samples was cut by cutter to reduce the size of particles before hydrolysis. Dry matter (DM) was determined by drying the samples overnight at 105 °C.

Enzymatic saccharification

The saccharification of tobacco samples were made in a 2 liter laboratory fermentation unit (Labfors Minifors, Belgium) [13]. For enzymatic hydrolysis cellulose (CLA) (Cellulast 1.5L, Novozymes A/S, Denmark; 700 U/g) from Trichoderma reesei (Sigma-Aldrich) and cellobiase (CLB) (Novozym 188, Novozymes A/S, Denmark; 250 U/g) from Aspergillus niger (Sigma-Aldrich) was applied dosed in a different concentration of CLA 14.88 cm^3/L (EX), 18.64 cm^3/L (BY) and CLB 18.32 cm^3/L (EX), 15.44 cm^3/L (BY). The temperature and pH of enzymatic hydrolysis were controlled at 50±0.2°C and pH 5.0±0.1.

Sugar content

The sugar content was determined spectrophotometrically with using of the 3, 5- dinitrosalicylic acid (DNS) method, after calibration. This method tests for the presence of free carbonyl group (C=O), the so-called reducing sugars. This involves the oxidation of the aldehyde functional group present in, for example, glucose and the ketone functional group in fructose. Simultaneously, 3, 5-dinitrosalicylic acid (DNS) is reduced to 3-amino, 5-nitrosalicylic acid under alkaline conditions because dissolved oxygen can interfere with glucose oxidation, sulphite, which itself is not necessary for the colour reaction, is added in the reagent to absorb the dissolved oxygen [14]. All samples were diluted 10 times and subsequently 300 µl of DNS were added to 300 µl of samples. The mixtures were heated at 90 °C for 10 minutes to develop the red-brown colour. After the heating, 100 µl potassium sodium tartrate (Rochelle salt) was added in all samples and thereafter the samples were put in a cold water bath and the absorbance was recorded with a spectrophotometer (Nanocolor UV/VIS, Macherey-Nagel) at 540 nm [14]. The sugar content was measured at the received fermentation broth and it was given per unit dry material weight basis.

Conductive heat pre-treatment

For the conductive heat treatments a hot-plate magnetic stirrer (ARE Heat Magnetic Stirrer) was used. The treatment was carried out at 85° C and the temperature was kept controlled by electronic contact thermometer.

Alkaline pre-treatment

The alkaline pre-treatment was performed with thermal treatment too. This type of treatment was different from the main thermal treatment because in this case of the pH of the treated samples was adjusted to 10 with 0.1 M sodium hydroxide solution.

Microwave pre-treatment

Microwave pre-treatments are carried out in Labotron 500 (Bucher-Guyer AG) professional laboratory microwave equipment. Labotron 500 laboratory microwave unit operated with output power of 250 W and 500 W 2450 MHz frequency [15].

RESULTS AND DISCUSSION

The purpose of the pre-treatment is to make the lignocellulosic structure more accessible to enzymatic hydrolysis. The micowave irradation (MW) has special effect beyond the heat-generation, so we compared the efficacy of MW irradiation with the convective heat transfer, and both of thermal pretreatments were compared with the effect of alkaline treatments as well.

Effect of different type of pre-treatment

The effects of different type of pre-treatments (PT) on the glucose yield are shown in the Figure 1 and Figure 2. Two different controls were used, for better understanding. At first there was used no enzyme and no PT as control1, than enzyme was added for the samples but any kind of PT were not applied as control2. The samples without enzymes have produced glucose in a slight extent under the repeatability limit of glucose assay method, meanwhile the enzyme treated EX and BY samples produced comparing amount of glucose c.

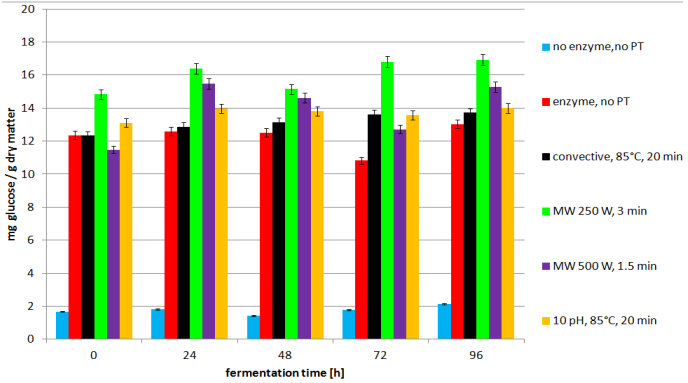

Figure 1. *Effect of different pre-treatment on glucose production at EX samples*

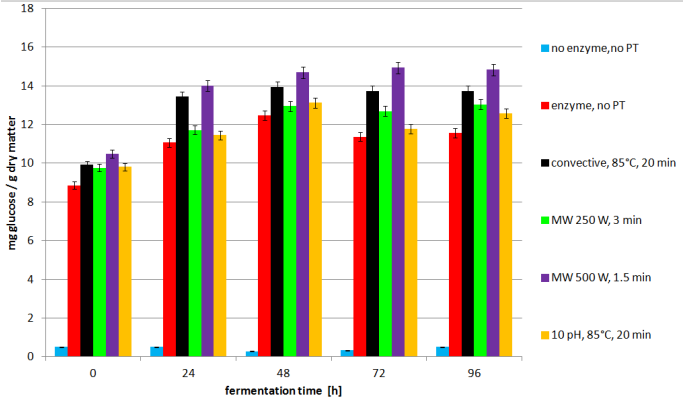

Figure 2. *Effect of different pre-treatment on glucose production at BY samples*

Considering the glucose yield the MW pre-treatment of EX at 250 W and 500W power level was more effective than conventional thermal pre-treatment. But the lower MW power resulted in lower glucose yield in the case of by-product tobacco than that of obtained from convective heated samples. The MW pre-treatment was the most effect both of samples, but the 500 W MW power treatment was the most successful at the BY, by contrast the 250 W MW power treatment was the best. Regarding the time difference: 500 W – 1.5 min, 250 W- 3 min, the irradiated energy was equal, but the effect of it, ie. the effect of the applied power level is different. This different could be explained by the different chemical composition and physicochemical structure of samples. The EX sample is the whole plant, it has lot of leafs as well, not only the stem, leaf stalk as the BY sample. The BY sample has a more complex structure, higher lignin content, lower surface area which resulted in lower ability for bioconversion. It is the reason of the absolute amount of glucose and the different at no enzyme no PT samples in the case of EX and BY.

The conventional heat treatment with the combination of the alkali treatment (pH10) affected also the glucose yield, but the increment was lower than obtained after MW treatments.

Combined pretreatments

Since the lower power level had better effect on sugar yield of EX samples, 250 W power level was applied at the combined pre-treatments with different time and combination with convective heat transfer (30 min) at pH 10. The shorter (5 min) MW pre-treatment had better glucose yield than longer (10 min) one but the previous applied 3 min long MW treatment at the same power level gave the best results (Figure 3).

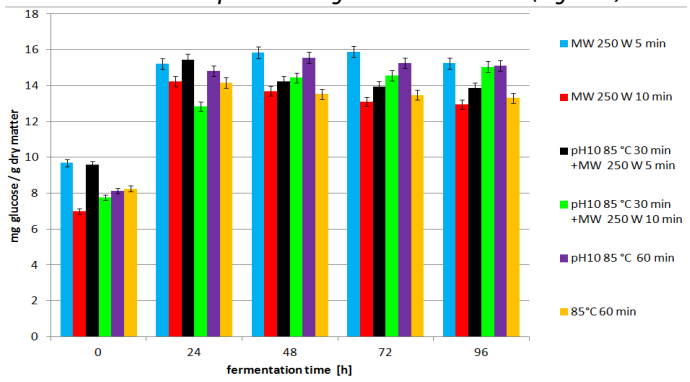

***Figure 3**: Combined pre-treatments effects on glucose yield at EX samples*

The MW plus convective heat treated alkali samples had similar results as obtained from MW treatment; the MW treatment itself was the defining element at the efficiency, and the alkali pH had quite the same, very similar result. The convective heat transfer alone, even quite long time (60 min) has just the same effect on glucose yield than lower (250W) MW power with 10 min irradiation without alkaline addition.

The tendency was the same at BY samples (Figure 4). The main determinative treatment was the MW. Since these samples had much more thick cellulose fibres more dissipated energy was needed for exploration, i.e. 500 W 5 min was concluded as the most effective pre-treatment method.

Table 1 and Table 2 summarized the effect of combined pre-treatment on sugar yield in % and the maximum achieved sugar yield in mg/g_{dm}.

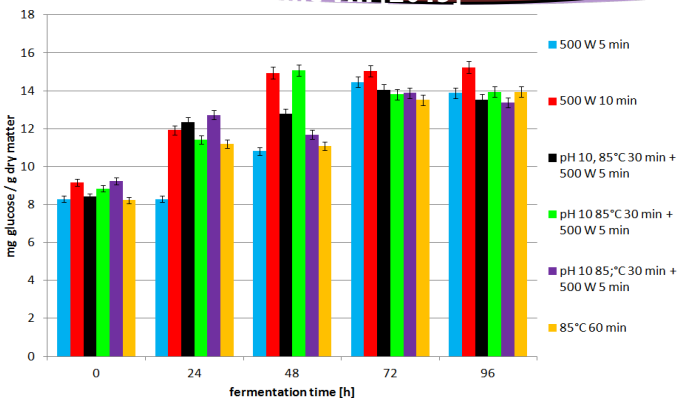

***Figure 4**. Combined pre-treatments effects on glucose yield at BY samples*

***Table 1.** Effectiveness of pre-treatments for BY samples*

pre-treatments	*Max. sugar yield (mg/g_{dm})*	*Effect of pre-treatment on sugar yield (%)*	*Time needed for max. sugar yield (h)*
MW 500 W, 5 min	*16.523*	*57.302*	*72*
MW 500 W, 10 min	*17.402*	*60.069*	*96*
10 pH, 85°C, 30 min +MW 250 W, 5 min	*16.039*	*59.953*	*72*
10 pH, 85°C, 30 min +MW 250 W, 10 min	*17.207*	*58.726*	*48*
10 pH, 85°C, 60 min	*15.868*	*66.435*	*72*
conductive heat treatment, 85°C, 60 min	*15.915*	*59.119*	*96*

***Table 2.** Effectiveness of pre-treatments for EX samples*

pre-treatments	*Max. sugar yield (mg/g_{DM})*	*Effect of pre-treatment on sugar yield (%)*	*Time needed for max. sugar yield (h)*
MW 250 W, 5 min	*15.89*	*60.938*	*72*
MW 250 W, 10 min	*14.24*	*50.934*	*24*
10 pH, 85°C, 30 min +MW 250 W, 5 min	*15.46*	*37.937*	*24*
10 pH, 85°C, 30 min +MW 250 W, 10 min	*15.05*	*48.458*	*96*
10 pH, 85°C, 60 min	*15.55*	*47.723*	*48*
conductive heat treatment, 85°C, 60 min	*14.16*	*41.723*	*24*

The data shows only MW treatment gives the bigger yield but the combined treatment enable to apply shorter fermentation time.

SUMMARY

The pre-treatment of two different type of tobacco samples was carried out in the experiments by using microwave irradiation. EX samples originated from the whole tobacco plants, it was a biomass plantation. The BY samples came from the tobacco factory, it was the byproduct of the tobacco production. At first step the effect MW pre-treatment on glucose yield was compare with the alkali and classical heat treated samples. The efficiency of different thermal and chemical pre-

treatments, their combination and the enzymatic hydrolysis was characterized by glucose yield measured by photometric glucose assay. The cellulose hydrolysis was carried out by cellulose and cellobiase enzymes. In MW experiments the power level (250 W and 500W) and irradiation time was varied.

Our experimental results show that in the case of BY samples the 500 W MW power, meanwhile the in the case of EX samples the 250 W MW power produced the maximum sugar yield. Increasing the duration of microwave irradiation, and applying combined alkaline/microwave process the pre-treatment with the magnetron power of 500W and 10 minutes resulted the maximum sugar yield from BY samples, but in combination with alkali treatment the fermentation period can be shortened, i.e. instead of 96 hour the maximum yield was achieved at 72 hours. In the case of EX samples the 250 W MW power and 5 minutes was the most effective, and the combination of MW and alkali treatment was proved suitable to reduce the overall time demand of hydrolysis process.

Acknowledgements

The research work was supported by the European Union and the State of Hungary, co-financed by the European Social Fund in the framework of TÁMOP-4.2.4.A/2-11/1-2012-0001 'National Excellence Program' (A2-JÁDJ-13-003). The members of research group are thankful for the financial support provided by the Hungarian Scientific Research Fund (OTKA), under contract number K105021.

References

[1.] *Ivan A. Ross, Medicinal Plants of the World: Chemical Constituents, Traditional and Modern Medicinal Uses, Volume 3, Humana Press, ISBN 978-1-59259-887-8, 2005.*

[2.] *Vyacheslav Andrianov, Nikolai Borisjuk, Natalia Pogrebnyak, Anita Brinker, Joseph Dixon, Sergei Spitsin, John Flynn, Paulina Matyszczuk, Karolina Andryszak, Marilyn Laurelli, Maxim Golovkin and Hilary Koprowski, Tobacco as a production platform for biofuel: overexpression of Arabidopsis DGAT and LEC2 genes increases accumulation and shifts the composition of lipids in green biomass, Plant Biotechnology Journal, Volume 8, pp. 1-11, 2009.*

[3.] *Usta, N., Use of tobacco seed oil methyl ester in a turbocharged indirect injection diesel engine, Biomass Bioenergy, Volume 28, pp. 77–86, 2005.*

[4.] *Koiwai, A., Suzuki, F., Matsuzaki, T., Kawashima, N., The fatty acid composition of seeds and leaves of Nicotiana species, Phytochemistry, Volume 22, pp. 1409–1412, 1983.*

[5.] *Vicente, G., Martínez, M., Aracil, J., Optimization of integrated biodiesel production. Part I. A study of the biodiesel purity and yield, Bioresour. Technol., Volume 98, pp. 1724–1733, 2007.*

[6.] *Sticklen, M., Plant genetic engineering to improve biomass characteristics for biofuels, Curr. Opin. Biotechnol. Volume 17, pp. 315–319, 2006.*

[7.] *Benchaporn Buaban, Hiroyuki Inoue, Shinichi Yano, Lily Eurwilaichitr, Bioethanol production from ball milled bagasse using an on-site produced fungal enzyme cocktail and xylose-fermenting Pichia stipitis, Bio mass and bio energy, Volume 33, pp. 822 – 827, 2009.*

[8.] *Morales-Rodriguez Ricardo, Anne S. Meyer, Krist V. Gernaey, Gürkan Sin, Dynamic model-based evaluation of process configurations for integrated operation of hydrolysis and co-fermentation for bioethanol production from lignocelluloses, Bioresource Technology, Volume 102, pp. 1174–1184, 2011.*

[9.] *Ballesteros, M., Olivia, J.M., Negro, M.J, Manzanares, P., Ballesteros, I., Ethanol form lignocellulosic materials by a simultaneous saccharification and fermentation process (SSF) with Kuyveromyces marxiamus CECT 10875, Process Biochemistry, Volume 39, pp. 1843-1848, 2004.*

[10.] *Liu, C.G., Wyman, C.E., Partial flow of compressed-hot water through corn stover to enhance hemicellulose sugar recovery and enzymatic digestibility of cellulose, Bioresource Technology, 96, 1978-1985, 2005.*

[11.] *Leonelli C., Mason T.J., Microwave and ultrasonic processing: Now is realistic option for industry, Chemical Engineering and Processing, Volume 49, pp. 885-900, 2010.*

[12.] *P V R Kovács, S Beszédes, L Ludányi, C Hodúr, G Keszthelyi-Szabó, Effect of temperature on biogas yield of microwave treated whey, Annals of Faculty of Engineering Hunedoara - International Journal of Engineering, 12:(4) pp. 189-192. (2014)*

[13.] *Prihardi Kahar, Kazuo Taku, Shuzo Tanaka, Enzymatic digestion of corncobs pretreated with low strength of sulfuric acid for bioethanol production, Journal of Bioscience and Bioengineering, 110, Volume 4, pp. 453–458, 2010.*

[14.] *Miller, G.L., Use of dinitrosalicylic acid reagent for determination of reducing sugar, Anal. Chem., Volume 31, pp. 426, 1959.*

[15.] *Sándor Beszédes, Aurelie Tachon, Balázs Lemmer, Marietta Ábel, Gábor Szabó, Cecilia Hodúr, Biofuels from cellulose by microwave irradiation, Annals of Faculty of Engineering Hunedoara - International Journal of Engineering, 10:(2) pp. 43-48. (2012)*

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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AS-CFD METHOD APPLICABILITY FOR ANALYZING Al 6061 ALLOY POROSITY

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Abstract: Numerical modeling is widely used in many fields, therefore establishing correlations between properties. In our case, for example, the process and parameters of infiltration, mass parameters modeling, energy equilibriums according to Darcy's equations describe fluid flow in a porous cavity. Using AS-CFD we can improve the infiltration process (with the help of numerical simulation): on the one side analyzing particle interaction and on the other side analyzing the flowing process. In this paper we have analyzed the AS-CFD simulation method applicability for analyzing Al6061 alloy porosity through a pre-established surface. High applicability is encountered when using low diameter particles (required so that the Al6061 alloy passes the ductility test) because in this case the time frame is very high (approximately 30 hours for a standard test).
Keywords: infiltration; modeling; porosity; AS-CFD; Al6061

1. INTRODUCTION

Aluminum is an important element with a complex applicability in various industries, nationally and internationally. Aluminum 6061 is widely used because of its properties: 2.71g/cm^3 density, Young: 68.9GPa, Poisson: 0.33μL. It is the most commonly used type of Al used, although it is differentiated in a few categories: 6061, 6061-T4, 6061-T6 (each one having physico-chemical properties which differ based on elaboration and destination). Maximum resistance is at 300MPa, 8% elongation, conductivity 77°F at 152W/m·K, fatigue resistance up to 100MPa.

Aluminum 6061 is used in building certain aircraft parts (wings, fuselage), passenger planes, sometimes Al2024 is more resistant, but Al6061 has a better machinability and high corrosion resistance. It is also used for building yachts, boats, train parts, bicycle parts, fishing ware.

A similar alloy is ASF (synthetic aluminum) and it is used in similar fields, its physico-chemical characteristics being somewhat close to those of Al6061-T6 alloy. In ASF alloy's case, a similar test has been performed by Shizhao Li et all in: "CFD approach for prediction of unintended porosities in aluminum syntactic foam: a preliminary study".

Numerical modeling is widely used in many fields, therefore establishing correlations between properties. In our case, for example, the process and parameters of infiltration, mass parameters modeling, energy equilibriums according to Darcy's equations describe fluid flow in a porous cavity.

In this paper, we have used the numerical modeling based AS-CFD to analyze Al6061 flowing through a porous surface (created in the program) therefore proving the possibility of predicting high porosity areas at the end of the infiltration process.

Using AS-CFD we can improve the infiltration process (with the help of numerical simulation): on the one side analyzing particle interaction and on the other side analyzing the flowing process.

2. NUMERICAL AND GEOMETRICAL MODELING

Al6061 flow through a porous surface during the infiltration process is a nonlinear analysis in which two processes dominate: flowing and solidification. According to numerical simulation we have calculated:

a) the interaction between two particles,

b) thermic equations in which Al6061 is considered an incompressible Newtonian fluid.

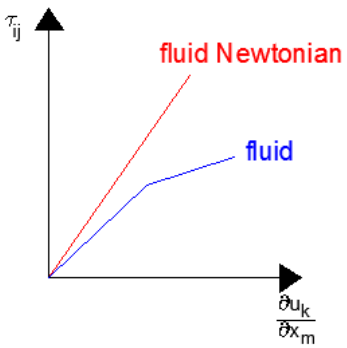

Figure 1. Variation graphic of a Newtonian fluid

As general equations used to express Newtonian flowing process we highlight:

$$\nabla u = 0 \qquad \text{eq1}$$

$$\rho\left(\frac{\partial u}{\partial t} + u \cdot \nabla u\right) = -\nabla p + \mu \nabla^2 u \qquad \text{eq2}$$

where: u – fluid speed, ρ – density, t – time, p – pressure

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Though this result is based on another principle:

$\tau_{ij} \approx$ *linear function for: effort size (tension)* $\equiv$ *speed gradient*

$$\frac{\partial}{\partial t}\left(\frac{\partial X}{\partial x}\right)=\frac{\partial}{\partial x}\left(\frac{\partial X}{\partial t}\right)=u \qquad \frac{\partial u_k}{\partial x_m}=\alpha_{ijkm} \qquad (eq3)$$

approx.81=Newton module

For isotropic fluids the equation is:

$$\tau_{ij}=\mu\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right)+\lambda\left(\frac{\partial u_l}{\partial x_l}\right)\rightarrow \nabla\cdot\vec{v} \qquad eq4$$

where: $\mu -$ *dynamic viscosity coefficient,* $\lambda -$ *elasticity coefficient*

For incompressible flow $\left(\frac{\partial u_l}{\partial x_l}\right)=0$, *and for isotropic and incompressible Newtonian fluid* τ_{ij} *variation is given by:*

$$\tau_{ij}=\mu\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right) \qquad eq5$$

Using AS-CFD we have established the model analyzed on a right prismatic surface.

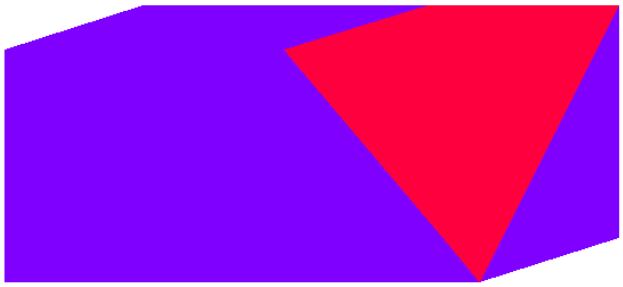

***Figure 2**. Prismatic surface AS-CFD modeled*

Tridimensional geometrical modeling is based on the following characteristics: general surface – regular rectangular prism, spherical particles, fraction volume approximately 33%. The surface can be divided in regular spherical surfaces or cubes in order to reach the 33%. Infiltration process parameters (adopted by Dopler) are important to differentiate the numerical simulation approximations.

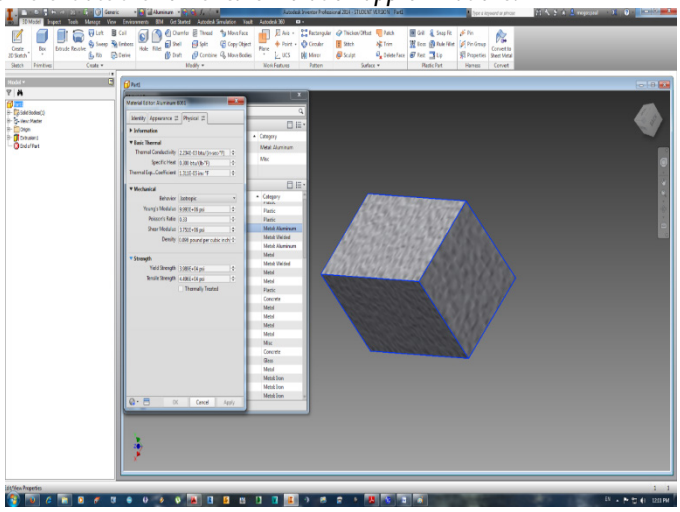

***Figure 3**. Geometrical modeling of the prismatic surface using Inventor Professional 2014*

AS-CFD modeling consists of creating a regular rectangular prism, with rectangular base L=20cm, l=10cm, h=10cm. The characteristics are presented in Figure 4, pressure 50Pa, external pressure 0.8MPa, all used for the simulation. Al6061 alloy density is 2.71 g/cm³.

3. RESULTS AND DISCUSSIONS

The simulation is presented in Figure 4 and shows variations on different particle diameters (spheres used to simulate): 700µm, 500µm and 300µm. The violet colored area represents Al6061 alloy, blue/green – area that is filled next and grey – area unaffected by flow.

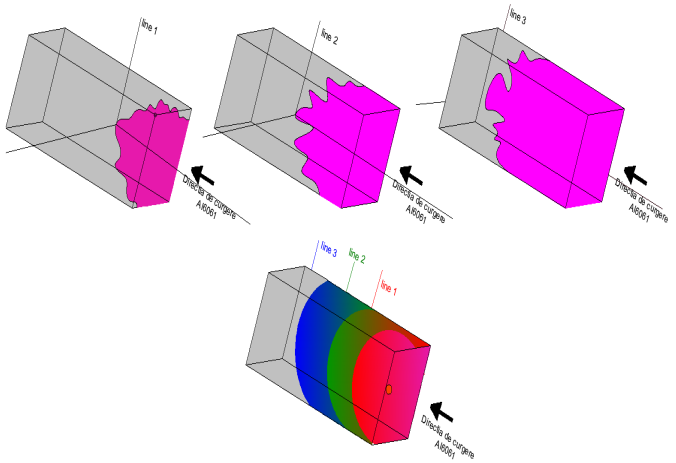

***Figure 4**. Al6061 alloy flow propagation in the used shape – simulation on the 3 advancement lines.*

The infiltration process is presented using AS-CFD and shows the program capacity of analyzing physical infiltration and propagation characteristics through a pre-established 3D surface (modeled using Inventor) of an Al6061 alloy. Flow symmetry and liquid fraction value are presented in Figure 4 (including air fraction volume) and finally, undetected porosities. These areas can be defined as unsecure areas and are analyzed and highlighted in the simulation.

The relation for Figure 5 is important to establish matches between sphere diameters and time frames, resulting for: 700, 500 and 300 µm.

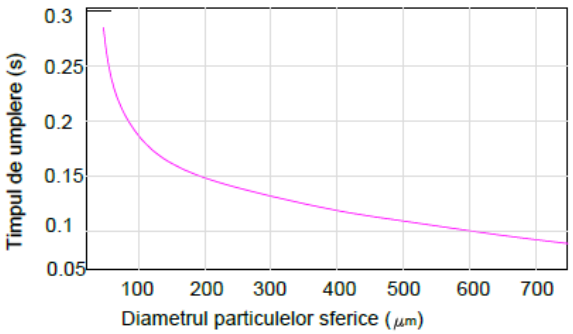

***Figure 5**. Relation between particle size and porous cavities filling time*

The filling time frame grows with decreasing spherical particle diameter used for simulating, therefore the graphic is a descending parable, such as Figure 5. Spherical particles dimension influences the simulation volume (CFD) which exponentially rises with increasing sphere diameter. Therefore at 700µm, 500µm, 300µm we have a time frame of 5 hours, 10 hours, 30 hours. Because of this it is important to follow the infiltration process for particles with 300µm diameter using AS-CFD because it requires a large time frame.

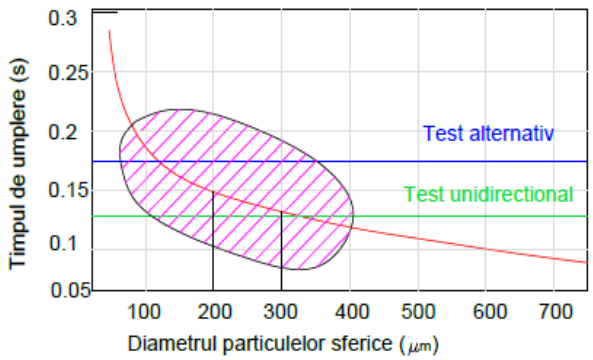

***Figure 6**. Ration between particle diameter, cavity filling time and ductility (according to alternative and unidirectional tests)*

At the same time, depending on these two parameters: filling time and spherical particles diameter used in the simulation we can characterize the ductility interval of Al6061 alloy, checking the alternative and unidirectional test variation (process highlighted in Figure 6). The graphic suggests that both tests, unidirectional and alternative, should use 200µm-300µm diameter spheres, with a time frame of 0.15s, hence the necessity of using an information simulation solution to analyze the whole process.

4. CONCLUSIONS

In this paper we have presented an analysis of the undefined porosity areas in Al6061 alloy using the infiltration process through a surface created using Autodesk Inventor Professional 3D, and for the network nodes we have designed spheres of different dimensions.

1. *AS-CFD simulation is similar to the method of approximating permeability on a pre-established surface. In these cases we can calculate undefined porosity areas based on the diameter of the spheres used in the simulation.*
2. *Decreasing Al6061 sphere diameters involves an exponential growth of the time frame when simulating. This process involves difficulties in analyzing these irregular surfaces (in our case for particles of 300µm because of the very large time frame), but using AS-CFD we can obtain rapid and conclusive results.*
3. *Using AS-CFD we can also introduce the temperature parameters in correlation with volume and time of the infiltration process. Therefore, we can obtain conclusive information between the experimental data and the numerical simulation.*
4. *Undetermined or undefined porosity on our model made in AS-CFD influences the ductility of the Al6061 alloy so that not all implicated surfaces can participate in the process, but only the low diameter ones (in our case 300µm) i.e. the ones that require the highest time frame.*

***Acknowledgement**:*

This work is supported by the Sectorial Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and the Romanian Government under the POSDRU 2014/ Cod Contract: 134398.

Bibliography

[1.] Banhart. J., 2001, Manufacturing, Characterization and Application of Cellular Metals and Metal Foams, Progress in Materials Science, 46, 559-632.

[2.] Damronglerd, P., and Zhang, Y.W., 2012, Numerical simulation of solidification of liquid copper saturated in porous structures fabricated by sintered steel particles, International Journal of Numerical Methods for Heat & Fluid Flow, 22, 94-111.

[3.] Dopler, T., Modaressi, A., and Michaud, V., 2000, Simulation of Metal-Matrix Composite Isothermal Infiltration Processing, Metallurgical and Materials Transactions B, 31B, 225-234. FLOW-3D User's Manual, version 10.1.

[4.] Krummel, A.T., Datta, S.S., Münster, S., and Weitz, D.A., 2013, Visualizing Multiphase Flow and Trapped Fluid Configurations in a Model Three-Dimensional Porous Medium, AIChE Journal, 59, 1022-1029.

[5.] Navacerrada, M.A., Fernández, P., Díaz, C., and Pedrero. A., 2013, Thermal and acoustic properties of aluminum foams manufactured by the infiltration process, Applied Acoustics, 74, 496-501.

[6.] Shizhao Lia, Jon Spangenberga, Jesper Hattela, A CFD approach for prediction of unintended porosities in aluminum syntactic foam: a preliminary study, Procedia Materials Science 4 (2014) 257 – 262.

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ISSN:2067-3809

ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 1 [JANUARY–MARCH]
ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 2 [APRIL–JUNE]
ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 3 [JULY–SEPTEMBER]
ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 4 [OCTOBER–DECEMBER]

fascicule 4
[October - December]
tome VII [2015]
ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

Mohamed A. A. El-SHAER

ANALYSIS OF A COMPOSITE CONTINUOUS GIRDER WITH A SINGLE RECTANGULAR WEB OPENING

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Abstract: *In this paper, a non-linear finite element analysis has been done to analyze the deflection in the steel section and internal stresses in the concrete slab for continuous composite girders with rectangular opening in the steel web. ANSYS computer program (version 14.5) has been used to analyze the three-dimensional model. The reliability of the model was demonstrated by comparison with experimental results of continuous composite beam without opening in the steel web carried out by another author. The parametric analysis was executed to investigate the width, height, and position of the opening in one span on the behavior of composite girder under vertical load. The results indicated that when the width of opening less than 0.05 of length of single span and the height less than 0.15 of steel web, the deflection and internal stresses increased less than 10 % comparing to continuous composite girders without opening.*
Keywords: *Composite steel-concrete girders, finite element analysis (FEA), web opening, shear connection, the effective width*

INTRODUCTION

The use of composite steel beams with regular web-openings is becoming increasingly popular in multi-story building construction [1-3]. Openings are provided in the beam webs so that services could pass through the webs. In highway bridges and ship structures web openings in girders are provided in order to lighten the structure and to enable space for services, inspection and maintenance [4-7]. This form of construction results in reduced floor height, systematic installation of pipes or ducts and cost effectiveness but at the same time, causes penalty on the shear strength of the girders depending on the parameters of the openings [2,8]. The behavior of the composite girders (concrete slab-steel girder) has been the subject of several researches all over the world [9].

It is widely known that laboratory tests require a great amount of time and, in some cases, can even be impractical [10]. The finite element method (FEM) can be used as a very useful tool in predicting the failure load of composite concrete-steel beams and can allow very detailed information for the distribution of stresses and strains in composite beams [10-12]. Ibrahim et al. [13] used a finite element model to study the behavior of simple prestressed composite beams by means of a developed computer program (ANSYS 12) and compared the numerical results to the experimental results. The numerical results showed that the behavior in the concrete slab and steel beam responded well with the experimental results. Patil and Shaikh [14] presented 3D numerical models of steel-concrete composite beams to simulate their structural behavior with emphasis on the beam-slab interface. Simulations were occurred using version 14.0 of the ANSYS code, based on the FEM. The results were compared with those provided either by standards, experimental work, or found in the literature, and such comparisons demonstrated that the numerical approach followed is a valid tool in analyzing steel-concrete composite beam. A detailed literature review showed that the studies mostly focused on the behavior of simple composite girder with opening in steel web. Also the review showed that a little information available on the structural analysis of composite continuous girders with rectangular openings in the steel web. Therefore, the present study is concerned with the behavior of this type of structure using FEM.

FINITE ELEMENT MODEL

The analysis of continuous composite girders with rectangular opening in the steel web was performed using ANSYS computer program (version 14.5). Model components encountered throughout the current study, corresponding finite element representation and corresponding elements designation in ANSYS are presented as follows:

Element type selection

The three-dimensional element SOLID 186 is adopted to discretize the concrete slab, which is able to simulate cracking behavior of the concrete under tension (in three orthogonal directions), crushing in compression and evaluate the material non-linearity and enable the coverage of reinforcement (reinforcement bars scattered in the concrete region). The steel section is modeled using the SHELL 43 element, which facilitates non-linearity of the material and shows linear deformation in the plane in which it is present. The modeling of the shear connectors is done by the BEAM 189 element, which allows the configuration of the cross-section enables consideration of the non-linearity of the material and includes bending stresses. The TARGE 170 and CONTA 173 elements are used to represent the contact slab-beam interface. These elements can simulate the existence of pressure between them in the case of contact and separation between them in the case of no contact. The slab-beam contact materials also take into account slipping and uplift between the parties.

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Material modeling

In this study, the main components of the composite section are modeled with relevant ANSYS elements as follows:

= ***Modeling of concrete***

The concrete is considered to be homogeneous and initially isotropic. The adopted stress-strain (f_c-□) relation is based on work done by Desayi and Krishnan [15] as shown in Figure 1.

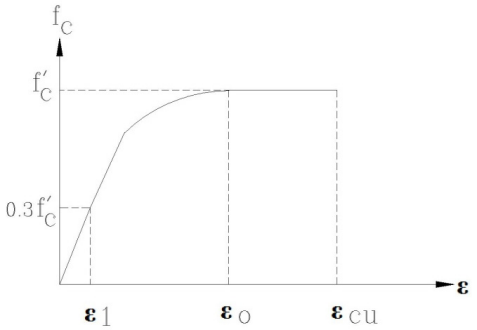


Figure 1. *Compressive stress-strain curve for concrete used in ANSYS model*

A compressive uniaxial stress-strain relationship for the concrete model was obtained by using Eqs. (1-4) to compute the multilinear isotropic stress-strain curve for concrete.

$$f_c = \varepsilon E_c \quad for \quad 0 \le \varepsilon \le \varepsilon_1 \qquad (1)$$

$$f_c = \frac{\varepsilon E_c}{1+(\frac{\varepsilon}{\varepsilon_o})^2} \quad for\ \varepsilon_1 \le \varepsilon \le \varepsilon_o \qquad (2)$$

$$f_c = f_c^{'} \quad for \quad \varepsilon_o \le \varepsilon \le \varepsilon_{cu} \qquad (3)$$

$$\varepsilon_1 = \frac{0.3 f_c^{'}}{E_c} \quad (Hooke's\ law) \qquad (4)$$

$$\varepsilon_o = \frac{2 f_c^{'}}{E_c}$$

where, $\varepsilon 1$ = strain corresponding to (0.3fc'), εo = strain at peak point, εcu = ultimate compressive strain.

= ***Modeling of steel girder***

The bilinear stress-strain relationship indicated in Figure 2 is used in this study [16]. The strain hardening modulus (E_t) is assumed to be (0.03 Es). This value is selected to avoid convergence problems during iteration.

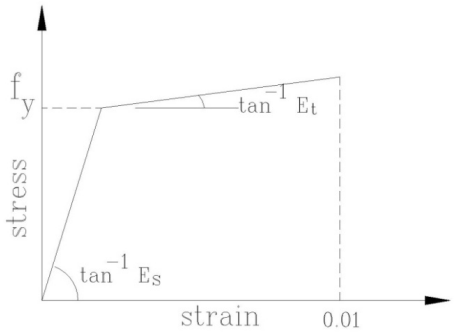


Figure 2. *Stress-strain curve for steel girder used in ANSYS model*

= ***Modeling of shear connectors***

The equation used to model the behavior of the shear connectors is:

$$F_d = F_{du}(1-\frac{1}{e^{\Delta u_s}})^O 0.558 \qquad (5)$$

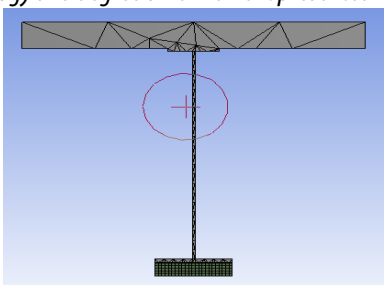
where, F_d is the dowel force, ΔUs = tangential displacement (mm), F_{du} = ultimate dowel force (Millard-Johnson Equation) given by [17]:

$$F_{du} = 1.3\phi^2\sqrt{1.2 f_c^{'} f_y} \qquad (6)$$

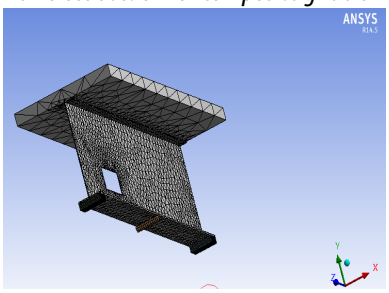
where, Ø is the diameter of the stud.

Geometrical modeling and finite element meshing

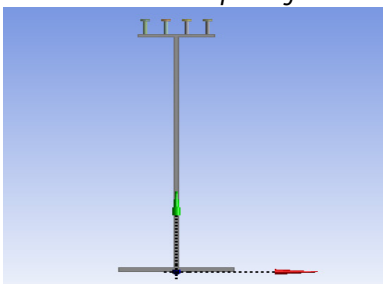
The numerically modeled girders are typically composed of continuous girders with two equal spans as previously discussed. The model is defined by four types of elements that form the concrete slab with added reinforcements, steel girder, and shear connectors. The elements are established separately, but the nodes are coupled one by one on the interface between them. The finite element mesh developed followed the same methodology and degree of refinement presented in Figure 3(a-d).



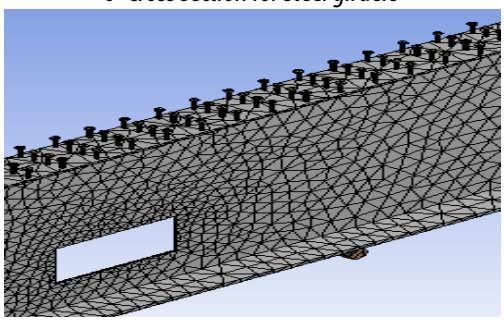
a- Cross section for composite girders



b- Continuous composite girder



c- Cross section for steel girders



d- Continuous composite steel girders

Figure (3 a-d). *Finite element model*

THE VALIDATION OF THE MODEL

The validation of the model was examined by comparison with experimental results of continuous composite girders without opening in the steel web carried out by Arizumi, and Hamaha [18]. The parameters and material properties of the continuous composite beam are shown in Figure 4 and Table 1.

Table (1). *Material properties for continuous composite beam*

Concrete Slab			Steel Girder	
E_c (GPa)	f_c' (MPa)	F_t (MPa)	E_s (GPa)	f_y (MPa)
27.70	48.30	4.83	207.70	302.25

Figs. 5-7 indicate the experimental and analytical results of deflection distribution, strain distribution at bottom flange of steel section and slipping distribution between steel section and concrete slab for continuous composite beam. It is shown from these figures that the results obtained by finite element solution have a good agreement with experimental results.

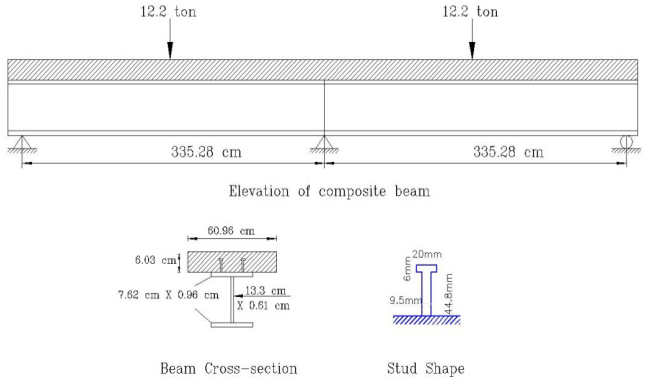


Figure 4. *Continuos composite beam*

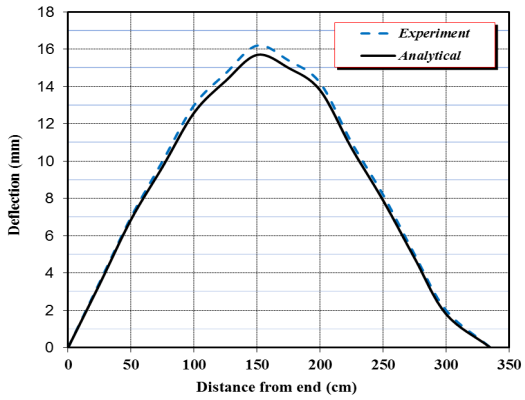


Figure 5. *Deflection distribution for continuous beam (to one span)*

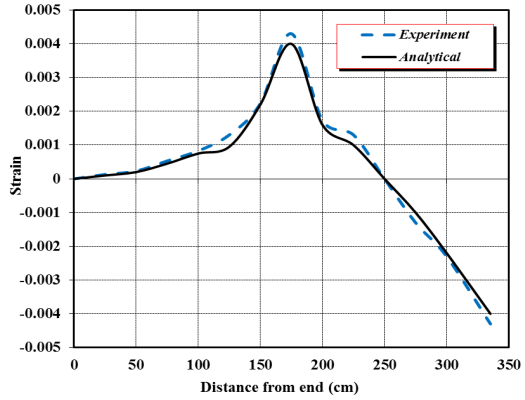


Figure 6. *Strain distribution at bottom flange of steel beam*

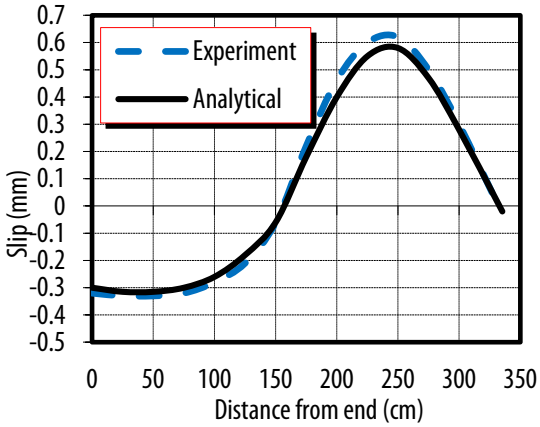


Figure 7. *Slipping distribution between concrete slab and steel beam*

PARAMETRIC STUDY

In this study, continuous composite girders two equal span with constant T-section are used as shown in Figure 8. The opening was made in the steel web of the left span while the right span was kept solid. The material properties of the steel and concrete are given in Table 2 where Ec and Es are the modulus of elasticity of the concrete and steel respectively, fc' is the concrete cube strength, and fy is the steel yield stress. The cross-section of the girder is shown in Figure 9 and the dimensions of the cross-section are given in Table 3. Throughout this study, it is assumed that the material of the composite girders (concrete slab and steel beam) is homogeneous, isotropic and linear elastic. The analysis was carried out using a finite element computer program (finite element modeling package ANSYS 14.5).

For a rectangular opening, the height (d) of the rectangular openings ranged from 0.05H

to 0.50H, where H is the depth of the steel I-section. The width (b) of the selected opening ranged from 0.02L to 0.15L, where L is the span length. Several positions of openings in the left span are studied.

Effect of opening height on the relative vertical deflections

Figures 10-13 show the effect of opening height d, for b = 0.10L and 0.15L, on the relative vertical deflections (maximum deflections of the two spans relative to the corresponding deflections of the solid composite girder, Δ1/Δs and Δ4/Δs respectively) of the two spans. These Figures show that when the opening height increases, the deflections Δ1 and Δ4 increase, especially when the opening is located close to the interior support. When the opening is located at mid-span, the deflection Δ1 increases and Δ4 decreases. From these Figures we obtain that, for small opening heights (up to about 0.15H) the opening effect is relatively small in both spans (less than 10%). Increasing the opening height further, the deflections are significantly affected. The most significant effect is obtained when the opening is located at the composite girder center line (close to the interior support) or in zone 2. This may be attributed to the opening weakens the maximum shear stress zone in the first position, and the maximum positive bending moment zone (zone 2) in the second position. On the other hand, Figure 14 indicates the deflection behavior of continuous composite girder with rectangular opening in steel web at d=75cm, b =250cm and the distance between the edge of the opining and intermediate support = 200cm.

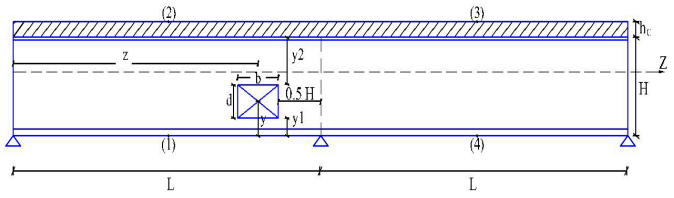


Figure 8. *Elevation of continuous composite girder with rectangular opening in steel web*

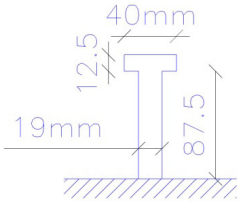


Figure (9-a). *Stud shape*

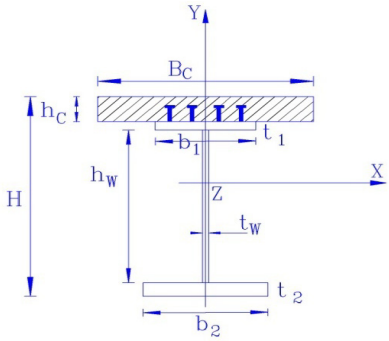


Figure (9-b). *Girder cross-section*

Table (2). *Material properties for continuous composite girder*

Concrete Slab		*Steel Girder*	
E_c *(GPa)*	f_c' *(MPa)*	E_s *(GPa)*	f_y *(MPa)*
34.30	*30.00*	*214.00*	*370.00*

Table (3). *Dimension of cross-section for continuous composite girder (Refer to Figure 10-b for definitions)*

Concrete Slab					
B_c *(cm)*	h_c *(cm)*	*Top Mesh Reinf.*		*Bottom Mesh Reinf.*	
230.0	*20.0*	*(6 Φ 12/m)*		*(6 Φ 16/m)*	
Steel Girder					
t_1 *(mm)*	b_1 *(mm)*	t_2 *(mm)*	b_2 *(mm)*	t_w *(mm)*	h_w *(mm)*
20.0	*300.0*	*30.0*	*450.0*	*15.0*	*1550.0*

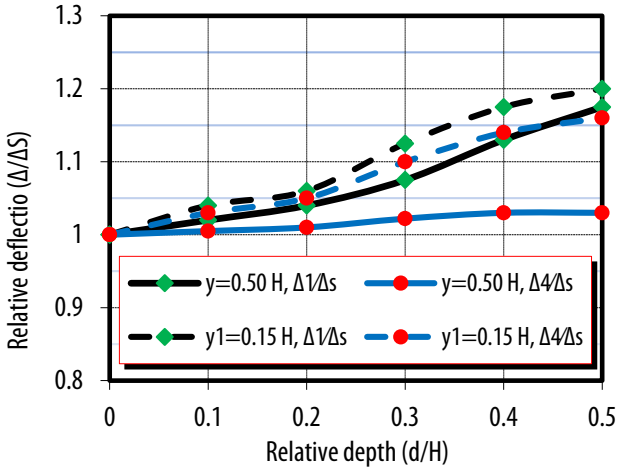


Figure 10. *Effect of opening height on the maximum deflections of the two spans for b= 0.10L (Opening to the left span)*

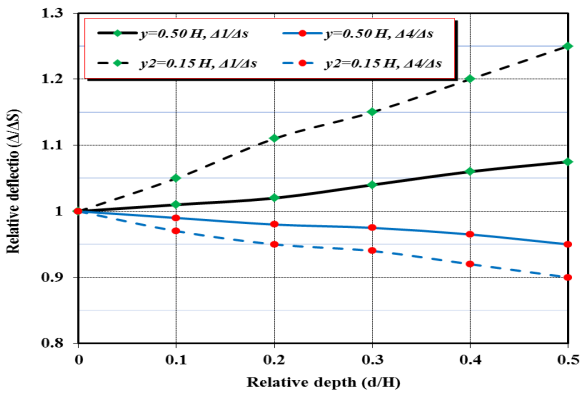


Figure 11. *Effect of opening height on the maximum deflections of the two spans for b= 0.10L (Opening at the mid-span of left span)*

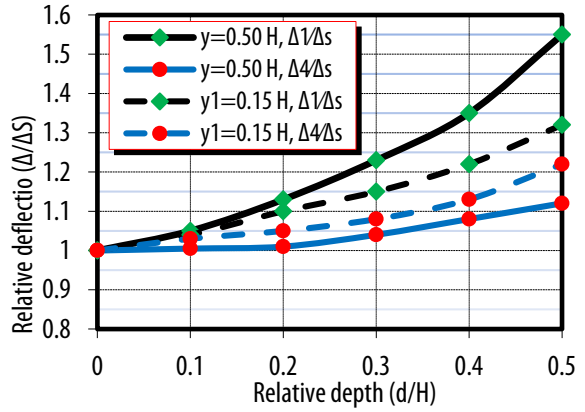


Figure 12 *.Effect of opening height on the maximum deflection of the two spans for b= 0.15L (Opening to the left span)*

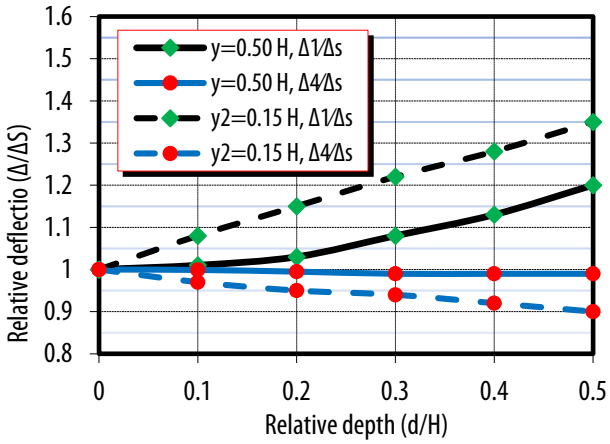


Figure 13. *Effect of opening height on the maximum deflection of the two spans for b= 0.15L (Opening at the mid-span of left span)*

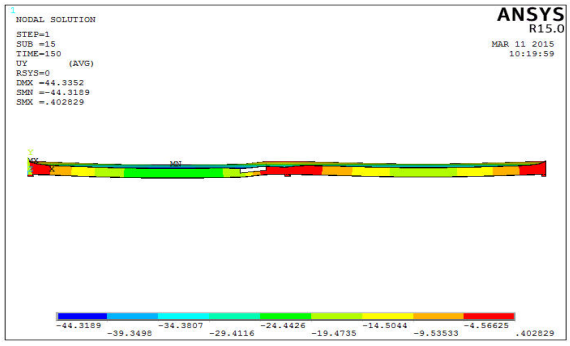


Figure 14. *Deflection shape for two continuous composite girders with opining in the steel web*

Effect of opening width on the relative vertical deflections

Figs. 15 and 16 show the effect of the opening width (d = 0.50 H) on the relative vertical deflections, (Δ1/Δs and Δ4/Δs) of the two spans. Figure 15 shows the case when the opening is positioned close to the interior support, while Figure 16 shows the case when the opening is positioned at the mid-span of the composite girder (in the compression zone and at the center line of the composite girder in both cases). From Figure 15, it can be noted that, increasing the opening width increases the deflections (Δ1 and Δ4) for both spans. The effect of opening width on the deflection is small for an opening width of less than 0.05L. As the opening width increases, the deflections significantly increase. The most significant effect of the opening width occurs when the opening is positioned at the composite girder center line. While positioning the opening at the mid-span caused dramatic changes in the deflection. From Figure 16 it can be seen that increasing the opening width increases the deflection Δ1 but decreases the deflection in the solid span Δ4. It was found that, for small opening widths (up to about 0.05L) the opening effect is relatively small in both spans (less than 10%). Whereas, increasing the opening width further has a significant effect on the deflection. This may be due to the variation in the span's inertia as a result of the opening. Comparing the effect of the height and width of the opening on the deflections of the spans, it can be noted that the opening width has a more significant effect than the opening height.

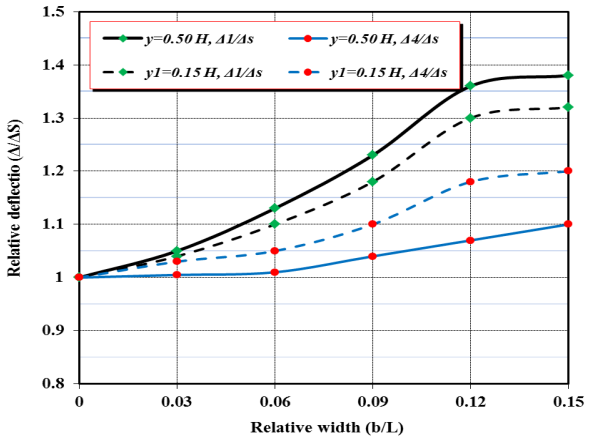


***Figure 15**. Effect of opening width on the maximum deflections of the two spans for d= 0.50H (Opening to the left span)*

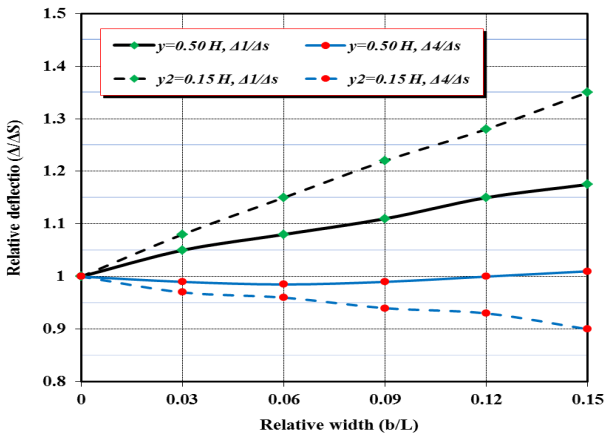


***Figure 16**. Effect of opening width on the maximum deflections of the two spans for d=0.50H (Opening at the mid-span of left span)*

Effect of opening position along z-direction on the relative vertical deflections

To study the effect of the opening position along Z-direction, rectangular openings with constant dimensions (b=0.15L and d=0.50H) were analyzed. The value of Z-direction ranged from 0.10L to 0.90L. The opening was kept under the top fiber of the upper flange of the girder cross-section (Y2=0.15H).

Figure 17 shows the effect of the opening position along Z-direction on the relative vertical deflections of the two spans, (Δ1/Δs and Δ4/Δs). The results indicate that when the position of the opening is at the maximum shear zone close to the left support and in the maximum positive moment (Z up to 0.10L and Z ≈ 0.30 L to 0.50L) the deflection (Δ1) increases while the deflection (Δ4) decreases. When the position of the opening is at the zones where the moment and/or the shear stress are small, the deflection (Δ1) decreases whereas the deflection (Δ4) increases. Moreover, the results indicate that when the opening is moved towards the interior support (in the maximum negative moment), the deflections (Δ1) and (Δ4) increase.

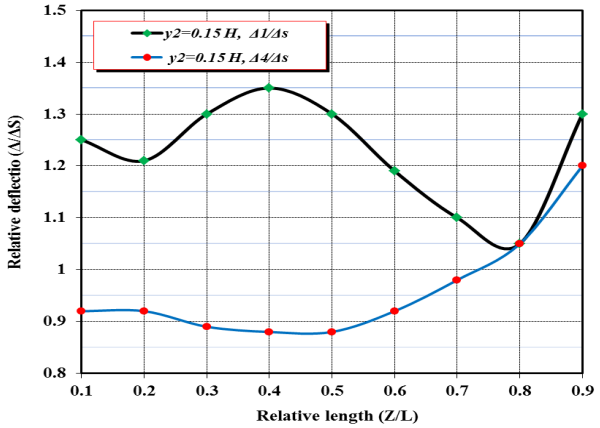


***Figure 17**. Effect of opening position along the girder span on the maximum deflections of the two spans for (y2 = 0.15 H) from the top fiber*

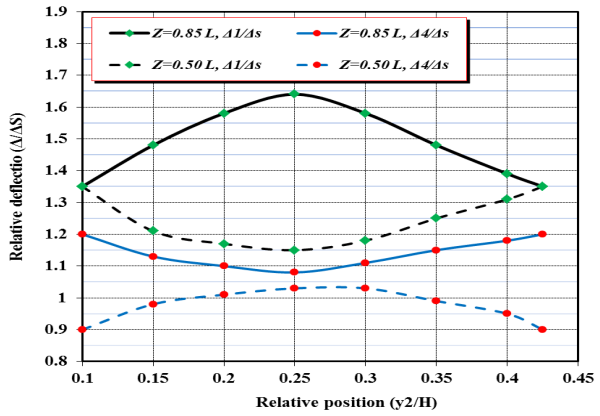


***Figure 18**. Effect of opening position along the girder height on the maximum deflections of the two spans for opening dimension of (d = 0.50 H) and (b = 0.15 L)*

Effect of opening position along Y-direction on the relative vertical deflections

The opening position was studied along Y-direction at the left of the interior support and at the mid-span. It can be seen from Figure 18 that

when the opening was positioned to the left of the interior support the opening increases the deflections (Δ1 and Δ4) significantly and the most increase in deflection occurred when the opening was positioned in the maximum shear zone. Moreover, Figure 18 indicates that when the opening is positioned at the mid-span near the composite girder chords, the deflection (Δ1) increases while the deflection (Δ4) decreases. On the other hand, Figure 18 shows that when the opening is moved towards the composite girder center line, a reversible effect on the deflection of both spans is obtained.

Effect of opening height on the relative normal stress distribution for concrete slab

Figures 19 and 20 show the effect of opening height for b = 0.10L and 0.15L on the relative compressive stresses (σ2/σs, and σ3/σs for zones 2 and 3 respectively), when the opening is located at left of the interior support.

It can be seen that from Figs. 19 and 20 that increasing the opening height increases the compressive stresses for zones 2 and 3 especially when the opening is positioned in the intermediate steel web height. The most pronounced effect happened when the opening height exceeds 0.25H. This is due to increasing the opening height decreases the bottom chord height of the opening, which leads to a huge increase in the compressive stresses and consequently a local failure in this chord.

Figures 21 and 22 show the effect of opening height on the relative compressive stresses when the opening is located at the mid-span of left span. It can be seen from Figures 21 and 22 that increasing the opening height (for b = 0.10 L and 0.15L) decreases the compressive stresses (σ2) significantly. The most pronounced decrease obtained when the opening height ranged from 0.15H to 0.35H. This is due to the wide increase in the compressive stresses and consequently a local failure in the top chord of the opening. On the other hand, Figures 21 and 22 indicate that an increase in the opening height decreases the compressive stresses (σ3) up to 10% for the third zone. When the opening is positioned at the girder center line, an increase in the opening height increases (σ2) significantly and decreases (σ3). Figures 23 and 24 shows the stress distribution in the reinforced concrete slab in the area of intermediate support for two continuous composite girders and around the opening in steel web.

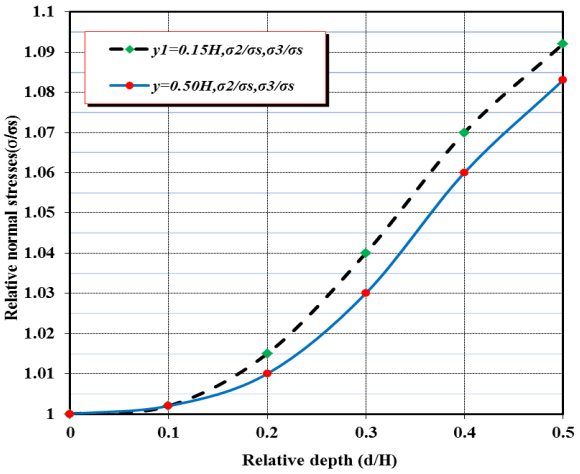


Figure 19. *Effect of opening height on the compressive stresses of the two spans for b=0.10L Opening to the left span*

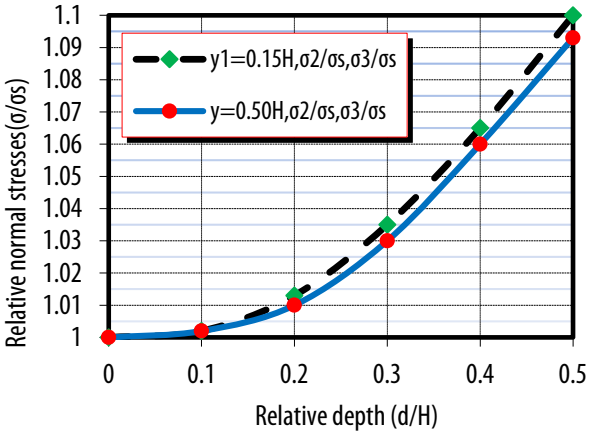


Figure 20. *Effect of opening height on the compressive stresses of the two spans for b= 0.15L Opening to the left span*

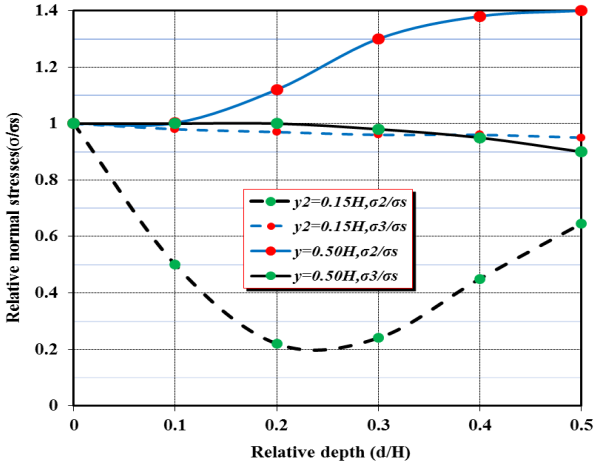


Figure 21. *Effect of opening height on the compressive stresses of the two spans for b= 0.10L Opening at the mid-span of left span*

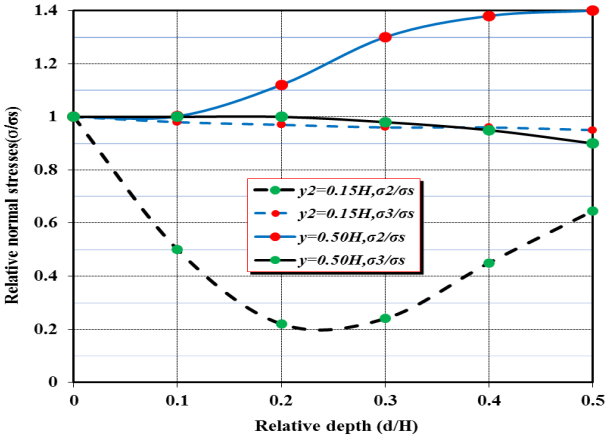


Figure 22. *Effect of opening height on the compressive stresses of the two spans for b= 0.15L Opening at the mid-span of left span*

At the ends of the left and right supports to a point of zero bending moment in the composite section, the concrete slab is compressed as shown in Figure 23. While at the distant between the two points of zero bending moment above the intermediate support the concrete slab is tensioned and the concrete in this zone suffers from cracks as shown in Figure 24. On the other hand, Figure 25 shows the stress distribution in the steel web around the opining for two continuous composite girders. It can be seen that the stresses at corner of opening have the maximum values.

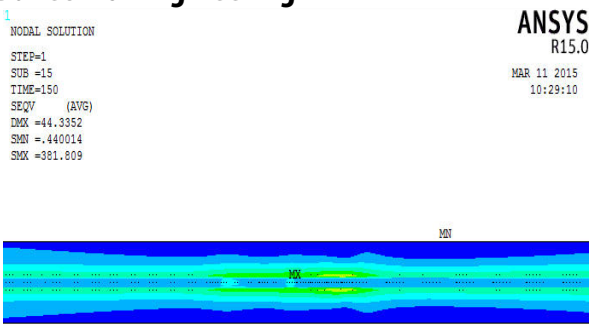


***Figure 23**. Stress distribution in the reinforced concrete slab in the area upper intermediate support for two continuous composite girders*

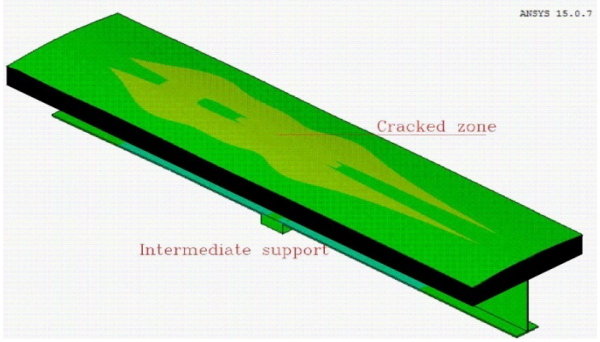


***Figure 24**. Cracked zone in the reinforced concrete slab upper intermediate support for two continuous composite girders*

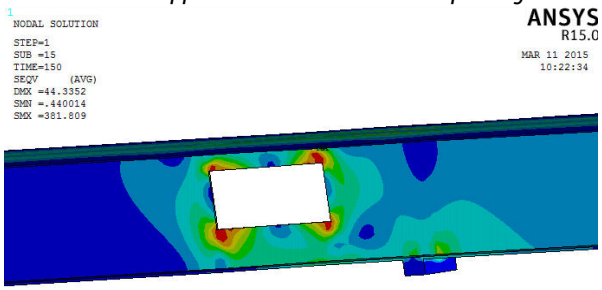


***Figure 25**. Stress distribution in the steel web around the opining for two continuous composite girders*

Effect of opening width on the normal stress distribution for concrete slab

Figures 26, and 27 show the effect of the opening width (d=0.50H) on the relative compressive stresses. When the opening is positioned to the left of the interior support (in zone 3 and at the composite girder center line), the stresses (σ2 and σ3) increase with an increase in the opening width (Figure 26). The opening width effect is similar on both σ2 and σ3. The most pronounced effect in the stress distribution (σ2 and σ3) is explicitly noted when the opening is positioned at the intermediate support. When the opening is positioned at mid-span, it is found that the stresses (σ2) are highly affected by the increase in the opening height either when the opening is positioned in the compression zone (zone 2) or at the composite girder center line (Figure 27). This shows the opening effect on the stress distribution. Moreover, Figure 27 shows that when the opening is positioned in zone 2, the stresses (σ3) decrease with the increase in opening height, while a negligible effect on (σ3) is obtained when the opening is positioned at the girder center line.

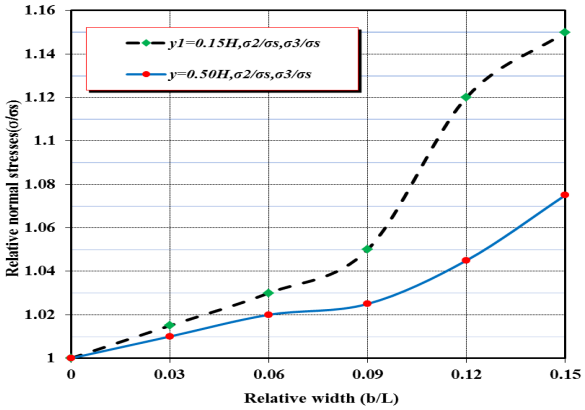


***Figure 26** . Effect of opening width on the maximum compressive stresses of the two spans for d=0.50H Opening to the left span*

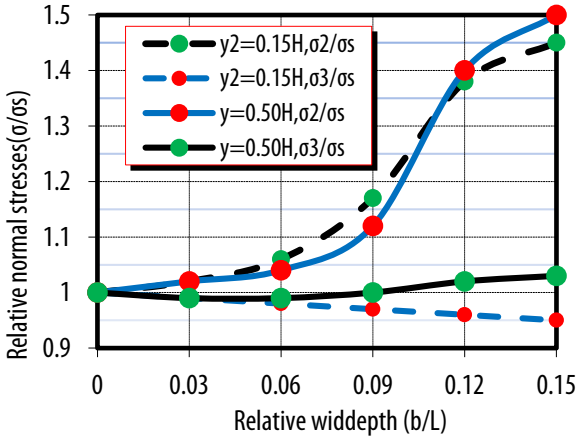


***Figure 27**. Effect of opening width on the maximum compressive stresses of the two spans for d=0.50H Opening at the mid-span of left span*

Effect of opening position on the normal stress distribution

To study the effect of opening position on the continuous composite girder stress distribution, two values namely Z= 0.5L and Z= 0.85L were selected along the depth of steel section (H) with opening size b=0.15L and d=0.50H.

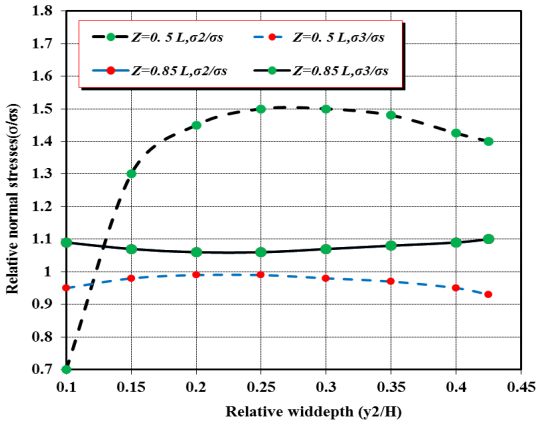


***Figure 28**. Effect of opening position along the girder depth on the maximum compressive stresses of the two spans for opening dimension of (d = 0.50H) and (b = 0.15L)*

Figure 28 shows the effect of the opening position on the σ2 and σ3. It can be seen that when the opening position changes along the depth (H) to the left of the interior support, both σ2 and σ3 increase similarly. The

maximum value obtained when the opening is located close to the top and bottom fibers for the composite girder cross section. At the mid-span, when the opening is positioned close to the top and bottom fibers of the composite girder, the σ3 decreases, while negligible changes are obtained when the opening moves toward the section center line. At the same time, σ2 decreases significantly when the opening is located in zone (2). When the opening moves away from the top flange of the composite girder, the stresses (σ2) increase. This indicates the effect of stress concentrations around openings at these positions.

CONCLUSIONS

Non-linear finite element model used in this study was able to simulate the behavior of deflection in the steel section and internal stresses in the concrete slab for continuous composite girders with rectangular opening in the steel web. The results indicated that when the width of opening less than 0.05 of the length of single span and the height less than 0.15 of steel web, the deflection and internal stresses in the concrete slab increased less than 10 % comparing to continuous composite girders without opening. Moreover, the results showed that the position of opening must be located in the zones with very small internal stresses.

REFERENCES

[1.] *Bernice V.Y., Wong, Ian W., and Burgess "The influence of tensile membrane action on fire-exposed composite concrete floor-steel beams with web-openings" , Elsevier , Science Direct, procedia engineering, 62 pp 710-716 (2013).*

[2.] *Yatim M.Y.M, Shanmugam N.E., and Wan Badaruzzaman W.H., "Behaviour of partially connected composite plate girders containing web openings" thin- walled structures 72, pp 102-112, (2013).*

[3.] *Lawson R.M., Lim J. , Hicks S.J., and Simms W.I., "Design of composite asymmetric cellular beams and beams with large web openings" Elsevier, Journal of constructional steel research , 62, pp 614-629, (2006).*

[4.] *Darehshouri S.F., Shanmugam, and Osman S..A. "An analytical method for ultimate shear strength of composite plate girders with web openings" Journal of Engineering structures, 56, pp 610-620, (2113).*

[5.] *Fahmy E. H., "Analysis of composite beams with rectangular web openings" Elsevier, Construction engineering unit, engineering department, American university in Cairo Egypt, Vol. 37 No. 1, pp 47-62,1996.*

[6.] *Bengi A., liker K. , Sabahattin A., and Yusuf E.E "flexural behavior of RC beams with rectangular square or circular web opening" Journal of Engineering structures, 56, pp 2165-2174, (2013).*

[7.] *Donghua Z., Longqi Li, Jurgen S., Wolfgang K., and Peng W., " Elastic deflection of simply supported steel I-Beam with a web opening " SciVerse Science Direct, international conference on advances in computational modeling and simulation , 31 pp 315-323 (2012).*

[8.] *Lian V.T., Shanmugam N.E. "Openings in horizontally curved plate girder webs", Thin-Walled Structures; 41:245–69 (2003).*

[9.] *Darehshouri S. F., Shanmugam N. E., and Osman S. A. "Collapse behavior of composite plate girders loaded in shear." J. Struct. Eng., 138(3), March, pp. 318–326, (2012).*

[10.] *Queiroz F.D., Vellascob P.C.G.S., and Nethercot D.A., "Finite element modeling of composite beams with full and partial shear connection" Journal of Constructional Steel Research 63 pp. 505–521(2007).*

[11.] *Alessandro Zona, "Finite element response sensitivity analysis of continuous steel-concrete composite girders", Steel and Composite Structures, Vol. 6, No. 3 pp. 183-202 (2006).*

[12.] *Persaud R., and Symons D. "Design and testing of a composite timber and concrete floor system" The Structural Engineer, pp. 22-30, (2006).*

[13.] *Ibrahim, M.A., Mohsen S.K., and Ahmed Q.W. "Finite element modeling of composite steel-concrete beam with external prestressing." International Journal of Civil and Structural Engineering, Vol. 3, No. 1, pp. 101-116, (2012).*

[14.] *Patil P.S., and Shaikh M.G. "A study of shear connector in composite beam in combined bending and shear by ANSYS." International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Vol. 3, Issue-3, August (2014).*

[15.] *Desayi P., and Krishnan S., "Equation for the stress-strain curve of concrete." Journal of the American Concrete Institute, 61, pp. 345-350, (1964).*

[16.] *European Committee for Standardisation (CEB), Eurocode 3, Design of Steel Structures, Part 1.1: General Rules and Rules for Buildings, DD ENV, 1993-1-1, EC3, (1993).*

[17.] *Millard S., and Johnson R., "Shear transfer across cracks in reinforced concrete due to aggregate interlock and dowel action.", Magazine of Concrete Research, 36 (126), pp. 0-21, (1984).*

[18.] *Arizumi Y., and Hamada S., "Elastic-plastic analysis of composite beams with incomplete interaction by finite element method", (1980).*

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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TESTING OF HYBRID COMPOSITES

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Abstract: *The presented article deals about mechanical testing of hybrid materials for automotive production. It describes thetest samples production and test processes methods forcomposite material´s testing. We´ve tested hybrid materials clustered from raw fibres of hemp, cotton, sisal and jute in combination with carbon fabric. The objective of the thesis is to present the testing methods for confirmation or declination of the ability of hybrid bio-composites usage in automotive industry. The results are statistically evaluated.*

Keywords: *Hybrid materials, natural materials, composites, testing, automotive industry*

INTRODUCTION

After many tastings of pure "synthetic" composite materials as carbon, aramid or glass fibres, we´vebegan to deal with the idea of combination of the natural materials and the carbon fibres. The reason of idea was simple – the costs. The carbon fibres are too expensive for serial production so far, so we´ve decided to decrease the costs of composite car components by implementing some natural fibres into the composite´s structure. The goal has been to test material made from carbon fibre and variously natural fibres, whereby the research should concentrate on the possibility of applications of such a materials in the car production. Our ambition is to create a material, which will bestrong, resistant and ecological.[6]

Nowadays the composites are utilised in all areas of the car industry. We know number of composite materials types, whereby we´ve been concentrated us on composites from carbon fibres. These composites have big potential for car production thanks their excellent strength properties and first of all for their weight. Recently „imported" from the aerospace industry, they have already found many applications, particularly in high performance cars where they are often the primary structural material. However, a big concern relating to the wider application of carbon fibres is their fluctuating price and availability in comparison to other structural reinforcements. This adds an element of commercial risk to ongoing vehicle production [4]. On the other side, we have here natural - renewable and mainly recyclable materials as: hemp, flax, jute, Indian hemp, sisal, Abaco or coconut fibres, that can be potential usable for composite materials (Figure1).

Base types of natural fibres:

- *bast fibres (jute, flax, hemp, kenaf,. . .),*
- *leaf fibres (manil, sisal, pineapple),*
- *seed fibres (coconutfibre, cotton, kapok),*
- *core fibres (kenaf, hemp a jute),*
- *core and grass fibres (wheat, corn, rise)*
- *other(wood androots). [2]*

Figure 1*: Used natural fibres [1]*

HYBRID COMPOSITES- THE SAMPLES PRODUCTION

Our experiment was in progress through more phases, which forewent the decision of choosing the materials for hybrid components. During the first phase we´ve made samples from composite materials, and in the second phase we´ve tested them. We carried out the material tensile test and the Charpy impact test at a bending.

By the samples production we´ve used following materials and their variants:

- *carbon fibres 160g/m2*
- *jute fibres shear 50 mm 10 g*
- *sisal fibres shear 50 mm 10 g*
- *cotton fibres shear 50 mm 10 g*
- *hemp fibres shear 50 mm 10 g*
- *250 mm jute fibres*
- *250 mm sisal fibres*
- *250 mm cotton fibres*
- *250 mm hemp fibres*
- *epoxide resin L 285*

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The produced samples were divided in two types.

- *1st type -made so that between too layer of carbon was placed one layer of natural 50mm shear. This first type of samples was made in four various modifications, when the middle layer was the shear of jute, sisal, cotton and hemp.*
- *2nd type - made so that between too layer of carbon was placed one layer of 250mm fibres laid in one direction (Figure 2). This second type of samples was also made in four various modifications.*

***Figure 2**: 2nd type of natural fibres sample made from straight laid 25cm fibres*

According to this kind of layers laying were samples from these sheets made, blanked and prepared for testing per DIN EN ISO 527 – 4 standards(tension test) and EN ISO 179 - 1 standard (impact test).

For better results precision, there were three samples of each material for tension test made. For impact test at a bending we´ve made samples only from the first type of materials – samples with shear. There were five samples of the first type made.

The tests should prove that natural fibres in combination with carbon fibre can be characterized by same or better properties as single carbon fibre composites.

We´ve used for samples production vacuum technology. This kind of composites production is verified for us and by the help of it we are achieving good results. Simultaneously it's technologically easy production method.

Whole sample´s production process was customised for chosen samples types. We´ve created cutting plan and on his base we´ve produced sheets of composites with shear and straight fibres.

After the main sample matrix preparations, we´ve produced hard composite sheets. These sheets were trimmed into specified sample´s dimensions (Figure 3).

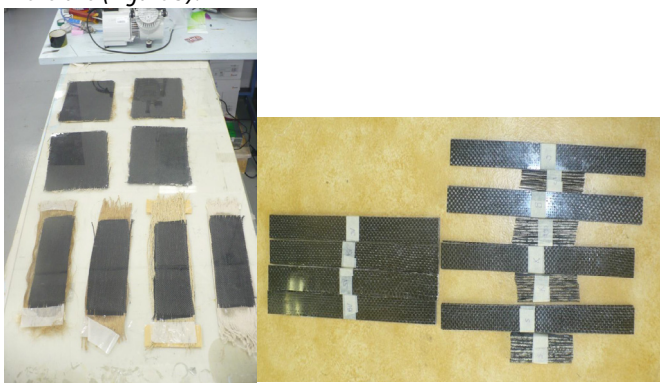

***Figure 3**: Finished composite sheets (left) and prepared – cut out samples for testing (right)*

TESTING

Two testing methods were for testing chosen:

- *material tension test*
- *impact test at a bending*

Composite material tension test

Composite material tensile test was realised by static tensile test. We´ve used test device TIRA – Test 2300 made by VEB TIW Rauestein. Test principle is to charge the specified testing sample till its breaking. There were 24 samples with specific dimensions - 250 x 25 mm and 1,4 mm thickness (Figure 4) tested.

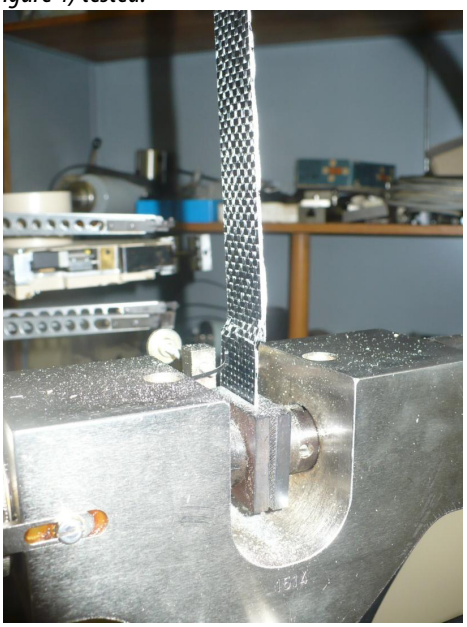

***Figure 4**: Test samples after braking*

We´ve tested 2 types of samples in 4 modifications. There were 3 samples from each modification for more-accurately results. For better orientation, we´ve marked the samples as:

First type of samples – carbon with shear of natural fibres:

- *K1, K2, K3 – samples made from carbon and hemp shear*
- *B1, B2, B3 – samples made from carbon and cotton shear*
- *S1, S2, S3 – samples made from carbon and sisal shear*
- *J1, J2, J3 – samples made from carbon and jute shear*

Second type of samples – carbon with 25cm fibres:

- *KV1, KV2, KV3 – samples made from carbon and hemp fibres*
- *BV1, BV2, BV3 – samples made from carbon and cotton fibres*
- *SV1, SV2, SV3 – samples made from carbon and sisal fibres*
- *JV1, JV2, JV 3 – samples made from carbon and jute fibres*

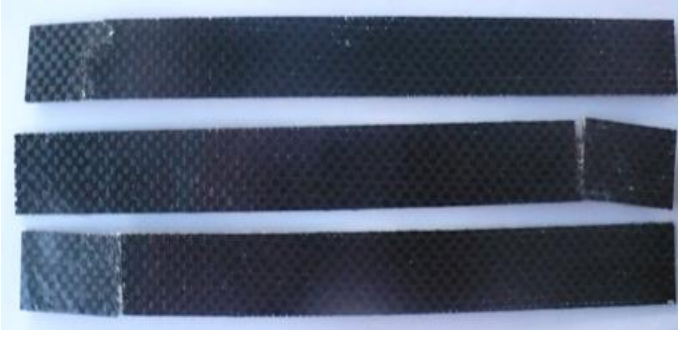

***Figure 5**: Beaked samples after testing (samples S1, S2, S3)*

The next tables Table 1 and Table 2 showresults from each test included with arithmetical averages of results for each one sample type. Those will be our initial result for final evaluation:

***Table 1**. Hybrid composite material tension test results – samples with shear of natural fibres (Figure 5)*

Sample	Strength [N]	Averages strength [N]	Fracture limit [MPa]	Avareges fracture limit [MPa]
K1	3964	3437,33	133	125
K2	3632		155	
K3	2716		87	
B1	3047	3162,67	110	123,67
B2	3720		138	
B3	2721		123	
S1	3010	3170	73	73
S2	3047		69	
S3	3453		77	
J1	4915	3386	204	142,67
J2	2522		106	
J3	2721		118	

***Table 2**. Hybrid composite material tension test results – samples with 25cm fibres (Figure 6)*

Sample	Strength [N]		Fracture limit [MPa]	
KV1	5163	5444,33	115	115
KV2	6235		129	
KV3	4935		101	
BV1	7154	6738,67	114	122,33
BV2	6490		122	
BV3	6572		131	
SV1	6116	6805,67	82	89
SV2	7873		101	
SV3	6428		84	
JV1	6357	6036	131	127,67
JV2	6517		141	
JV3	5234		111	

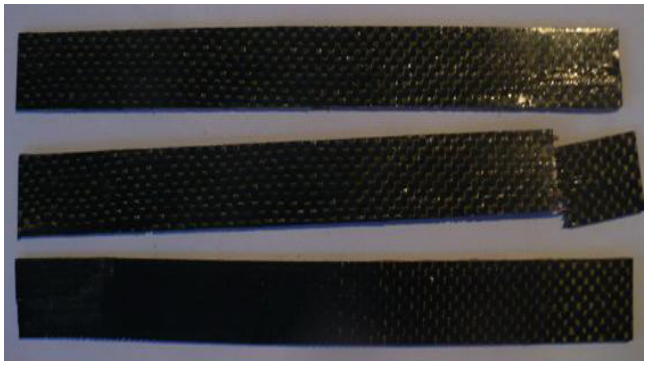

***Figure 6**: Beaked samples after testing (samples JV1, JV2, JV3)*

Impact test at a bending

For impact test at a bending we´ve used the Charpy´s pendulum. The weight of the pendulum has been 150g. Measured value is the work and the results value is toughness of the material. The toughness has been counted as W – work to s – cross-section surface.

For impact test we´ve prepared five samples of four composite´s types:

1. *samples K made from 2 layers of carbon and 1 layer of hemp shear*
2. *samples B made from 2 layers of carbon and 1 layer of cotton shear*
3. *samples S made from 2 layers of carbon and 1 layer of sisal shear*
4. *samples J made from 2 layers of carbon and 1 layer of jute shear*

Table 3 show results of samples testing.

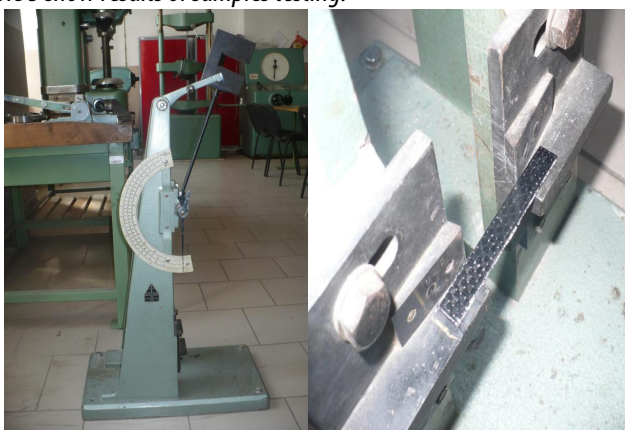

***Figure 7**: Charpy´s pendulum (left) and placing the sample for testing (right).*

***Table 3.** Impact testing results*

Sample	Outcome [kg.cm]	Work K [J]	S_0 [cm^2]	KC [J]
K1	10	0,981	0,094	10,44
K2	10,5	1,03005	0,119	8,66
K3	6,5	0,637	0,094	6,78
K4	10,5	1,03005	0,119	8,66
K5	8,5	0,83385	0,094	8,87
B1	6,5	0,63765	0,108	5,9
B2	5,5	0,53955	0,111	4,86
B3	6,5	0,63765	0,108	5,9
B4	9	0,8829	0,12	7,36
B5	7,5	0,73575	0,111	6,63
S1	7,5	0,73375	0,164	4,49
S2	8	0,7848	0,164	4,79
S3	7	0,6867	0,176	3,9
S4	10	0,981	0,179	5,48
S5	8	0,7848	0,164	4,79
J1	7,5	0,73575	0,096	7,66
J2	8	0,7848	0,095	8,26
J3	6,5	0,63765	0,092	6,93
J4	7,5	0,73575	0,095	7,74
J5	8	0,7848	0,096	8,18

***Figure 8**: Charpy´s hammer test samples after testing (test samples J).*

RESULTS

For results interpretation we´ve calculated arithmetical average of results for every sample´s types.

Composite material tension test

For this kind of test we´ve evaluated two parameters – failure force needed to breaking the sample and the fracture limit of sample.

As you can see, the second type samples - made from 2 layers of carbon and 1 layer of 250mm natural fibres, needed higher tensile strength to break as the samples of first type.

As in the graph shown is, the strength needed for breaking the samples with the 250 sisal fibres is 53,4% higher than the strength for breaking the shear samples. Finally there is a makeable difference between the sample´s type, and it´s clear that the samples with 250 fibres account better results.

Maximum and minimum strength needed for breaking the sample is shown in next table.

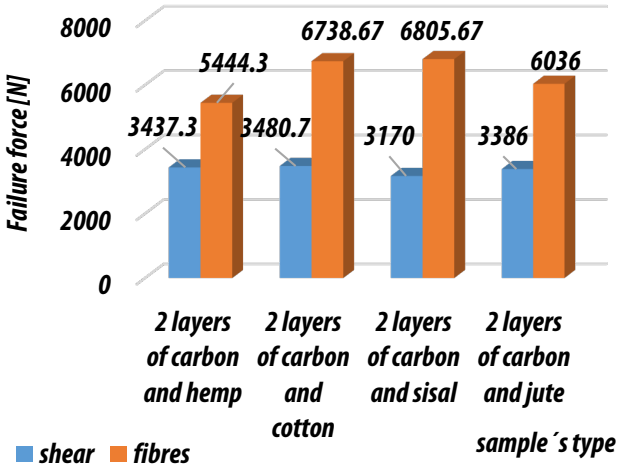

Figure 9*. Graph of the dependencies between strength and sample type by static tensile test*

Table 4 *.Strength needed for breaking the samples*

First type samples (natural shear)	
Maximum strength	3480,7N – cotton shear
Minimum strength	3170N – sisal shear
Second type samples (250mm natural fibres)	
Maximum strength	6805,67N – sisal fibres
Minimum strength	6036N – jute fibres

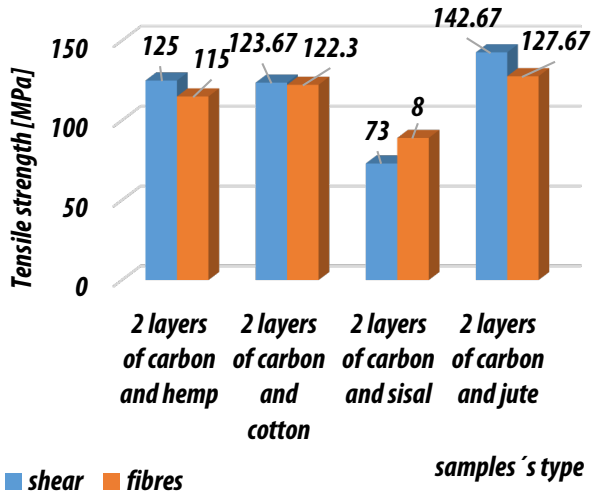

Figure 10*. Graph of the dependencies between tensile strength and sample type by static tensile test*

Results of tensile strength testing doesn't matched with the result of "strength needed for breaking the samples" measuring. As the results show, higher fracture limit have mostly the first type samples made from natural shear.

Table 5*. Fracture limit results*

First type samples (natural shear)	
Maximum fracture limit	142,67MPa – jute shear
Minimum fracture limit	73MPa – sisal shear
Second type samples (250mm natural fibres)	
Maximum fracture limit	127,67MPa – jute fibres
Minimum fracture limit	89 MPa – sisal fibres

Impact test at a bending

Next table (Table 6) and graphs on Figure 11 and Figure 12, are showing arithmetical average of needed work for sample breaking and the tenacity. The test has been taken only for first type samples (natural shear).

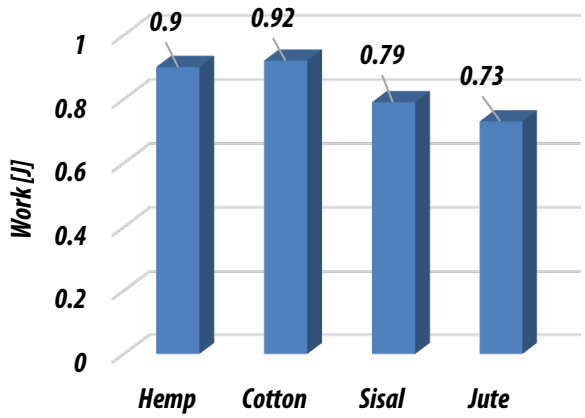

Figure 11. *Graph of the work in the impact at a bending test*

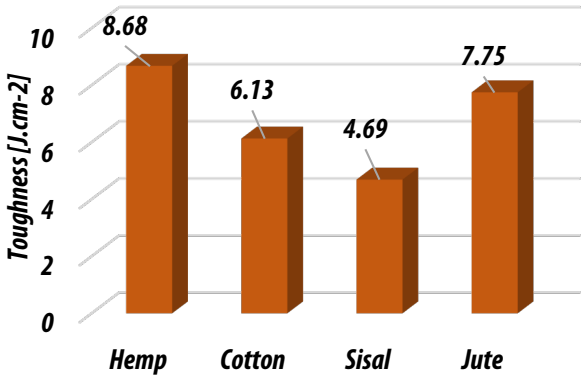

Figure12*. Graph of the toughness in the impact at a bending test*

Table 6*. Work and tenacity results*

Maximum work	0,92J – cotton shear
Minimum work	0,73J – jute shear
Maximum tenacity	8,68J – hemp shear
Minimum tenacity	4,69J – sisal fibres

COMPOSITES SAMPLES CONFRONTATION

Because one of our goals of the experiment was to define the ability of using the natural materials, we needed some confrontation with pure - in our case carbon composite. We´ve used the result of another experiment made on our department [3].

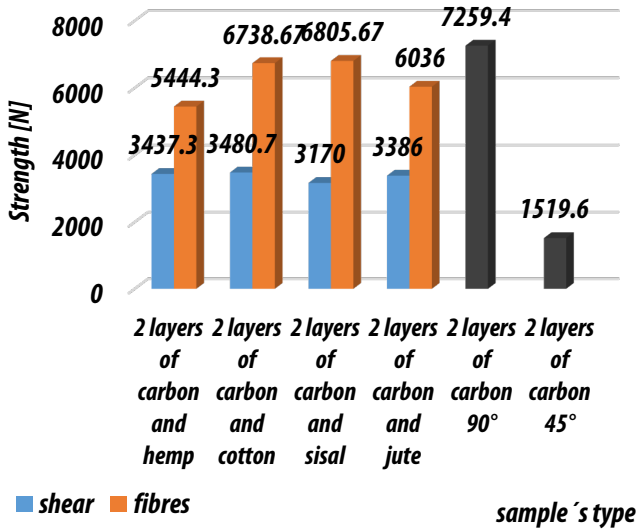

***Figure 13**. The confrontation graph of breaking strength of the samples with natural fibres and the pure carbon samples*

For comparing we´ve choose 2 samples: made from 3 carbon layers laid under 90° angle, and made from 3 carbon layers laid under 90° angle. These samples have had the best results in mentioned experiment [3]. The comparing of tension test results can be seen in the next graph.

This graph shows that the samples made from tree carbon layers laid under 90° angle needed the biggest strength of 7259,4 MPa to break[3]. The biggest strength needed to break the hybrid composite is 6805,67 MPa by composite with sisal. That is 6,25% less than pure carbon sample. The carbon samples laid under 45° are very weak also against samples with natural fibres.

The results of samples with sisal fibres are comparable to pure carbon samples, what suggests that the hybrid composites with natural fibres have some potential to be used. The availability, ecological potential, and price of the hybrid composites can compete another composite materials

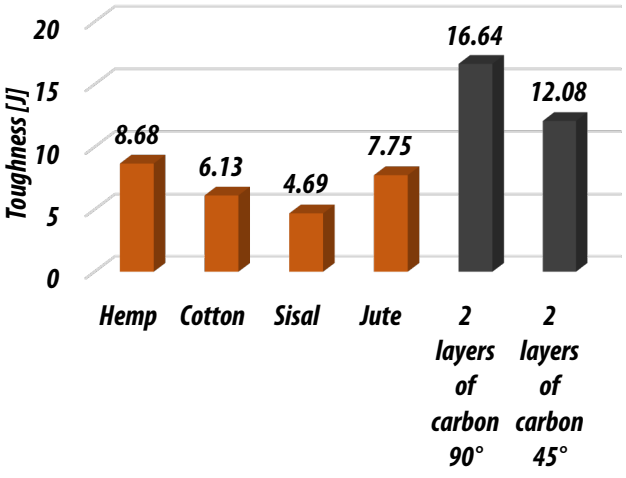

***Figure 14**. The confrontation graph of toughness of the samples with natural fibres and the pure carbon samples*

As you can see on the graph above, the highest tenacity have had the samples made from 3 layers of carbon fibre laid under 90° angle – 16,64J [3]. The hybrid composites samples are in the tenacity comparison much worse. The best results show composites with hemp shear – 8,68J, what is 47,83% less than the best result.

WEIGHT OF THE SAMPLES

One of the main composites advantage is their weight. Weight of the samples made whole from carbon (3 layers, size of sample: 250x25mm) [3] is 4,6g. Hybrid composite samples with the same size made from 2 layers of carbon and for example sisal shear is 8g. Weight of the samples made from 2 layers of carbon and sisal fibers is up-to 16g. That is up-to 76% more by shear and by fibers sample up-to 247% more. This results are disadvantageous, and we can say that hybrid composites are losing in this parameter.

CONCLUSION

In the 21th century, there is an enormous demand to create new, better, harder, lighter, ecologically materials. Especially car industry must complywith more and more reduced natural fuel sources, and new materials are one of the best ways to do it.With focusing on the new materials potential, the primary goal of this work/paper was to find out if the hybrid composites that combined the carbon fibres and natural fibres can compete another materials, especially purely carbon composites, which have the incomparable properties.

The results shows that the hybrid composites aren't able to compete the composites from carbon fibres.Strength needed to break the first type sample was double and by the second type minimal against strength needed to break pure carbon sample and the fracture limit difference was about triple over. Also tenacity results were double to triple less the by pure carbon samples.

The problem can also be the production technology of applying the natural fibres, because as we find out during the experiment, it´s difficult to lay precisely thick layer the natural fibres. Another disadvantage is the weight of hybrid composites. This, for car production important variable, emerge as very problematic. Natural fibres are able to change their volume, and so they can absorb more resin and so to magnify their weight. It´s been showed that pure carbon composites are double to triple lighter as the hybrid composites.

Only benefit of the hybrid composites is that their come from nature and are ecological. Natural fibres will probably never compete the artificially produces fibres in this kind of industry. We can use them in the interior or another part of cars, but their strength properties aren't suitable for applying for example in the construction of a car.

Acknowledgment:

This article was prepared within the solution of a grant objective VEGA 1/0600/13 – Research and development of progressive composite coatings and layers for mechanical parts innovation.

References

[1.] MORAVČÍK, Roman – HAZLINGER, Marián – HUDAKOVÁ, Mária – MARTINKOVIČ, Maroš – ČIČKA, Roman: Náuka o materiáloch I. Trnava: AlumniPres, 2010. 249 s. ISBN 978-80-8096-123-7

[2.] Composites with ceramic matrix (CMCs) [online]. Available online: <http://www.matnet.sav.sk/index.php?ID=1122>.

[3.] *MURZA, Bc. Mário: Evaluation of selected mechanical properties of fiber composite automotive components. Diploma work. Košice: Technical University of Košice, Mechanical Faculty, 2013. 68 s.*

[4.] *MANGINO, Enrico, Joe CARRUTHERS a Giuseppe PITARRESI. The future use of structural composite materials in the automotive industry [online]. International Journal of Vehicle Design: The Journal of the International Association for Vehicle Design. Geneva: Inderscience Enterprises Ltd., 2007, Volume 44, 3-4, s. 211-232. DOI: 10.1504/IJVD.2007.013640. Available online: <citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.138.1771 &rep=rep1&type=pdf>.*

[5.] *VARGA, Bc. Peter: Testing of components made from composite materials,Diploma work. Košice: Technical University of Košice, Mechanical Faculty, 2013. 85 s.*

[6.] *DÚBRAVČÍK, Michal: Application of Natural Fibres in Hybrid Composite Materials, Materials Science Forum Vol 818 (2015) pp 311-315, (2015) Trans Tech Publications, Switzerland, 10.4028/www.scientific.net/MSF.818.311*

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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ELECTROANALYSIS OF ASCORBIC ACID (VITAMIN C) USING A CLAY MODIFIED CARBON PASTE

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Abstract: Ascorbic acid (Vitamin C) is a water soluble organic compound that participates in many biological processes. This paper reports the synthesis of Clay modified carbon paste electrode and its application for the electrochemical detection of ascorbic acid (AA). The influence of variables such the concentration of ascorbic acid adsorbed onto Clay, and the pH of solution were tested. The capacity of prepared electrode (Clay-CPE) for selective detection of AA was confirmed in a sufficient amount of ascorbic acid. The observed linear range for the determination of AA concentration was from 1.13 mM to 5.68 mM.
Keywords: Ascorbic acid; Carbon paste electrode; cyclic voltammetry; Electrochemical detection

INTRODUCTION

Ascorbic acid AA (vitamin C) is a water soluble organic compound involved in many biological processes. AA is used in large scale as an antioxidant in food, animal feed, beverages, pharmaceutical formulations and cosmetic applications. It is also important in helping to produce collagen, a protein needed in the development and maintenance of bones, cartilage, joint limings, skin, teeth, gums and blood vessels [1-3]. Due to the above importance of AA, its determination in their solution is more important. Many analytical techniques including sensors and biosensors [4 – 6] have been suggested for a detection of ascorbic acid in very varied types of samples. Other methods, based on the most commonly employed physico-chemical methods for identification of AA such high performance liquid chromatography [7-9] or capillary electrophoresis [10-13]. Investigations aimed at the development of modern analytical techniques for AA determination are directed towards increasing their sensitivity, specificity, simplicity and rapidity [14-17]. Electrochemical detection is an attractive alternative method for detection of electroactive species, because of its inherent advantages of simplicity, ease of miniaturization, high sensitivity and relatively low cost. In this paper, we describe the electrochemical analysis of ascorbic acid on a clay modified carbon paste electrode. The electrochemical characterization of adsorbed electroactive AA was evaluated using cyclic voltammetric (CV) and Electronic Impedance Spectroscopy (EIS) analysis.

EXPERIMENTAL

Apparatus and software

Voltammetric experiments were performed using a voltalab potentiostat (model PGSTAT 100, Eco Chemie B.V., Utrecht, The Netherlands) driven by the general purpose electrochemical systems data processing software (voltalab master 4 software) run under windows 2007. The three electrode system consisted of a chemically modified carbon paste electrode as the working electrode a saturated calomel electrode (SCE) serving as reference electrode, and platinum as an auxiliary electrode.

Electrodes

Modified electrodes were prepared by mixing a carbon powder and the desired weight of clay. The body of the working electrode for voltammetric experiments was a PTFE cylinder that was tightly packed with carbon paste. The geometric area of this electrode was 0.1256cm^2. Electrical contact was made at the back by means of a bare carbon.

Procedure

The initial working procedure consisted of measuring the electrochemical response at Clay-CPE at a fixed concentration of AA. Standard solution of AA was added into the electrochemical cell containing 100 mL of supporting electrolyte. The mixture solution was kept for 20 s at open circuit and deoxygenated by bubbling pure nitrogen gas prior to each electrochemical measurement. The cyclic voltammetry was recorded in the range from -0.6 V to 1,5 V. Optimum conditions were established by measuring the peak currents in dependence on all parameters. All experiments were carried out under ambient temperature.

RESULTS AND DISCUSSION

Surface characteristics

The morphology of the electrode surface of Clay was observed by scanning electron microscopy (Figure 1). We find that the matrix is formed by compact particles fractions between 1 and 15 /m. Clay treaty has the following chemical composition given by transmission electron microscopy (TEM): O (22%), Mg (5.4%), Al (22.4%), K (2.7%), Ca (1%), Ti (1.8%) Fe (17.1%), Si (27.8%) and more metals order ppm (Figure 2). An examination of clay modified carbon paste electrode indicates some kind of agglomeration.

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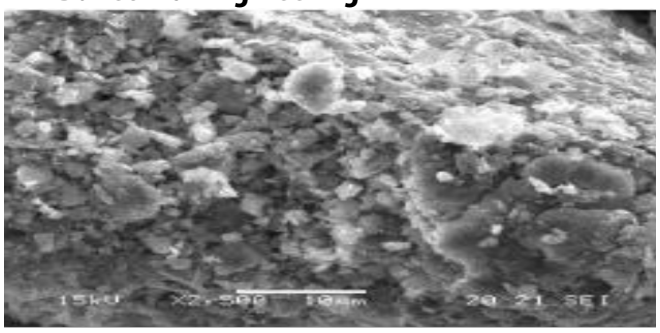


***Figure 1**: Scanning electron micrograph of Clay paste electrode.*

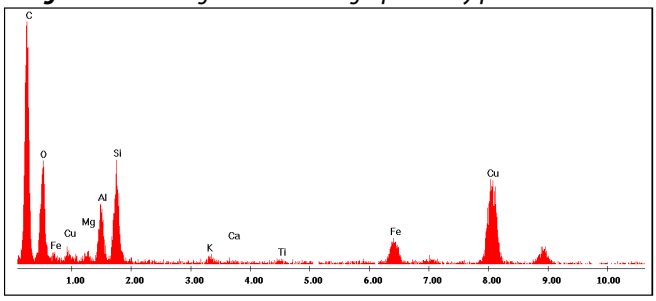


***Figure 2:** Chemical composition treated clay*

Electrochemical detection of ascorbic acid

Figure 3 shows a cyclic voltammograms (CV) in the potential range -0.6 V to 1.5 V recorded, respectively, for carbon paste and clay modified carbon paste electrode at 100 mV.s $^{-1}$. The voltammograms take different forms. No peak is observed in the case of Clay-CPE, it is recognized that carbon surface was effectively modified by clay.

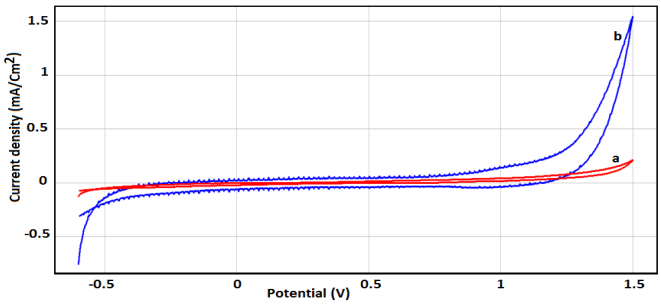


***Figure 3**: Cyclic voltammograms recorded for CPE (a) and bare Clay-CPE (b), in 0.1 M Na_2SO_4 at 100 mV/s*

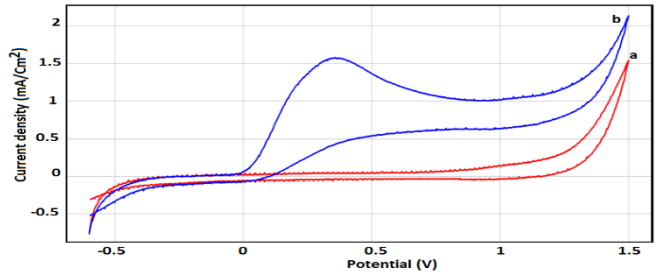
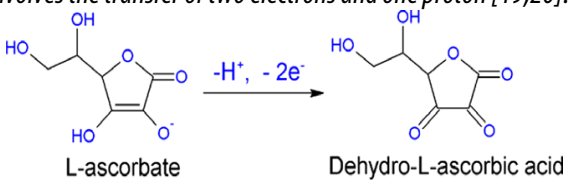


***Figure 4:** CVs recorded for 2.67 mM AA at pH=7 at bare Clay-CPE (a) and Clay-CPE/AA (b), scan rate 100 mV/s, preconcentration time (tp)= 6min*

The voltammograms of the Na2SO4 buffer as well as 2.27mM ascorbic acid in the buffer are shown as I and II in figure 4. No anodic peak current was observed in the voltammogram of the buffer but was observed at 0.42V in the 2.27 mM ascorbic acid solution in the buffer as shown in II of figure 4. No cathodic peak current was found indicating an irreversible heterogenous charge transfer in this system [18].

The scheme shows the oxidation of L-ascorbate to dehydro-L-ascorbic acid involves the transfer of two electrons and one proton [19,20].



***Scheme:** mechanism of electrochemical oxydation reaction of AA at Clay/CPE*

Optimization of experimental conditions

Optimum conditions for the electrochemical response were established by measuring the peak current in dependence on all parameters.

= ***Influence of accumulation time***

Figure 5 shows the effect of the accumulation time; this significantly affects the oxidation peak current of AA. The peak current of 2.27 mmol L^{-1} AA increases greatly within the first

6min. Further increase in accumulation time does not increase the amount of AA at the electrode surface owing to surface saturation, and the peak current remains constant. This phenomenon is due to the cavity structure of clay-CPE that improves the ability of the electrode to adsorb electroactive AA. Maybe this is attributed to the saturated adsorption of AA on the Clay–CPE surface. Taking account of sensitivity and efficiency, accumulation time was 6 min in the following experiments.

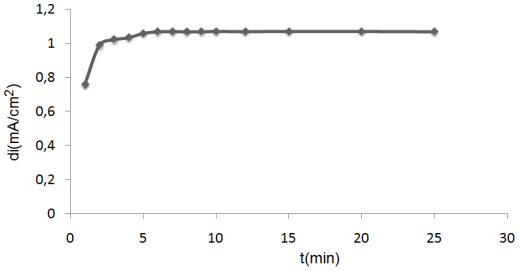


***Figure 5:** Effects of accumulation time on oxidation peak currents of 2.27 mmol L^{-1} AA (pH=7) at Clay-CPE, supporting electrolyte is Na_2SO_4 0.1M*

= ***Effect of scan rate***

The influences of scan rate on the oxidation peak potential (Ep) and, peak current (Ip) of AA, (0.1M Na_2SO_4, pH=7) were studied by cyclic voltammetry. The figure 6 shows both the anodic currents linearly increase with the scan rate over the range of 60 to 160 mVs-1, the oxidation potential of AA moves to positive values, suggesting that the electron transfers for AA at the clay modified CPE is adsorption controlled reaction. The figure 7 shows the linear relationship between the scan rate anodic peak currents of AA at Clay/CPE.

Calibration graph

In order to obtain an analytical curve for the developed sensor, we carried out cyclic voltammograms for oxidation an AA at different concentrations in 0.1mol L^{-1} Na_2SO_4 (pH=7) at a sweep rate of 100 mVs^{-1}. Figure 8 shows the CV curves of different concentration of AA at Clay/CPE was increased from 1.13 mM to 5.68 mM. The anodic peak current increases linearly with the concentraton of AA (Figure 9). These results show that ascorbic acid concentration can be measured quantitatively by cyclic voltammetry.

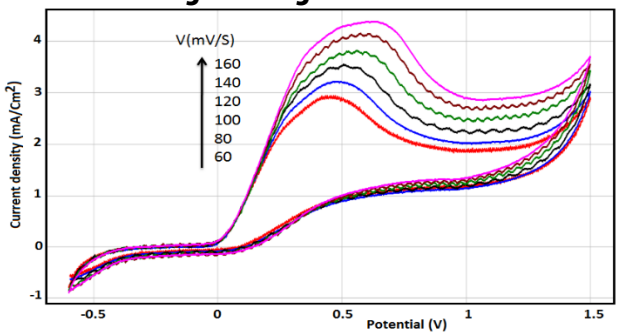


***Figure 6**: CVs acquired on Clay-CPE with 4.5 mM AA in the buffer solution at different scan rates from 60 to 160 mV.s^{-1}. Inset is the plot of the peak current of AA versus scan rate*

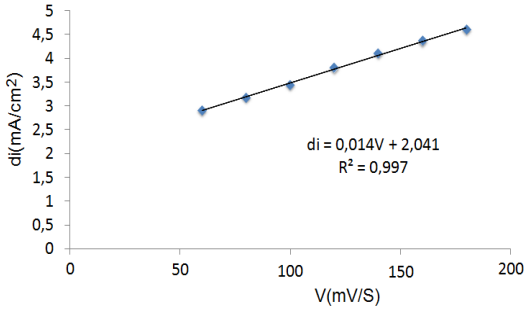


***Figure 7:** Plot of peaks area versus scan rate*

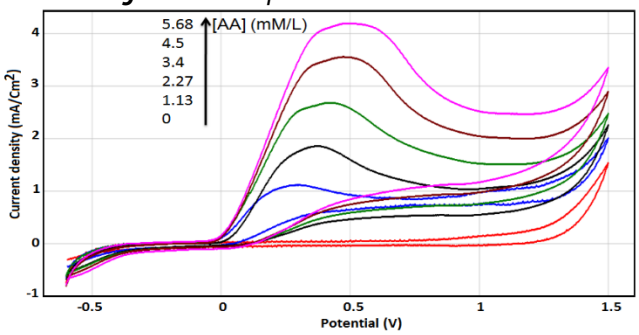


***Figure 8:** Cyclic Voltammograms of different concentration of AA (1.13mM to 5.68mM) at Clay/CPE in 0.1 M Na_2SO_4 pH=7, Scan rate 100 mV/s*

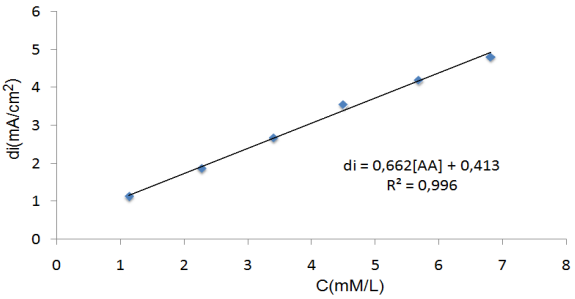


***Figure 9:** Plot of peaks area versus added concentration of AA*

Figure 10 shows the behavior of impedance diagrams recorded for clay modified carbon paste electrode in buffer solution, in the presence of different concentrations of AA compound. We conclude that modified electrode reacts with the studied compound.

Effect of pH

The effect of varying pH on the current response of Clay modified carbon paste electrode at constant ascorbic acid concentration (6.81 mM) is shown in Figures 11 and 12. As can be seen, the peak current gradually reduce with the increase of pH.

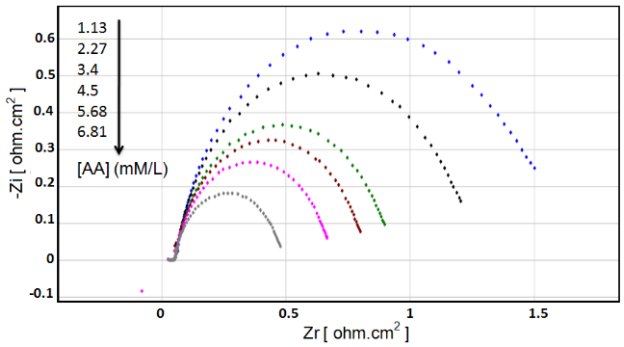


***Figure 10:** Nyquist diagrams of clay modified carbon electrode, in presence of different concentration of AA, at open circuit potential*

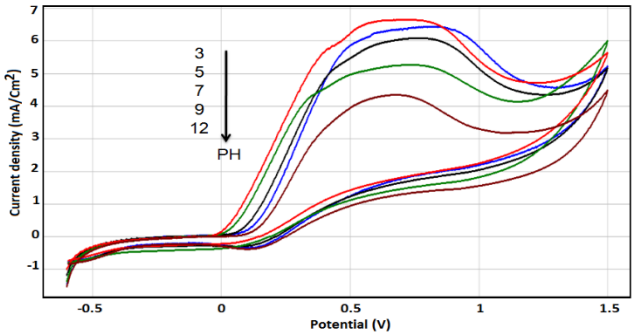


***Figure 11:** Effect of pH on the oxidation of AA at the Clay modified CPE*

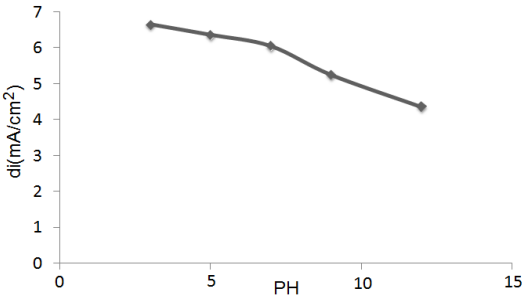


***Figure 12:** Plot of the relationship between solution pH and the oxidation peak Current.*

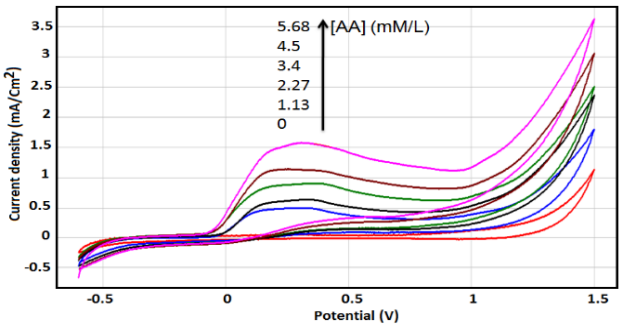


***Figure 13:** Cyclics Voltammograms of different concentration of AA (1.13mM to 5.68mM) at Clay/CPE in 0.1M Na_2SO_4, Scan rate 100 mV/s*

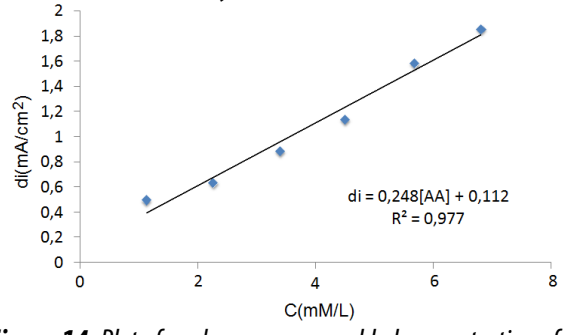


***Figure 14:** Plot of peaks area versus added concentration of AA*

DETERMINATION OF AA IN PHARMACEUTICAL SAMPLE

In order to evaluate the performance of Clay-modified carbon paste electrode by practical analytical applications, the determination of AA was carried out in A, vitamin C tablet is finely powdered. The analytical curves were obtained by CV experiments in supporting electrode (Figure13). It was founded that the peaks currents increase linearly versus AA added into the buffer solution (Figure 14).

CONCLUSION

It was demonstrated here that Clay modified electrode exhibits higher electrocatalytic activity towards ascorbic acid oxidation. The obtained results revealed that determination of AA can be easily performed using the clay. The proposed methodology was successfully applied in quantifying ascorbic acid in electrolyte solution with very satisfactory recovery percentages values for the application of the analytic methods proposed. The sensitivity signal is proportional to the concentration value of AA.

REFERENCES

[1.] J.Velisek; K.Cejpek, J.Czech.: Biosynthesis of food constituents: Vitamins. 2. Water-soluble vitamins :Part 1 – a Review, Food Sci. 25 (2) 49-64, 2007.
[2.] C.L.Linster; E.Van Schaftingen: Vitamin C, Febs J. 274 (1)1-22, 2007.
[3.] M.W.Davey; M.Van Montagu; D.Inze; M.Sanmartin; A.Kanellis; N.Smirnoff; I.J.JBenzie; J.J.Strain; D.Favell: Plant L-ascorbic acid: chemistry, function, metabolism, bioavailability and effects of processing J. Sci. Food Agric. 80 (7) 825-860, 2000.
[4.] I. F. Abdullin, E. N. Turova, G. K. Ziyatdinova, G. K. Budnikov : Potentiometric Determination of Ascorbic Acid: Estimation of Its Contribution to the Total Antioxidant Capacity of Plant Materials, Journal of Analytical Chemistry, 57 (4) 353-355, 2002.
[5.] Y.Wang; H.Xu; J.M.Zhang; Li. : Electrochemical Sensing in Paper-Based Microfluidic Devices Sensors 8 (11) 2043-208, 2008.
[6.] U.Yogeswaran; S.M.Chen.: A review on the electrochemical sensors and biosensors composed of nanowires as sensing material Sensors 8 (1) 290-313, 2008.
[7.] W.A.Behrens; Madere: A Highly Sensitive High-Performance Liquid-Chromatography Method for the Estimation of Ascorbic and Dehydroascorbic Acid in Tissues, Biological-Fluids, and Foods Anal. Biochem. 165 (1) 102-107, 1987.
[8.] R.Shakya; D.A.Navarre, J. Agric.: Changes in the Antioxidant Activity During the Development in Fruits of Psidium cattleianum Sabine Food Chem. 54 (15) 5253-5260, 2006.
[9.] A.J.Melendez-Martinez; I.M.Vicario; F.J.Heredia: Provitamin A carotenoids and ascorbic acid contents of the different types of orange juices marketed in Spain, Food Chem. 101 (1) 177-184, 2007.
[10.] J.Wang; M.P.Chatrathi; B.M.Tian; R.Polsky: A microfluidic chip for ammonium sensing incorporating ion-selective membranes formed by surface tension forces Anal. Chem. 72 (11) 2514-2518, 2000.
[11.] M.W.Davey; G.Bauw; Van Montagu.: Simultaneous High-Performance Capillary Electrophoresis Analysis of The Reduced and Oxidized Forms of Ascorbate and Glutanathione, J.Chromatogr. B 697 (1-2) 269-276, 1997.
[12.] B.Klejdus; J.Petrlova; D.Potesil; V.Adam; R.Mikelova; J.Vacek; R.Kizek; V.Kuban: Simultaneous determination of water- and fat-soluble vitamins in pharmaceutical preparations by high-performance liquid chromatography coupled with diode array detection, Anal. Chim. Acta 520 () 57-67, 2004.
[13.] W. Okiei, M. Ogunlesi, L. Azeez, V. Obakachi, M. Osunsanmi, G. Nkenchor: The Voltammetric and Titrimetric Determination of Ascorbic Acid Levels in Tropical Fruit Samples, Int. J. Electrochem. Sci., 4 (9) 276 – 287, 2009.
[14.] B.P.KLEIN and A.K. PERRY: Ascorbic Acid and Vitamin A Activity in Selected Vegetables from Different Geographical Areas of the United States, J. Food Science 47(3) 941 – 945, 2006.
[15.] L.Casella, M.Gullotti, A.Marchesini: Rapid Enzymatic Method for Vitamin C Assay in Fruits and Vegetables Using Peroxidase, J. Food Science 54(2) 374 – 375, 2006.
[16.] M. M. Rahman, M. R.Khan, M. M. Hosain: Analysis of Vitamin C (ascorbic acid) Contents in Various Fruits and Vegetables by UV-spectrophotometry, 42 (4) 417-424, 2007.
[17.] S.Tilahun, P. Paramaguru, B. Rajamani : Capsaicin and Ascorbic Acid Variability in Chilli Paprika Cultivars as Revealed by HPLC Analysis, J. Plant Breed. Genet. 01 (02) 85-89, 2013.
[18.] A. M. Pisoschi , A. Pop , G. P. Negulescu ,A.. Pisoschi : Determination of Ascorbic Acid Content of Some Fruit Juices and Wine by Voltammetry Performed at Pt and Carbon Paste Electrodes, Molecules 16 (10) 1349-1365, 2011.
[19.] A. Malinauskas, R. Garjonyte, R. Maz˘eikiene, I. Jurevic iute: Electrochemical response of ascorbic acid at conducting and electrogenerated polymer modified electrodes for electroanalytical applications: a review , Talanta 64 (1) 121-129, 2004.
[20.] A. S. Lamari, A. El fattouh. S. El Quatli, R. Najih, A.Chtaini : Electrochemical Detection of Ascorbic Acid Using A Polymer Modified Carbon Paste Electrode , Acta Technica Corviniessis–Bulletin of Engineering 2 (8) 39-42, 2013

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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COOLING THE INTACT LOOP OF PRIMARY HEAT TRANSPORT SYSTEM USING SHUT DOWN COOLING SYSTEM AFTER EVENTS SUCH AS LOCA

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Abstract: Power and energy industries have their unique challenges but they all need to rely on the efficient running of their piping systems and therefore optimum design and continual effective maintenance are essential. The ability to ensure accurate delivery of a product and raw materials, especially over long distances and significant elevation change is vital to the overall operation and success of a process plant. For such analysis Flowmaster is a useful code. The purpose of this paper is to model the shutdown cooling system (SDCS) operation for CANDU 6 nuclear power plant in case of LOCA accident, using Flowmaster calculation code by delimitating models and setting calculation assumptions, input data for hydraulic analysis, assumptions for the calculation and input data for calculating thermal performance check for heat exchangers that are part of this system.

Keywords: CANDU, HYDRAULIC, LOCA, THERMAL

INTRODUCTION

Power and energy industries have their unique challenges but they all need to rely on the efficient running of their piping systems and therefore optimum design and continual effective maintenance are essential. The ability to ensure accurate delivery of a product and raw materials, especially over long distances and significant elevation change is vital to the overall operation and success of a process plant. For such analysis Flowmaster is a useful code. This code has been applied for analysis of systems of CANDU reactors because of the possibility of defining by the user the incompressible and compressible fluids and also the solid materials based on thermodynamic and thermo-physical properties of these models based on the corresponding generic database of the program.

Considering this, the following paper has analyzed the failure operating modes for loss of coolant accident (LOCA) defined in the design documentation.

The first chapter of the study provides an overview of the shutdown cooling system and an overview of the operating modes of the system. Also in this section is presented a summary of the LOCA accident, both general considerations and aspects of nuclear safety.

Furthermore is performed the modeling of the Shutdown Cooling System (SDCS) in case of accident mode, using Flowmaster calculation code, by delimiting models and developing supportable computing assumptions of the geometric configuration and input data for hydraulic analysis and the calculation assumptions and input data for thermal calculation in order to verify the functioning of the heat exchangers that are part of this system.

Abnormal operating conditions for the Shutdown Cooling System were analyzed using Flowmaster calculation code and then was made a comparison of the results with data obtained from a series of models developed in PIPENET.

From the results of thermal-hydraulic analysis and comparison with data from the runnings performed with PIPENET was found that in all operating conditions of the system in case of LOCA accident type, performance requirements specified in the design documentation are confirmed by analysis. After modeling the Shutdown Cooling System, its functionality was demonstrated by achieving the required performance.

OVERVIEW OF THE SHUTDOWN COOLING SYSTEM AND THE COMPUTER CODE USED FOR ANALYSIS

The Shutdown Cooling System (SDCS) is provided to cool the Primary Heat Transport System (PHTS) from 177°C to 54°C and hold the system at 54°C for an indefinite period of time.

During normal operation with the reactor at power, the SDCS is kept full with heavy water at 38°C (100°F) and pressure at or just above atmospheric.

There are two cool down options available. The initial phase of the two options is similar and involves the use of the CSDV's (Condenser Steam Discharge Valves) to lower the PHTS temperature from 260°C at the rate of 2.8°C/min. During this phase, the PHTS pumps circulate the coolant through the steam generators. If the SDCS pumps are to be used in the next phase of cool down, the PHTS temperature has to be brought down to 149°C first through the CSDV's. Cool down to 54°C at the rate of 2.8°C/min is carried out using the SDCS pumps and heat exchangers (HX).

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A. Operating the SDCS in case of LOCA

Following a Large LOCA, with or without Class IV power, SDCS is required to cool the PHTS intact loop. For the first 900 seconds (15 minutes) upon receipt of the LOCA signal, the Moderator Temperature Control (MTC) program controls the "moderator rapid cool down". Following the first 900 seconds after LOCA, the re-circulated cooling water flow rate of 200 L/s, is made available to the SDCS by limiting the opening of the large temperature control valves (an MTC program action) to limit the flow to the heat exchangers.

In this case, for cool down of PHTS intact loop, the operator has to bring in the SDCS manually following a large LOCA, which will act, as a backup heat sink for thermo-syphoning for intact loop.

In this paper was analyzed the case of cooling the intact loop of the PHTS, using the SDCS after 15 minutes or 30 minutes from the initiation of LOCA, using both pumps and heat exchangers of shutdown cooling system and also the case when can be used only one pump and one heat exchanger (Class IV or Class III available).

Loss of coolant accident, LOCA is the most severe challenge of all security systems asking for the majority of project requirements for these systems.

B. Fundamentals in FLOWMASTER

For the development of thermal-hydraulic analysis of the shutdown cooling system was used the computing program Flowmaster V7.8. Mentor Graphics, from Wilsonville, Oregon, USA, is the software manufacturer. Flowmaster is a one-dimensional thermal-hydraulic calculation code for dimensioning, analyzing and verifying the pipeline systems operation.

This code provides a graphical virtual working environment and allows the design, redefine and test the whole system of the fluid flow.

Steady state or transient modules of Flowmaster code for single-phase fluids were designed specifically in order to model the heat transfer effects in many application areas. The modules allow users to develop transient analysis for such kind of events.

Each component of Flowmaster is a mathematical model for an equipment that is included in a facility.

Selected components are connected via nodes in order to form a network, which constitutes a computerized model of the system.

The equations which govern the mathematical model developed in Flowmaster are:

≡ the mass conservation equation:

$$\frac{\partial \rho}{\partial t}+\frac{\partial}{\partial x}(\rho u)+\frac{\partial}{\partial y}(\rho v)+\frac{\partial}{\partial z}(\rho w)=0 \qquad (1)$$

≡ energy conservation equation:

$$E_{in}+E_g-E_{out}=E_{st}, \qquad (2)$$

where: E_{in} is the energy entered into the system; E_g is the energy generated by the fluid volume within the system; E_{out} is the energy discharged from the system; E_{st} is the energy stored in the fluid volume.

≡ momentum conservation equation:

$$\rho g_x-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right)=\rho\frac{du}{dt} \qquad (3)$$

$$\rho g_y-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right)=\rho\frac{dv}{dt} \qquad (4)$$

$$\rho g_z-\frac{\partial p}{\partial z}+\mu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right)=\rho\frac{dw}{dt} \qquad (5)$$

These equations require that the same amount of energy, mass and momentum that enters into a volume must leave the volume. Equations (3), (4) and (5) are the Navier-Stokes equations. From the Navier-Stokes equation can be derived Bernoulli (6). This is a relationship between the pressure and the velocity along the height of a volume of fluid.

$$\frac{v^2}{2g}+z+\frac{p}{\rho g}=C \qquad (6)$$

where: v=velocity; g=gravity acceleration; z = height; p = static pressure; ρ = density; c = constant.

A Flowmaster network contains a number of components (pipes, tubing, pumps, fans, flow and pressure sources, etc.) and links between them. Points in which some components are linked to other components are called nodes.

When a network is prepared for simulation, each component and node must have a unique label. Filling the entire schematic representation (Flowmaster network) is an essential part of any simulations.

The nodal diagram (Flowmaster network) achieved consisted of a sequence of segments separated by nodes, which represent portions of pipe trails sections, without diameter or branches variations along them. Various equipments or components (except for retaining tabs) are represented by pressure loss coefficients.

For simulating, using Flowmaster code, the heavy water flow in the SDCS in order to determine the variation of pressure and flow at various points of the circuit, it was done a nodal scheme - Flowmaster network.

Flowmaster computing code is confirmed with an exact calculation of the thermal side of the analyze and with PIPENET program on the hydraulic side of it.

APPLICATION OF FLOWMASTER CODE IN THERMAL-HYDRAULIC ANALYSIS OF THE SDCS

A. Models and computing hypotheses

In order to develop the thermal-hydraulic analysis of the shutdown cooling system, in case of LOCA, were done the following calculation models that cover the requirements of the design theme.

≡ **Model I.** Hydraulic calculation model for operating in failure mode type LOCA for the shutdown cooling system, model in which the cooling of the PHTS is started at 177 °C using heat exchangers, HX1 and HX2, to provide the cold source, while the circulation will be maintained by the SDCS pumps, P1 and P2.

≡ **Model II.** Hydraulic calculation model for operating in failure mode type LOCA for the shutdown cooling system, model in which the cooling of the PHTS is started at 177 ° C using one heat exchanger, HX1 or HX2, to provide the cold source, while the circulation will be maintained by one of the SDCS pumps, P1 or P2.

≡ ***Model III.*** *Thermal calculation model for the heat exchangers, HX1 and HX2, related to the shutdown cooling system, for operating in failure mode of the shutdown cooling system. For this case the heat exchangers HX1 and HX2 are cooled with water flow coming from the intermediate cooling water system. The inlet temperature considered on the secondary side of the heat exchangers is 30℃. In model III, the shutdown cooling system is working with its associated pumps, P1 and P2.*

≡ ***Model IV.*** *Thermal calculation model for the heat exchangers, HX1 and HX2, related to the shutdown cooling system, for operating in failure mode of the shutdown cooling system. The heat exchangers HX1 and HX2 are also cooled with water flow coming from the intermediate cooling water system. The difference between model III and model IV is that the inlet temperature on the secondary side of the heat exchangers is 35 ℃. In model IV, the shutdown cooling system is working with both shutdown cooling system pumps.*

≡ ***Model V.*** *Thermal calculation model for the heat exchangers, related to the shutdown cooling system, for operating in failure mode of the shutdown cooling system (in which case it is used only one pump and one heat exchanger related to the shutdown cooling system). For this case the inlet temperature on the secondary side of the heat exchangers is 30 ℃.*

≡ ***Model VI.*** *Thermal calculation model for the heat exchangers related to the shutdown cooling system, for operating in failure mode of the shutdown cooling system (in which case they only use one pump and one heat exchanger related to the shutdown cooling system). The inlet temperature on the secondary side of the heat exchangers according to the manual design of the cooling water system is 35 ℃.*

For the considered analysis were made a set of design assumptions. For the hydraulic analysis the hypotheses are as follows:

» *System condition at the baseline of cooling is a state of stationary hydraulic regime;*
» *Hydraulic resistances of PHTS lines are determined taking into account the pressure drop values on these lines, for nominal operating regime;*
» *Hydraulic resistances of SDCS lines are determined taking into account the dimensional characteristics and their composition (fittings on these lines);*
» *Pumps that do not work are modeled as lines with hydraulic resistance determined from the curve of increasing pressure for the respective pumps;*
» *For the heat exchangers and steam generators we will consider only the primary circuit, that is modeled as a pipeline with the hydraulic resistance;*
» *Pressure in the system is fixed at one of the output collectors of the reactor by boundary condition.*
» *Interfaces with other systems were neglected, connecting pipes to these systems are not functional for the analyzed regimes.*

Assumptions considered for calculating thermal analysis were also set as it follows:

» *The accumulated energy in metal tubes and shell is neglected;*
» *The compressibility of the agents is neglected;*
» *In the shell and in the heat exchanger's tubes, the flow is single phase;*
» *The initial thermal condition is that the temperature in the entire system is considered the same.*
» *The paper does not take into account the preparatory steps aimed at achieving either of the necessary cooling configurations, thus neglecting transient hydraulic regimes preceding the making of one or another of the cooling schemes analyzed.*

For the accomplishment of the hydraulic calculation with the help of the calculating code Flowmaster V7, pressure values have been entered, corresponding to hydrostatic pressure determined at the output collector of the reactor by boundary condition. Thus, for all hydraulic calculation models were considered appropriate pressure values for the inlet/outlet components of the nodal scheme according to Table I.

TABLE I*. Boundary conditions for the hydraulic analysis*

Operation mode	Point position	Temperature (^{0}C)	Pressure (bar)
Model I	Output collector from the reactor (pressure source: 314)	177	95
Model II	Output collector from the reactor (pressure source: 314)	177	95

B. Description of collected data and output files

Output files for the thermo-hydraulic calculation with the Flowmaster program are structured according to the type of simulation (hydraulic or thermal) as follows:

» *Hydraulic calculation results for each component (flow, velocity, Reynolds number, pressure loss, etc.);*
» *Hydraulic calculation results in each node (pressure);*
» *Thermal calculation results suitable for components in which heat transfer occurs (thermal load, overall heat transfer coefficient , temperature difference between input and output);*
» *Thermal calculation results in each node (temperature).*

TABLE II*. Hydraulic analyze. Model I*

Component	Flow rate (l/s)
Flow through P1 SDCS	115 l/s
Flow through P2 SDCS	114 l/s
Flow through HX1 SDCS	104 l/s
Flow through HX2 SDCS	103 l/s
Flow through inlet collectors HD6, HD2, HD4, HD8	HD6 – 104 l/s HD2–1.4*10^{-10} l/s HD4–2.27*10^{-9} l/s HD8 - 103 l/s
Flow through outlet collectors HD5, HD1, HD3, HD7	HD5 - 104l/s HD1- 1.85*10^{-9} l/s HD3–1.73*10^{-9} l/s HD7 – 103 l/s
Flow through P1, P2, P3, P4 PHTS	P1 – 4*10^{-10} l/s P2–1.55*10^{-9}l/s P3 – 54 l/s P4 – 54 l/s
Flow through fuel channels R1, R2, R3 and R4	R1 – 2.15*10^{-10} l/s R2 – 50 l/s R3 – 1.79*10^{-9} l/s R4 – 50 l/s

≡ ***Model I.*** *Hydraulic calculation model for operating in failure mode for the shutdown cooling system, model in which the cooling of the PHTS starts at 177°C using heat exchangers, HX1 and HX2, (water is circulated by SDCS's pumps, P1 and P2). According to the results, calculated hydraulic parameter values are in Table II.*

≡ ***Model II.*** *Hydraulic calculation model for operating in failure mode for the shutdown cooling system, model in which the cooling of the PHTS is done at 177 °C using one heat exchanger, HX1 or HX2, to provide the cold source, while the circulation will be maintained by one of SDCS's pumps, P1 or P2.*

According to the results, calculated hydraulic parameter values are in Table III.

TABLE III*. Hydraulic analyze. Model II*

Component	Flow rate (l/s)
Flow through P1 SDCS	115 l/s
Flow through P2 SDCS	1.7 l/s
Flow through HX1 SDCS	104 l/s
Flow through HX2 SDCS	1.9 l/s
Flow through inlet collectors HD6, HD2, HD4, HD8	HD6 – 104 l/s HD2–7.75*10^{-12} l/s HD4–7.3*10^{-12} l/s HD8 – 1.9 l/s
Flow through outlet collectors HD5, HD1, HD3, HD7	HD5 - 104l/s HD1- 4.14*10^{-12} l/s HD3–4.11*10^{-12} l/s HD7 – 1.9 l/s
Flow through P1, P2, P3, P4 PHTS	P1–4.97*10^{-12}l/s P2–5.2*10^{-12} l/s P3 – 67 l/s P4 – 34.8 l/s
Flow through fuel channels R1, R2, R3 and R4	R1–6.9*10^{-12} l/s R2 – 36.7 l/s R3–5*10^{-12} l/s R4 – 36.7 l/s

≡ ***Model III.*** *Thermal calculation model for the heat exchangers, HX1 and HX2, related to the shutdown cooling system, for operating in failure mode of the shutdown cooling system. This model concerns the time evolution of the temperature in PHTS.*

According to the results the parameter values for the heat transfer of heat exchangers HX1 and HX2, at the moment of achieving the cooling requirement for PHTS (temperature in PHTS must be 54°C) are in Table IV.

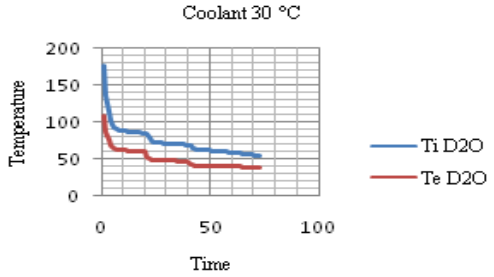

Figure1*. Examination for 2 HX for cooling agent 30 °C*

TABLE IV*. Thermal analysis. Model III*

Thermal load of SDCS HX1/ HX2	10.99 MW(th)
Outlet temperature for D_2O of PHTS	54.06 °C
Outlet temperature for the cooling water of SDCS HX1 and HX2	30.165 °C

In figure 1 is highlighted a plot of temperature decrease of PHTS coolant for inlet and outlet of the SDCS heat exchangers.

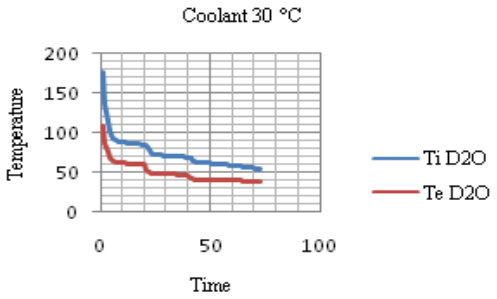

Figure1*. Examination for 2 HX for cooling agent 30 °C*

≡ ***Model IV.*** *Thermal calculation model for the heat exchangers, HX1 and HX2, related to the shutdown cooling system, for operating in failure mode of the shutdown cooling system. (LOCA). The inlet temperature on the secondary side of the heat exchangers is 35 °C. In modelul IV, the shutdown cooling system is working with his own pumps, P1 and P2. The result are shown in tabel V:*

TABLE V*. Thermal analysis. Model IV*

Thermal load of SDCS HX1/ HX2	8.95 MW(th)
Outlet temperature for D_2O of PHTS	54.16 °C
Outlet temperature for the cooling water of SDCS HX1 and HX2	41.32 °C

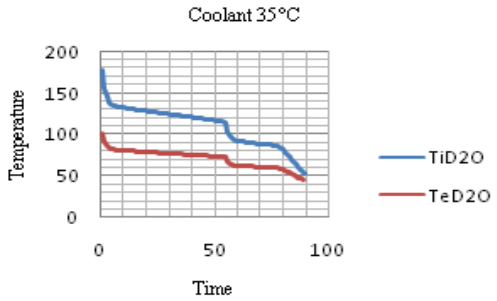

Figure 2*. Examination for 2 HX for cooling agent 35 °C*

In figure 2 is highlighted a plot of temperature decrease as it is shown in figure 1. The difference between model III and model IV is the inlet temperature of the cooling water that passes through the heat exchangers.

≡ ***Model V.*** *Thermal calculation model for the heat exchangers, HX1 or HX2, related to the shutdown cooling system, for operating in failure mode of the shutdown cooling system (LOCA).*

In model V, the SDCS is working with one heat exchanger and one of the shutdown cooling system pumps, P1 or P2. In tabel VI are provided the mainly results for this case of operating.

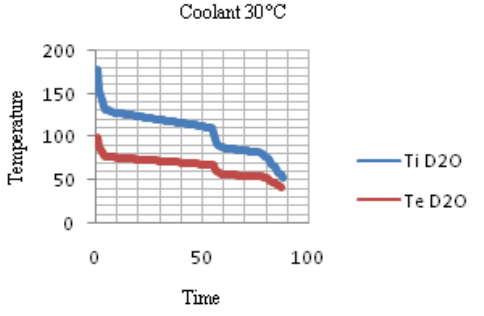

Figure 3*. Examination for 1 HX for cooling agent 30 °C*

TABLE VI. *Thermal analysis. Model V*

Thermal load of SDCS HX1/ HX2	*5.4 MW(th)*
Outlet temperature for D_2O of PHTS	*52.43 °C*
Outlet temperature for the cooling water of SDCS HX1 and HX2	*41.18 °C*

Figure 3 is also highlighted a plot of temperature decrease of PHTS coolant for inlet and outlet of the SDCS heat exchangers.

≡ ***Model VI.*** *Thermal calculation model for the heat exchangers, HX1 and HX2, related to the shutdown cooling system, for operating in failure mode of the shutdown cooling system (LOCA). In this modelul, the SDCS is working with one heat exchanger and one of the shutdown cooling system pumps, P1 or P2.*

The inlet temperature on the secondary side of the heat exchangers is 35°C. In table VII are shown the results of this analyze.

TABLE VII. *Thermal analysis. Model VI*

Thermal load of SDCS HX1/ HX2	*4.17 MW(th)*
Outlet temperature for D_2O of PHTS	*52.2 °C*
Outlet temperature for the cooling water of SDCS HX1 and HX2	*43.5 °C*

In figure 4 is also revealed a graphic of the temperature decrease for PHTS coolant.

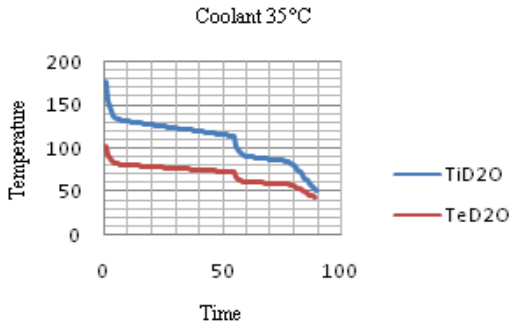

Figure 4. *Examination for 1 HX for cooling agent 35 °C*

TABLE VIII. *Comparative results for hydraulic analyze. Model I*

	Data obtained by using PIPENET code	*Data obtained in by using FLOWMASTER*
Flow through P1	*118.4 l/s*	*115 l/s*
Flow through P2	*118.4 l/s*	*114 l/s*
Flow through HX1 SDCS	*106.6 l/s*	*104 l/s*
Flow through HX2 SDCS	*106.6 l/s*	*103 l/s*
Flow through inlet collectors HD6, HD2, HD4, HD8	*HD6 – 106.6 l/s HD2 – 0 l/s HD4 - 0 l/s HD8 – 106.6 l/s*	*HD6 – 104 l/s HD2–1.4*10^{-10} l/s HD4–2.27*10^{-9} l/s HD8 - 103 l/s*
Flow through outlet collectors HD5, HD1, HD3, HD7	*HD5 – 106.6 l/s HD1- 0 l/s HD3 - 0 l/s HD7 – 106.6 l/s*	*HD5 - 104l/s HD1- 1.85*10^{-9} l/s HD3–1.73*10^{-9} l/s HD7 – 103 l/s*
Flow through PHTS- P1, P2, P3, P4	*P1 – 0 l/s P2 – 0 l/s P3 – 58.6 l/s P4 – 58.6 l/s*	*P1 – 4*10^{-10} l/s P2–1.55*10^{-9}l/s P3 – 54 l/s P4 – 54 l/s*
Flow through fuel channels R1, R2, R3 şi R4	*R1 – 0l/s R2 – 53 l/s R3 – 0 l/s R4 – 53 l/s*	*R1 – 2.15*10^{-10} l/s R2 – 50 l/s R3 – 1.79*10^{-9} l/s R4 – 50 l/s*

For hydraulic analyzes there were built two PIPENET models considered in order to verify the results obtained in Flowmaster. The results are as follows in Table VIII or IX.

TABLE IX. *Comparative results for hydraulic analyze. Model II*

	Data obtained by using PIPENET code	*Data obtained by using FLOWMASTER*
Flow through P1	*118.4 l/s*	*115 l/s*
Flow through P2	*0 l/s*	*1.7 l/s*
Flow through HX1 SDCS	*106.6 l/s*	*104 l/s*
Flow through HX2 SDCS	*0.3 l/s*	*1.9 l/s*
Flow through inlet collectors HD6, HD2, HD4, HD8	*HD6 – 106.6 l/s HD2 – 0 l/s HD4 - 0 l/s HD8 – 0.3 l/s*	*HD6 – 104 l/s HD2–7.75*10^{-12} l/s HD4–7.3*10^{-12} l/s HD8 – 1.9 l/s*
Flow through outlet collectors HD5, HD1, HD3, HD7	*HD5 – 106.6 l/s HD1- 0 l/s HD3 - 0 l/s HD7 – 0.3 l/s*	*HD5 - 104l/s HD1- 4.14*10^{-12} l/s HD3–4.11*10^{-12} l/s HD7 – 1.9 l/s*
Flow through PHTS- P1, P2, P3, P4	*P1 – 0 l/s P2 – 0 l/s P3 – 71 l/s P4 – 35.4 l/s*	*P1–4.97*10^{-12}l/s P2–5.2*10^{-12} l/s P3 – 67 l/s P4 – 34.8 l/s*
Flow through fuel channels R1, R2, R3 şi R4	*R1 – 0l/s R2 – 38 l/s R3 – 0 l/s R4 – 37.9 l/s*	*R1–6.9*10^{-12} l/s R2 – 36.7 l/s R3–5*10^{-12} l/s R4 – 36.7 l/s*

CONCLUSIONS

Under the present paper, there was carried out the thermal-hydraulic analysis of the simultaneous operation of the shutdown cooling system and of the primary heat transport system, associated to a CANDU 6 NPP (nuclear power plant), in LOCA accident regime, using Flowmaster calculation code.

The modelling of heavy water flow through the shutdown cooling system and primary heat transport system was performed to determine the distribution of flows, pressure in various areas of the hydraulic circuit and the pressure loss corresponding to the components but also for the heat calculation of the heat exchangers related to the system.

The configurations corresponding to the shutdown cooling system coupled to the primary heat transport system are in accordance with the thermo-mechanical schemes of the systems similar to those at Cernavoda NPP.

Within this work there were performed complex hydraulic/thermo-hydraulic analyzes for the shutdown cooling system coupled with the primary heat transport system. Hydraulic analyzes developed using Flowmaster program aimed at the verification of the hydraulic models as well as the determination of flow and pressure loss in baseline cooling processes in degraded mode.

The results of the thermo-hydraulic analysis show that in all cases analyzed, for the LOCA accident regime, the performance requirements are confirmed by analysis.

The heat exchangers of the shutdown cooling system have the ability to perform the cooling of the primary heat transport system at 177°C to 54°C in approximately 79 minutes, if the inlet temperature at reactor cooling water (RCW) is 30°C.

After 79 minutes, the residual heat necessary to be extracted from the primary circuit by means of both heat exchangers of the shutdown cooling system is approx. 10 MW and the thermal load of the heat exchanger is 10.99 MW.

If the inlet temperature of the RCW heat exchangers is 35°C, then the cooling from 177°C to 54°C of the primary heat transport system will be made in approx. 86 minutes.

After 86 minutes, the residual heat necessary to be extracted from the primary circuit by means of a heat exchanger of the shutdown cooling system is approx. 4.85 MW and the thermal load of the heat exchanger is 8.95 MW.

For the model in which the PHTS cooling is provided only by one of the heat exchangers of the SDCS, if the inlet temperature of the RCW heat exchangers is 30°C, the residual heat necessary to be extracted has a value of 3.71 MW. By means of the heat exchanger having the heat load of 5.4 MW, cooling from 177°C to 54°C is achieved in approx. 88 minutes.

If the inlet temperature of the operating heat exchanger is 35°C, then cooling from 177°C to 54°C of the primary heat transport system will be achieved in approx. 90 minutes.

After 90 minutes, the residual heat necessary to be extracted from the primary circuit by means of a heat exchanger of the shutdown cooling system is approx. 2.87 MW and the thermal load of the heat exchanger is 4.17 MW.

As a result of this thermal analysis wherein the inlet temperature of the intermediate cooling water at the heat exchangers is 35°C, there were observed a series of differences compared to the data sheets of the heat exchangers, HX1 and HX2, namely:

- *thermal load taken by the heat exchangers is smaller, but above the necessary;*
- *primary heat transport system may be cooled to a temperature of 54°C, but it would take longer time;*
- *intermediate cooling water temperature at the outlet of the heat exchanger has a higher value.*

Another observation is that both the operation with two heat exchangers, as well as that with a heat exchanger, in LOCA accident regime, SPTC cooling can be achieved by using the SRO. The only difference noticed between the two models considered is that for the operation with a heat exchanger instead of two, cooling is done in a longer, but covering time.

Regarding the temperatures, it is found a normal evolution in the PHTS cooling process, but which cannot be measured accurately and precisely because of the lack of information on the conditions under which the analyses were developed as the basis for the evolution curves of the residual heat present in the reactor after 15 minutes, and 30 minutes, respectively, from the start of the accident of the coolant loss type.

Analyzing the parameters of the cooling system for all cooling processes considered it was found that the values obtained for thermal-hydraulic parameters, as well as the duration up to reaching specified limits fall within the design values of the system. Cooling speeds situated below the value of 2.8 °C/min at the reactor outlet for all cooling regimes in case of LOCA type accidents.

ACKNOWLEDGMENTS

The work has been funded by the Sectorial Operational Programme Human Resources Development 2007-2013 of the Ministry of European Funds through the Financial Agreement POSDRU/159/1.5/s/134398.

REFERENCES

[1.] A. LECA and I. PRISECARU, "Thermo-physical and thermodynamic properties of solid, liquid and gas", Ed. Tehnică, Bucharest, 1994.

[2.] D. S. MILLER, "Internal Flow Systems, 2nd edition, published by Miller Innovations.

[3.] FLOWMASTER v7 – New user training, version 10.

[4.] Computer Applications in Hydraulic Engineering, 7th edition, Bentley Institute Press.

[5.] Requirements for the Safety Analysis of CANDU Nuclear Power Plants", AECB Consultative Document C-6, June 1980.

[6.] Safety Analysis: Event Classification , www.iaea.org .

[7.] NUCLEAR REGULATORY COMMISSION, Theoretical Possibilities and Consequences Of Major Accidents In Large Nuclear Power Plants, Rep. WASH 740, US Govt Printing Office, Washington, DC (1957).

[8.] INTERNATIONAL ATOMIC ENERGY AGENCY, Incorporation of advanced accident analysis methodology into safety analysis reports, IAEA-TECDOC-1351, Mai 2003.

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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A NEW APPROACH CONTROLLERS SYNTHESIS FOR THREE PHASE INDUCTION MOTOR DRIVES BASED ON THE ARTIFICIAL INTELLIGENCE TECHNIQUES

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Abstract: In this work, we introduced a new method toward the design of hybrid control with sliding-mode (SMC) plus fuzzy logic control (FLC) for induction motors. As the variations of both control system parameters and operating conditions occur, the conventional control methods may not be satisfied further. Sliding mode control is robust with respect to both induction motor parameter variations and external disturbances. By combination of a fuzzy logic control and the sliding mode control, the chattering (torque-ripple) problem with varying parameters, which are the main disadvantage in sliding-mode control, can be suppressed, Simulation results of the proposed control theme present good dynamic and steady-state performances as compared to the classical SMC from aspects for torque-ripple minimization, the quick dynamic torque response and robustness to disturbance and variation of parameters.
Keywords: Induction Motor (IM), Sliding Mode Control (SMC), Fuzzy Logic Control (FLC), Fuzzy Logic Sliding Mode Control (FLSMC), Torque Ripple

INTRODUCTION

Induction Motors (IM) are applied today to a wider range of applications requiring variable speed. Generally, variable-speed drives for induction motors require both wide operating range of speed and fast torque response, regardless of load variations. However, induction motor has disadvantages, such as complex, nonlinear, and multivariable of mathematical model, and the induction motor is not inherently capable of providing variable speed operation.

Field oriented control method is used for advanced control of induction motor drives. By providing decoupling of torque and flux control demands, the vector control can govern an induction motor drive similar to a separate excited direct current motor without sacrificing the quality of the dynamic performance.

However, the field oriented control of induction motor drives presents two main problems that have been providing quite a bit research interest in the last decade. The first one relies on the uncertainties in the machine models and load torque, and the second one is the precise computation of the motor speed without using speed sensors.

The decoupling characteristics of the vector control are sensitive to machine parameters variations. Moreover, the machine parameters and load characteristics are not exactly known, and may vary during motor operations. Thus the dynamic characteristics of such systems are very complex and nonlinear. Therefore, many studies have been made on the motor drives in order to preserve the performance under these parameter variations and external load disturbances, such as nonlinear control, optimal control, variable structure system control, adaptive control and neural control [5], [6],[8], [11] and [12].

Sliding mode control (SMC), based on the theory of variable structure systems (VSS), has been applied to robust control of nonlinear systems [9]. Sliding mode control performs well in trajectory tracking of some nonlinear systems. It employs a discontinuous control law to drive the state trajectory toward specified sliding surface and maintain its motion along the sliding surface in the state space. It is a common opinion that the major drawback of sliding mode control is the so-called chattering phenomenon. Such a phenomenon consists of the oscillation of the control signal, tied to the discontinuous nature of the control strategy, at a frequency and with an amplitude capable of disrupting, damaging or, at least, wearing the controlled physical system (e.g., in mechanical systems with backlash).

Several methods of chattering reduction have been reported. One approach [3], [13] places a boundary layer around the switching surface such that the relay control is replaced by a saturation function. Another method [3], [14] replaces a max–min-type control by a unit vector function. These approaches, however, provide no guarantee of convergence to the sliding mode and involve a tradeoff between chattering and robustness.

Reduced chattering may be achieved without sacrificing robust performance by combining the attractive features of fuzzy control with SMC [2], [7], [10] and [15]. Fuzzy logic, first proposed by Zadeh [16], has proven to be a potent tool for controlling ill-defined or parameter-variant plants. By encapsulating heuristic engineering rules a fuzzy logic controller can cope well with severe uncertainties, although a heavy computational burden may arise withsome implementations. Fuzzy schemes with explicit expressions for tuning can avoid this problem [4].

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In this paper, we presented a new hybrid nonlinear control method which is based on sliding mode control and fuzzy logic method, sliding mode control approach is employed to design the induction motor speed and flux controllers. The dynamic decouple control has been accomplished under the condition that the parameter of stator resistance variants and theload torque is time variant. In order to reduce the undesired chattering phenomenon of signum function, the fuzzy control method is used, which can be used to design a new fuzzy switching function to replace the traditional sliding mode signum function, Finally, simulations and a comparison are presented to demonstrate the contribution of this approach.

2. MODELLING OF INDUCTION MOTOR

The induction motor model can be developed from its fundamental electrical and mechanical equations. In stationary reference frame the voltage equations are given by:

$$\begin{aligned} V_{s\alpha} &= R_s I_{s\alpha} + \frac{d\phi_{s\alpha}}{dt} \\ V_{s\beta} &= R_s I_{s\beta} + \frac{d\phi_{s\beta}}{dt} \\ V_{r\alpha} &= 0 = R_r I_{r\alpha} + \frac{d\phi_{r\alpha}}{dt} + \omega\phi_{r\beta} \\ V_{r\beta} &= 0 = R_r I_{r\beta} + \frac{d\phi_{r\beta}}{dt} - \omega\phi_{r\alpha} \end{aligned} \quad (1)$$

The stator and rotor flux linkages are defined using respective self-leakage inductances and mutualinductance as given bellow:

$$\begin{aligned} \phi_{s\alpha} &= L_s I_{s\alpha} + M_{sr} I_{r\alpha} \\ \phi_{s\beta} &= L_s I_{s\beta} + M_{sr} I_{r\beta} \\ \phi_{r\alpha} &= L_r I_{r\alpha} + M_{sr} I_{s\alpha} \\ \phi_{r\beta} &= L_r I_{r\beta} + M_{sr} I_{s\beta} \end{aligned} \quad (2)$$

The electromechanical torque is given by:

$$T_e = p\frac{M_{sr}}{L_r}\cdot\left[\bar{\phi}_r \wedge \bar{I}_s\right] = p\frac{M_{sr}}{L_r}\cdot\left[\phi_{r\alpha}\cdot i_{s\beta} - \phi_{r\beta}\cdot i_{s\alpha}\right] \quad (3)$$

The mechanical equation is given by:

$$J\cdot\frac{d\Omega}{dt} = T_e - T_L - f_r\cdot\Omega \quad (4)$$

The state model of the induction motor is a nonlinear system multivariable taking the following form:

$$\dot{X}(t) = F(X,t) + B(X,t)\cdot U(t) \quad (5)$$

With:

$$\dot{X} = \begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \\ \dot{X}_4 \\ \dot{X}_5 \end{bmatrix} = \begin{bmatrix} \dot{i}_{s\alpha} \\ \dot{i}_{s\beta} \\ \dot{\phi}_{r\alpha} \\ \dot{\phi}_{r\beta} \\ \dot{\omega} \end{bmatrix}, \quad B(X,t) = \begin{bmatrix} d_1 & 0 \\ 0 & d_1 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}$$

$$F(X,t) = \begin{bmatrix} -a_1\cdot I_{s\alpha} + b_1\cdot\phi_{r\alpha} + c_1\cdot\omega\cdot\phi_{r\beta} \\ -a_1\cdot I_{s\beta} - b_1\cdot\omega\cdot\phi_{r\alpha} + c_1\cdot\phi_{r\beta} \\ a_3\cdot I_{s\alpha} - b_3\cdot\phi_{r\alpha} - \omega\cdot\phi_{r\beta} \\ a_3\cdot I_{s\beta} + \omega\cdot\phi_{r\alpha} - b_3\cdot\phi_{r\beta} \\ b_5\cdot\left[\phi_{r\alpha}\cdot I_{s\beta} - \phi_{r\beta}\cdot I_{s\alpha}\right] - c_5\cdot T_L - a_5\cdot\omega \end{bmatrix},$$

$$U(t) = \begin{bmatrix} U_1 \\ U_2 \end{bmatrix} = \begin{bmatrix} V_{s\alpha} \\ V_{s\beta} \end{bmatrix},$$

$$a_1 = \frac{1}{\sigma\cdot\tau_s} + \frac{1-\sigma}{\sigma\cdot\tau_r}, \quad b_1 = \frac{(1-\sigma)}{\sigma\cdot M_{sr}\cdot\tau_r}, \quad c_1 = \frac{(1-\sigma)}{\sigma\cdot M_{sr}}, \quad d_1 = \frac{1}{\sigma\cdot L_s},$$

$$a_3 = \frac{M_{sr}}{\tau_r}, \quad b_3 = \frac{1}{\tau_r}, \quad a_5 = \frac{f_r}{p\cdot J}, \quad b_5 = \frac{p^2\cdot M_{sr}}{J\cdot L_r}, \quad c_5 = \frac{p}{J}$$

with: $\tau_s = \frac{L_s}{R_s}$, $\tau_r = \frac{L_r}{R_r}$ *and* $\sigma = 1 - \frac{M_{sr}^2}{L_s L_r}$.

3. BASIC CONCEPTS OF THE CONTROL MANIFOLD

The design procedure for a state based sliding mode controller can be divided into two parts [1]:

Step 1: *Finding the switching function S defined by:*

$$S(X) = \left(\frac{\partial}{\partial t} + \lambda\right)^{r-1}\cdot e(X) \quad (6)$$

Such as the internal dynamics in sliding mode are stable.

$S(X)$ *is the sliding surface or switching surface . It is a surface in* $\Re^n$ *that divides the state space into two disjoint parts:* $S(X) > 0$ *and* $S(X) < 0$

Step 2: *Designing a controller U, which insures that the sliding mode is reached and subsequently maintained [1].*

$$U = \begin{cases} U^{eq} + U^n & \text{if } S(X) > 0 \\ U^{eq} - U^n & \text{if } S(X) < 0 \end{cases} \quad (7)$$

When the system is in sliding mode, the trajectory will remain on the switching surface. This can be expressed by:

$$S(X) = 0 \text{ and } \dot{S}(X) = 0 \quad (8)$$

This condition is called invariance condition of the sliding surface.

The total control is given by:

$$U = U^{eq} + U^n \quad (9)$$

where: U^{eq} *: The equivalent control.*

U^n *: The attractive control*

The derivative of the surface S(X) is:

$$\dot{S}(X) = \frac{\partial S}{\partial t} = \frac{\partial S}{\partial X}\cdot\frac{\partial X}{\partial t} = \frac{\partial S}{\partial X}\cdot\dot{X} \quad (10)$$

By introducing (5) and (9) in (10), we obtain:

$$\dot{S}(X) = \frac{\partial S}{\partial X}\cdot\left[F(X,t) + B(X,t)\cdot U^{eq}\right] + \frac{\partial S}{\partial X}\cdot\left[B(X,t)\cdot U^n\right] \quad (11)$$

During the sliding mode and the permanent state, the surface is zero $(S(X)=0)$ *and therefore, its derivative and the discontinuous part are also zero (*$\dot{S}(X)=0$ *and* $U^n = 0$*). Hence, we deduce the expression of the equivalent control:*

$$\frac{\partial S}{\partial X}\cdot\left[F(X,t) + B(X,t)\cdot U^{eq}\right] = 0 \quad (12)$$

$$U^{eq} = -\left[\frac{\partial S}{\partial X}\cdot B(X,t)\right]^{-1}\cdot\left[\frac{\partial S}{\partial X}\cdot F(X,t)\right] \quad (13)$$

For the equivalent command can take a finite value, it must:

$$\frac{\partial S}{\partial X}\cdot B(X,t) \neq 0 \quad (14)$$

By replacing the equivalent control by expression in (14) yields the new expression for the derivative of the surface:

$$\dot{S}(X)=\frac{\partial S}{\partial X}\cdot\left[B(X,t)\cdot U^{n}\right] \quad (15)$$

$$S(X)\cdot\dot{S}(X)=S(X)\frac{\partial S}{\partial X}\cdot\left[B(X,t)\cdot U^{n}\right]<0 \quad (16)$$

The basic form of the attractive control U^n is a relay. In this case the discontinuous control is given by [1]:

$$U^{n}=-k\cdot\text{sign}\ (S(X)) \quad (17)$$

where kis a strictly positive constant.

4. DESIGN OF FUZZY LOGIC SLIDING MODE FLSMC

Theconventional sliding mode control is based on the discontinuous function of state variables in the system that is used to create a "sliding surface". When this surface is reached, the discontinuous function keeps the trajectory on the surface of such so that the desired system dynamics is obtained.

In this paper, the controllers of speed and rotor flux are substituted by a fuzzy sliding mode control to obtain a robust performance. By keeping one part of the equivalent control (SMC) and adding the fuzzy logic control (FLC) we obtain the new method control (FSMC).

$$U_{FLSMC}=U^{eq}+U^{Fuzzy} \quad (18)$$

Where: U^{Fuzzy} : is FLC witch replacing the attractive control.

4.1. Synthesis of sliding mode controllers SMC

The first step of sliding mode control design is to select a sliding surface that models the desired closed-loop performance in state variable space. Then design the control such that the system state trajectories are forced toward the sliding surface and stay on it. Now, suppose that a sliding surface is given as:

$$S_1(e_1)=\lambda_1\cdot e_1+\dot{e}_1 \quad (19)$$

with: $e_1=\omega_{ref}-\omega$

$$S_2(e_2)=\lambda_2\cdot e_2+\dot{e}_2 \quad (20)$$

with: $e_2=\phi_{rref}^2-\phi_r^2$

Where λ_1 and λ_2 are non-zero positive gains.

Our objective is to control rotor speed ω and rotor magnitude flux given by: $\phi_r^2=\phi_{r\alpha}^2+\phi_{r\beta}^2$

Here ϕ_{rref} and ω_{ref} are the desired flux and the desired speed respectively.

$$S_1(e_1)=\lambda_1\cdot(\omega_{ref}-\omega)+(\dot{\omega}_{ref}-\dot{\omega}) \quad (21)$$

$$S_2(e_2)=\lambda_2\cdot(\phi_{rref}^2-\phi_r^2)+(\dot{\phi}_{rref}^2-\dot{\phi}_r^2) \quad (22)$$

The development of calculated derivatives of the surfaces gives:

$$\begin{aligned}\dot{S}_1(e_1)&=\lambda_1(\dot{\omega}_{ref}-\dot{\omega})+(\ddot{\omega}_{ref}-\ddot{\omega})\\&=\lambda_1\cdot\dot{\omega}_{ref}+\ddot{\omega}_{ref}-(\lambda_1-a_5)\cdot\dot{X}_5\\&+b_5\left[a_1(X_2\cdot X_3-X_1\cdot X_4)+c_1\cdot\phi_r^2\cdot X_5+X_1\cdot X_4-X_2\cdot X_3\right]+\\&+c_5\cdot\dot{T}_L+b_5\cdot d_1\cdot X_4\cdot U_1-b_5\cdot d_1\cdot X_3\cdot U_2\end{aligned} \quad (23)$$

$$\begin{aligned}\dot{S}_2(e_2)&=\lambda_2(\dot{\phi}_{rref}^2-\dot{\phi}_r^2)+(\ddot{\phi}_{rref}^2-\ddot{\phi}_r^2)\\&=\lambda_2\cdot\dot{\phi}_{rref}^2+\ddot{\phi}_{rref}^2-(\lambda_2-2\cdot b_3)\cdot\dot{\phi}_r^2\\&-2\cdot a_3\left[X_1\cdot\dot{X}_3+X_2\cdot\dot{X}_4-a_1(X_1\cdot X_3+X_2\cdot X_4)+b_1\cdot I_s^2\right]\\&-2\cdot a_3\cdot d_1\cdot X_3\cdot U_1-2\cdot a_3\cdot d_1\cdot X_4\cdot U_2\end{aligned} \quad (24)$$

with:

$$I_s^2=I_{s\alpha}^2+I_{s\beta}^2 \quad (25)$$

The surfaces derivatives can be written in the following condensed form:

$$\dot{S}=\left[\dot{S}_1(e_1)\quad\dot{S}_2(e_2)\right]^T=G(X)+Q(X)\cdot U \quad (26)$$

$$G(X)=\left[G_1(X)\quad G_2(X)\right]^T \quad (27)$$

$$\begin{aligned}G_1(X)&=\lambda_1\cdot\dot{\omega}_{ref}+\ddot{\omega}_{ref}-(\lambda_1-a_5)\cdot\dot{X}_5+\\&+b_5\left[a_1(X_2\cdot X_3-X_1\cdot X_4)+c_1\cdot\phi_r^2\cdot X_5+X_1\cdot X_4-X_2\cdot X_3\right]\\&+c_5\cdot\dot{T}_L\end{aligned} \quad (28)$$

$$\begin{aligned}G_2(X)&=\lambda_2\cdot\dot{\phi}_{rref}^2+\ddot{\phi}_{rref}^2-(\lambda_2-2\cdot b_3)\cdot\dot{\phi}_r^2-\\&-2\cdot a_3\left[X_1\cdot\dot{X}_3+X_2\cdot\dot{X}_4-a_1(X_1\cdot X_3+X_2\cdot X_4)+b_1\cdot I_s^2\right]\end{aligned} \quad (29)$$

$$Q(X)=\begin{bmatrix}b_5\cdot d_1\cdot X_4 & -b_5\cdot d_1\cdot X_3\\ -2\cdot a_3\cdot d_1\cdot X_3 & -2\cdot a_3\cdot d_1\cdot X_4\end{bmatrix} \quad (30)$$

The necessary condition for the states system follows the trajectory defined by the sliding surfaces is: $S_i(e_i)=0,(i=1,2)$, the equivalent part U^{eq} is the control to providing $\dot{S}_i(e_i)=0$.

For the nominal system $\dot{S}_i(e_i)=0$ give:

$$\begin{aligned}\dot{S}=0&\Rightarrow\left[\dot{S}_1(e_1)\quad\dot{S}_2(e_2)\right]^T=0\\&\Rightarrow G(X)+Q(X)\cdot U=0\\&\Rightarrow\ U=-Q^{-1}(X)\cdot G(X)=U^{eq}=\left[V_{s\alpha}\quad V_{s\beta}\right]^T\end{aligned} \quad (31)$$

4.2. Design of fuzzy logic controllers FLC for induction motor drive

The proposed fuzzy controller is presented in Fig. 1. The FLSMC is introduced to replace the sign function in SMC controller.

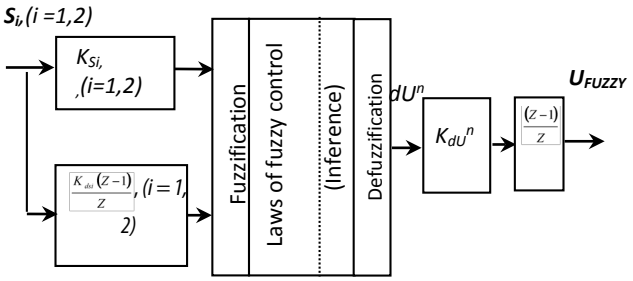
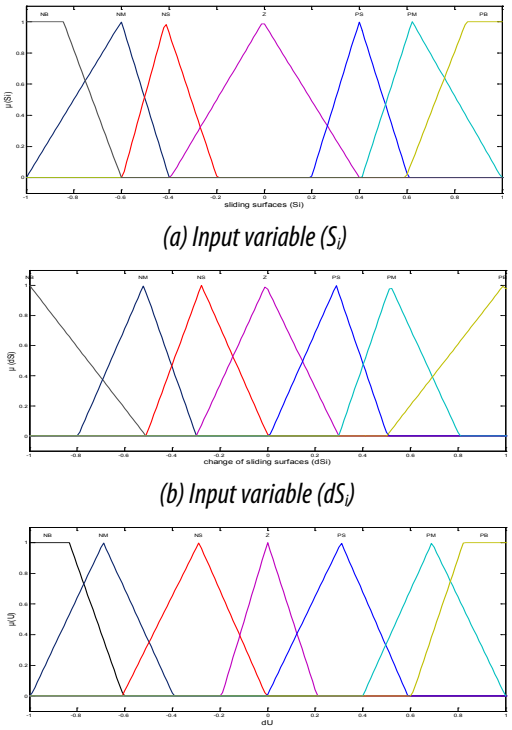


Figure 1. *Diagram of the fuzzy logic sliding mode controllers.*

FLSMC in this system uses Mamdani fuzzy inference system to relate two input variables to one output variable. The first input variable is the sliding surface $(S_i(e_i)=0,(i=1,2))$, while the other input is the change of sliding surface $(dS_i,(i=1,2))$. The output variable is the change of controllers $(dU_i,(i=1,2))$.

The membership functions for input and output variables are shown in Figure 2.



(a) Input variable (S_i)

(b) Input variable (dS_i)

(c) Output variable (dU_i)

Figure 2. *Membership functions*

(a) Membership function for input variable(S_i). (b) Membership function for input variable (dS_i). (c) Membership function for output variable dU_i).

*All input and output variables were normalized to be fit the range of $(-1 \text{ to } 1)$. The output variable (**dU_i**) is used to calculate the needed change of controllers which will be used to control the speed and rotor flux of induction motor. All fuzzy rules used in the proposed system are summarized in Table 1.*

Table 1. *Inference table (rules).*

dU_i		Change of surfaces (dS_i)						
	(i=1,2)	NB	NM	NS	Z	PS	PM	PB
Surfaces (S_i)	NB	NB	NB	NB	NM	NS	NS	Z
	NM	NB	NM	NM	NM	NS	Z	PS
	NS	NB	NM	NS	NS	Z	PS	PM
	Z	NB	NM	NS	Z	PS	PM	PB
	PS	NM	NS	Z	PS	PS	PM	PB
	PM	NS	Z	PS	PM	PM	PM	PB
	PB	Z	PS	PS	PM	PB	PB	PB

*For the defuzzifier of the crisp value of output (**dU_i**), we use the center of area defuzzifier.*

5. SIMULATION RESULTS AND DISCUSSION

The behavior of the overall system is tested by simulation for three phase induction machine represented at Figure 3.

A series of simulation tests were carried out on induction motor drive using both the sliding mode controller SMC and fuzzy logic sliding mode controller FLSMC based intelligent controller for various operating conditions.

Figure 4 shows speed response with both the SMC and FLSMC based controller. The FLSMC controller performed better performance with respect to rise time and steady state error. The speed response is well damped within a rise time of 0.025s.

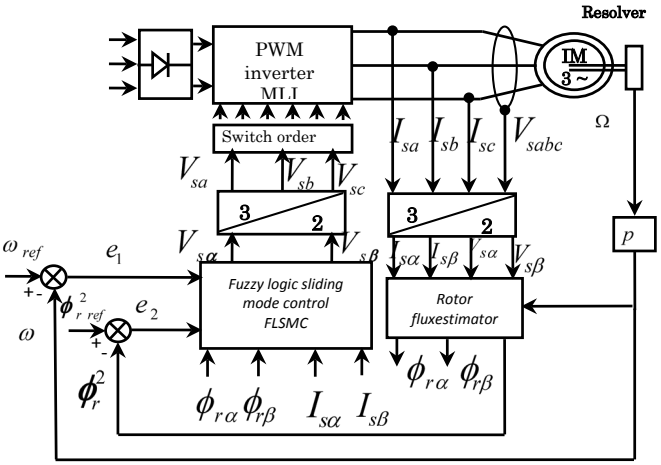


Figure 3. *Principe scheme of the proposed FLSMC of IM.*

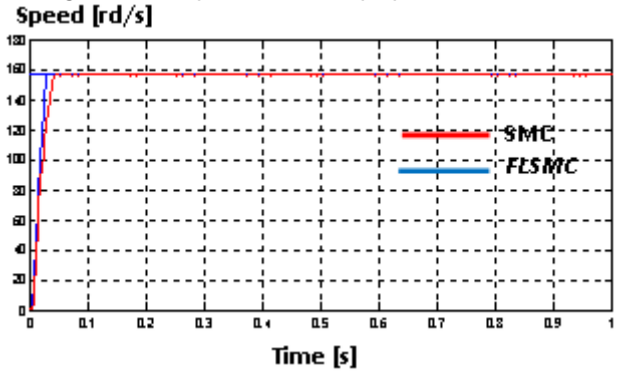


Figure 4. *Speed response comparison at no load (T_L =0).*

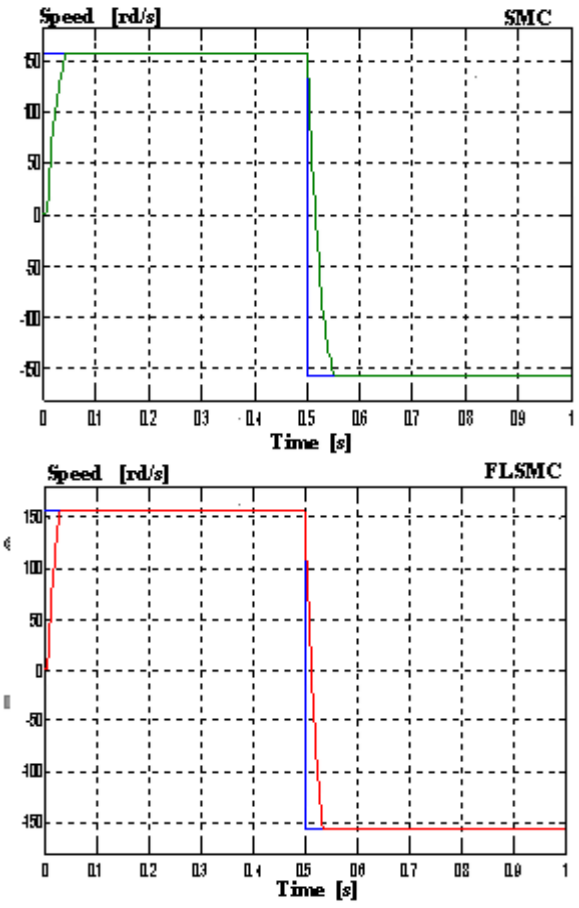


Figure 5.a. *Comparison results between the SMC and FLSMC at no load (T_L = 0 N.m). a) speed*

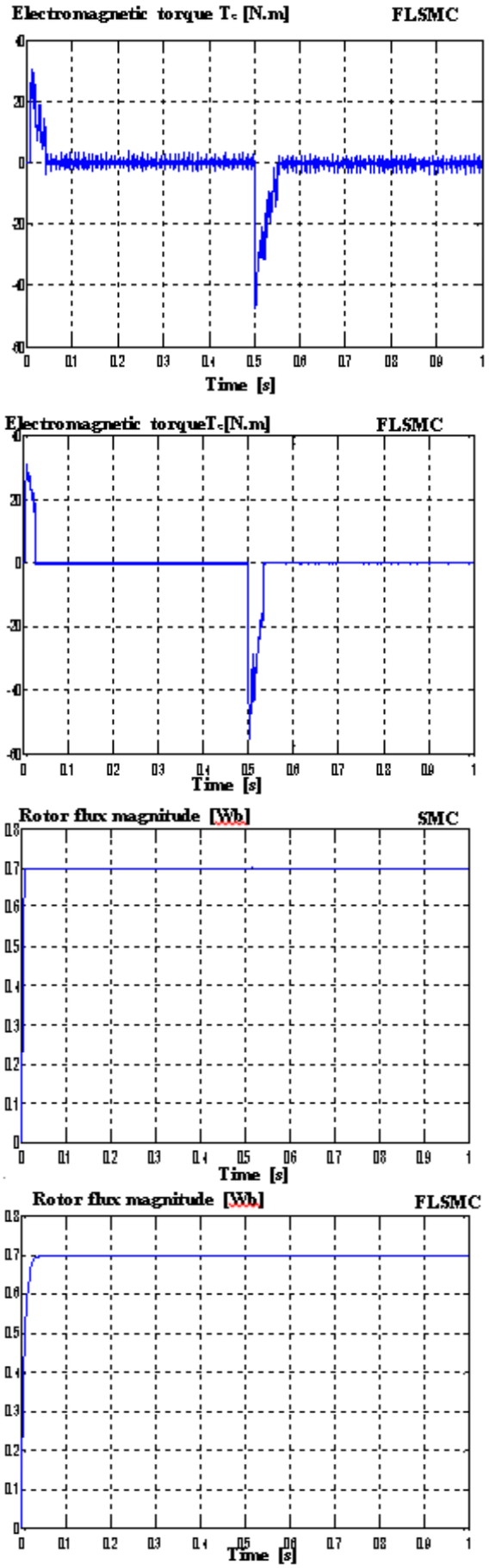


Figure 5.b-c. *Comparison results between the SMC and FLSMC at no load ($T_L = 0$ N.m). b) electromagnetic torque; c) rotor flux magnitude*

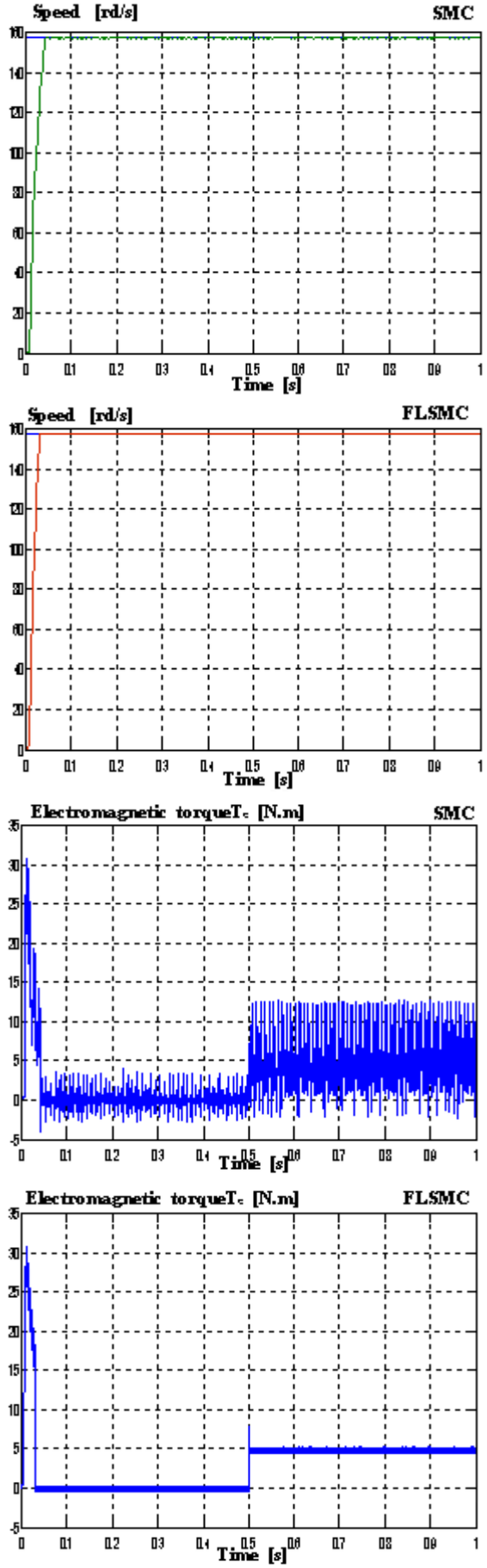


Figure 6.a-b. *Comparison results between the SMC and FLSMC when load ($T_L = 5$ N.m). a) speed; b) electromagnetic torque;*

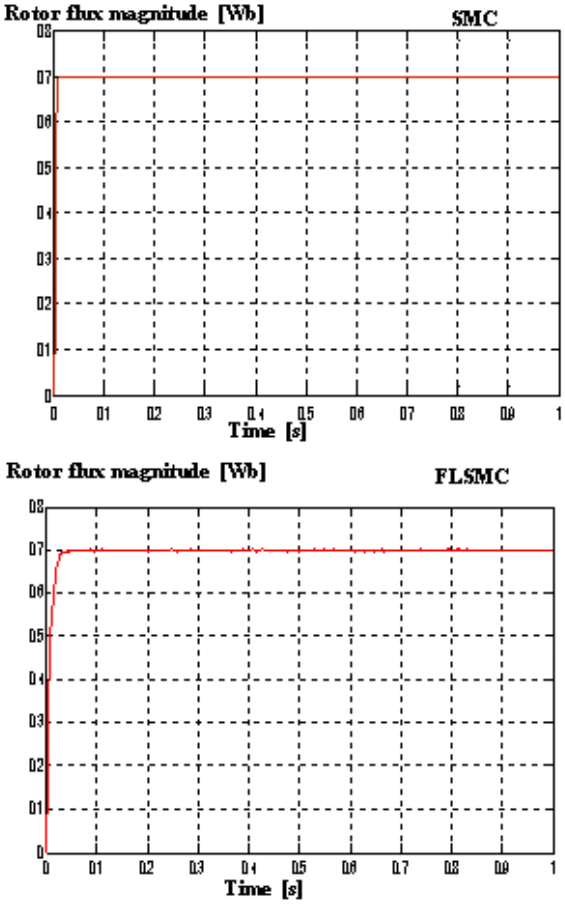


Figure 6.c. *Comparison results between the SMC and FLSMC when load ($T_L = 5$ N.m). c) rotor flux magnitude*

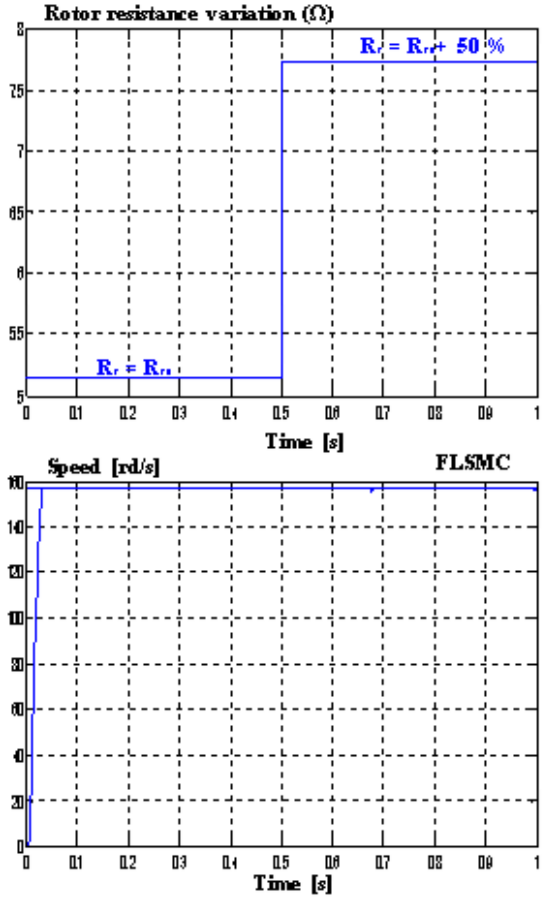


Figure 7. *Simulation results under rotor resistance variation*

In Figure 5, A comparison test using SMC and FLSMC controller have been performed starting-up towards 1500 rpm at no load ($T_L = 0$ N.m).

In this test, the simulation results show that the FLSMC gives good performances in minimization of the torque ripple with higher tracking precision.

The simulation test reported in Figure 6 shows the load disturbance rejection capabilities of each controller when using a step load from 0 to 5 N.m at 0.5 seconds.

A test of robustness has been also performed by tuning the rotor resistance parameter with the over-estimation.

Figure 7 shows the test of robustness realized with the sliding mode controller SMC and FSMC for different value of the rotor resistance.

Figure 8 shows the test of robustness realized with the sliding mode controller SMC and FSMC for different value of the moment of inertia.

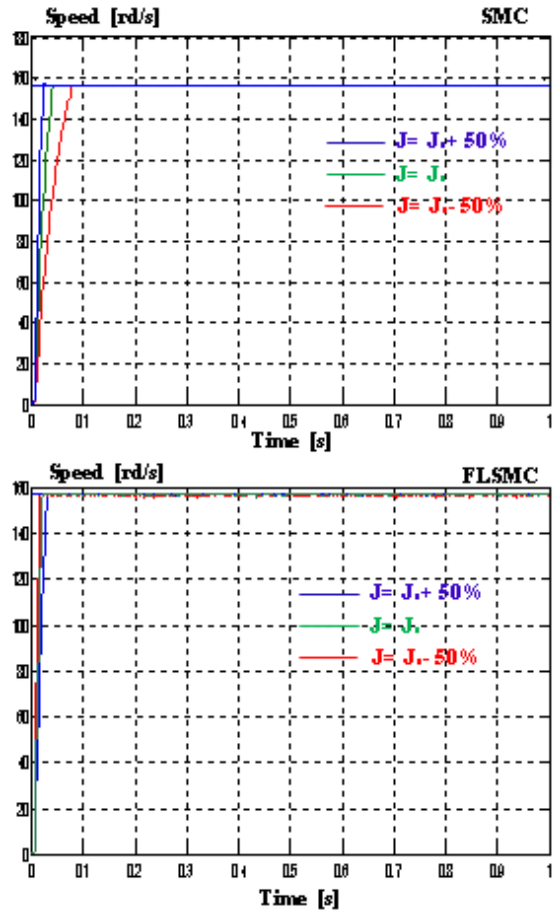


Figure 8. *Simulation results under variations of the moment of inertia.*

The variation of the moment of inertia has no significant influence on performances of the FLSMC proposed control.

6. CONCLUSION

A new hybrid technique control system to indirect vector controlled induction motor combining the features of SMC and fuzzy control has been presented in this paper. Fuzzy tuning schemes are employed to reduce chattering and accelerate the reaching phase. The FLSMC has the advantage in handling the torque ripple phenomenon and reducing the number of the fuzzy rules and the rules themselves were simplified. The drive system was simulated with fuzzy logic controller and SMC controller and their performance was compared. Here simulation results shows

that the designed FLSMC controller realizes a good dynamic behavior of the motor with a rapid settling time, no overshoot and has better performance than SMC controller. FLSMC control has more robust with regard to parameter variations and external disturbance.

Appendix:

s ,r: Stator and rotor index.
ref : Reference value.
α, β: Rotor reference frame.
V: Voltage, [V].
I : Current, [A].
Ω: Mechanical speed, [rad/s].
ϕ: Flux, [Wb].
T_e: Electromechanical torque, [N.m].
ω: Rotor angular frequency, [rad/s].
f_r: Viscose friction coefficient, [N.m.s/rad].
J: Moment of inertia, [Kg.m^2].
p: Pole pair number.
σ: Total leakage coefficient.
R_s , R_r: Stator, rotor resistance, [Ω].
L_s, L_r, M_{sr}: Stator, rotor and mutual inductance, [H].
$\tau_s\tau_r$: Stator and Rotor time constant,[s].

REFERENCES

[1.] *Fridman L, Moreno J and Iriarte R: Sliding modes after the first decade of the 21st century, LNCIS, vol. 412, Springer-Verlag Berlin Heidelberg 2011.*

[2.] *Ha Q. P, Rye D. C, and Durrant-Whyte H. F: Fuzzy moving sliding mode control with application to robotic manipulators, Automatica, Vol.35, No. 4, pp. 607–616,1999.*

[3.] *Ha Q. P, Nguyen Q. H, Rye D. Cand Durrant-Whyte H. F: Fuzzy sliding-mode controllers with applications, IEEE transactions on industrial electronics, Vol. 48, NO. 1, February 2001.*

[4.] *Ha Q. P: Robust sliding mode controller with fuzzy tuning, IEEE Electronics Letters, Vol. 32, No. 17, pp. 1626–1628, 1996.*

[5.] *Huang S.J, Huang C.L and Lin Y.S: Sensorless speed identification of vector controlled induction drives via neural network based estimation, Electric power systems research, Vol.48, pp. 1-10, 1998.*

[6.] *KIM G.S, HA I.J and KO M.S: Control of induction motors for both high dynamic performance and high power efficiency, IEEE transactions on industrial electronics, Vol. 39, pp. 323-333, 1992.*

[7.] *Laamayad T, Naceri F, Abdessemed R and Belkacem S: A fuzzy sliding mode strategy for control of the dual star induction machine, Journal of Electrical Engineering: Vol. 13, No. 01, 216-223, 2013.*

[8.] *Lin F.K and Liaw C.M: Control of indirect field-oriented induction motor drives considering the effects of dead-time and parameter variations, IEEE transactions on industrial electronics, Vol. 40, pp. 486-495, 1993.*

[9.] *Lin W.S and Chen C. S: Robust adaptive sliding mode control using fuzzy modeling for a class of uncertain MIMO nonlinear systems, IEE Proceeding, Control Theory and applications, Vol. 149, No. 3, May 2002.*

[10.] *Lu Y. S and Chen J. S: A self-organizing fuzzy sliding-mode controller design for a class of nonlinear servo systems, IEEE transactions on industrial electronics, vol. 41, pp. 492–502, October 1994.*

[11.] *Marino R, Peresada S and Tomei P: Adaptive output feedback control of current-fed induction motors with uncertain rotor resistance and load torque, Automatica, Vol.34, pp. 617-624, 1998.*

[12.] *Ortega R, Canudas C and Seleme I. S: Nonlinear control of induction motors: torque tracking with unknown load disturbances, IEEE Transactions on Automatic Control, Vol. 38, pp. 1675-1680, 1993.*

[13.] *Slotine J. J and Sastry S. S: Tracking control of nonlinear systems using sliding surfaces, with application to robot manipulators, International journal of control, vol. 38, pp. 465–492, 1983.*

[14.] *Spurgeon S. K: Choice of discontinuous control component for robust sliding mode performance, International journal of control, Vol. 53, pp.161-179, 1991.*

[15.] *Wang S. Y, Hong C. M, Liu C. C, and Yang W. T: Design of a static reactive power compensator using fuzzy sliding mode control, International journal of control, Vol. 63, No. 2, pp. 393–412, 1996.*

[16.] *Zadeh L. A: Fuzzy sets, Information and Control, Vol. 8, pp. 338–353, 1965.*

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BULLETIN OF ENGINEERING
ISSN:2067-3809

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ISSN:2067-3809

ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 1 [JANUARY–MARCH]
ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 2 [APRIL–JUNE]
ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 3 [JULY–SEPTEMBER]
ACTA TECHNICA CORVINIENSIS – BULLETIN OF ENGINEERING. Fascicule 4 [OCTOBER–DECEMBER]

fascicule 4
[October - December]
tome VII [2015]
ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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SYNTHESIS AND CHARACTERIZATION OF POLYIMIDE THIN FILMS BY THERMAL EVAPORATION AND SOLID STATE REACTIONS

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Abstract: In this research we describe the preparation of polyimide with pyromellitic dianhydride (PMDA) and p-phenylene diamine (PDA) thin films by physical vapor deposition. For this study , FTIR Spectrometer has been used to measure the effect of imidization temperature on the chemical structure of vapor-deposited thin films of the aromatic PI. When temperature increases, a general increase in all the absorption peaks is observed by FTIR . The surface topology of the PI films was further examined by using AFM atomic force microscopy as a function of the imidization temperature at 150,200,250 °C for 1 hour each in an air circulating oven. The thermal stability of polyimide was also improvedby using Thermogravimetric analysis (TGA).
Keywords: Polyimide thin films, thermal imidization temperature, thermal evaporation, polycondensation reactions

INTRODUCTION

Polyimides are one of the most important classes of high temperature polymers available today. They find wide spread application due to the wide range of chemistry and properties accessible [1]. Innovative polyimide design has led to their use in aerospace, microelectronics, automotive and packaging industries [2]. Polyimides have become important materials in the manufacture of a large number of technical products, e.g. varnishes, coatings etc, due to their excellent thermal stability and mechanical strength, high stability to ionizing, good film forming ability, and superior chemical resistance [3]. Since the excellent properties of polyimides are a result of combination of both chemical structure and final morphology of the products, it is important to understand the structural evolution within the material during imidization process, which directly affects the final thermal, mechanical and optical properties [4]. Polyimides are step or condensation polymers derived from both aliphatic or aromatic dianhydrides and diamines[5].

In this research polyimide films prepared by the vapor deposition, which are prepared by the reaction of a dianhydride and diamine mixture, which by solid state reactions is converted to polyimide by thermal treatment usually below 300 ^{0}C.

Vapor deposition of the precursors and solid state reactions of imidization are of a greater priority than the spin coating and dipping methods.

The physical vapor deposition as a "dry" method provides high purity for producing thin polymer films of controlled thickness, ratio of precursors and composition control of the so prepared layers [6]. The aim of the present work is to study, FTIR Spectrometer has been used to measure the effect of imidization temperature on the chemical structure of vapor-deposited thin films of the aromatic PI PMDA–PDA. AFM has been used to elucidate the effect of heating subsequent to imidization of PI.

Thermal degradation processes were also investigated through dynamic thermogravimetric analysis at different heating rates.

POLYIMIDE SYNTHESIZATION

Polyimide is synthesized by a two-step reaction, as shown in Figure 2. In this work, pyromellitic dianhydride (PMDA) and p-phenylene diamine (PDA), which are commercially available from Sigma-Aldrich. These two monomers, 2 gm each, were evaporated from two separated boats to form a poly(amic acid) (PAA) thin film on substrate. The substrates used were silicon wafer and glass.The deposition process began at vacuum of 2 X 10^{-5} mbar.

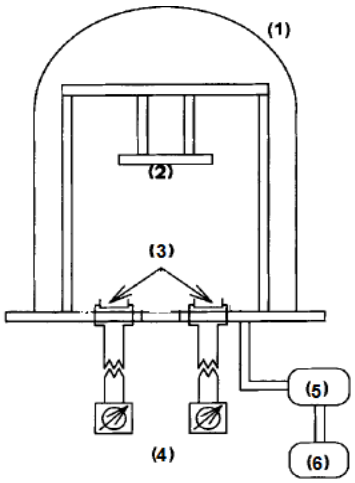

Figure 1. Schematic illustration of the PVD chamber

Figure 1 shows the scheme of the PVD apparatus. The resultant polyamic acid PAA film was then soft baked to remove nH_2O from the substrate

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followed by a thermal treatment at (150, 200 and 250°C) for 1 hour each in an air circulating oven.

In the case of PI the purpose of the thermal treatment is the run of polycondensation reactions in solid state till completion of the PI formation. As a consequence of these reactions leading to a release of water and imidization also a certain pack of the layer is achieved. The final thickness of films is $5 \pm 0.1 \mu m$.

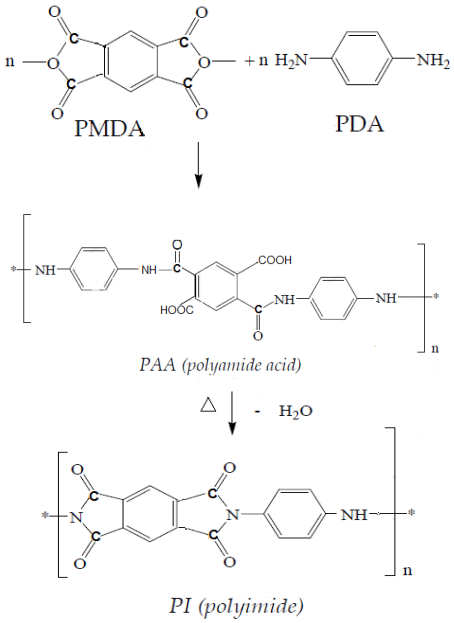

***Figure 2**. Synthesis of Polyimide in two steps*

Results and discussion

FTIR Analysis

FTIR measurements have been performed for different imidization temperatures to determine the completion of the imidization reaction of the polyimide films. This analysis rests on the transmission peak magnitude changes in the functional groups or in the characteristic linkages during the reaction. Figure 3 shows the changes in FTIR spectra of PMDA-PDA for different imidization temperatures (150, 200 and 250°C) for 1 hour each.

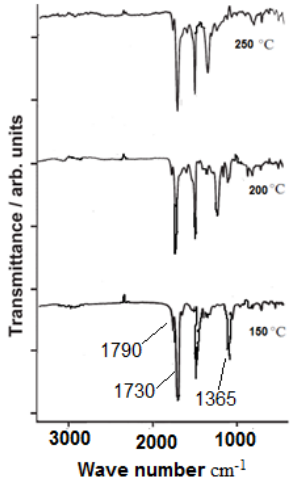

***Figure 3**. FTIR spectra of PMDA-PDA for different imidization temperature*

When temperature increases, a general increase in all the absorption peaks is observed. This suggests that residual PAA monomers continue to be converted into PI. This evolution is stabilized after exposure to temperature above 250 °C [3,7].

Spectra have been normalized to the classical aromatic ring C=C absorption band appearing around 1500 cm^{-1}, and the absorption peak at 1365 cm^{-1} (C-N) stretching vibration of imide ring was monitored during the curing from PAA to PI. The absorption peaks at 1790 cm^{-1} and 1730 cm^{-1} indicated that there was asymmetry and symmetric stretching vibration of C=O bondings. The absorption peak at 710 cm^{-1} was the flexural vibration of C=O bonds. [8,9].

Atomic Force Microscopy (AFM)

The AFM analysis also provides information on the changes in the surface morphology and roughness introduced by the heat treatment. Fig. 4 shows the AFM topographic images of the polyimide films and those subjected to imidization temperature150,200 and 250 °C for 1 hour each.

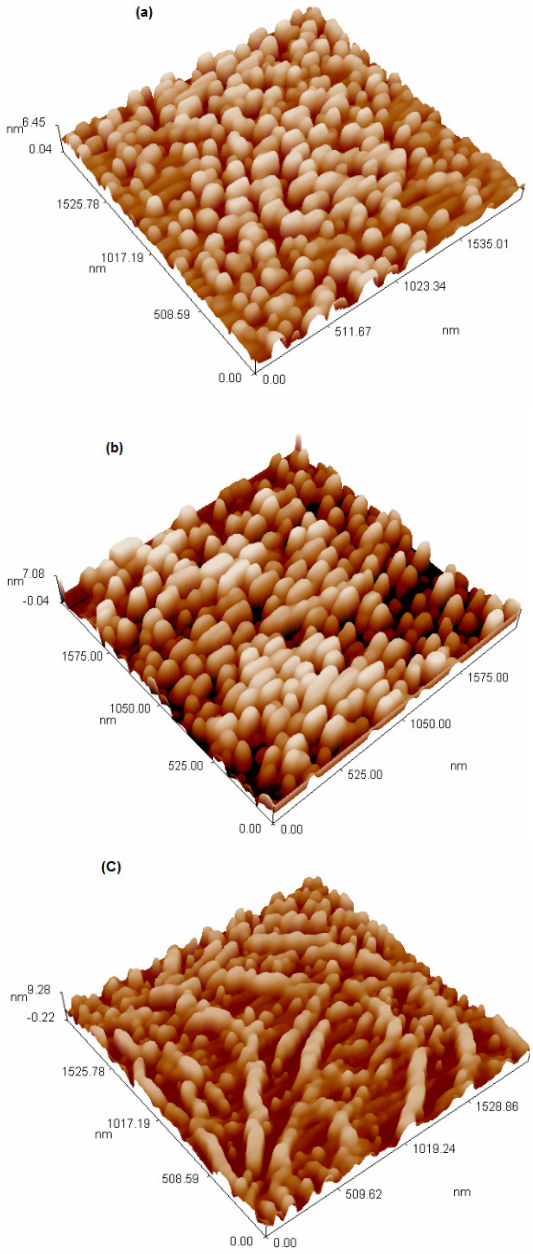

***Figure 4**. 3-D AFM images PI thin films*

The respective imidization temperatures from (a) to (c) are 150, 200 and 250 °C.

It can be clearly seen that the surface became rougher with increasing imidization temperature, creating a distinctive surface structure[10]. This indicates that films of PAA and fully cured PI have comparable roughness and thickness uniformity; i.e. curing does significantly roughen the surface for the conditions used in this work.

The surface topology of the PI films was further examined by using AFM. nodular aggregates are aligned in several row[11]. Moreover, the area of the dark spots, indicating the troughs on the surface increased when the imidization temperature increase, for instance, some kind of decomposition occurs at the elevated temperatures before the imide chain decomposition [6,12].

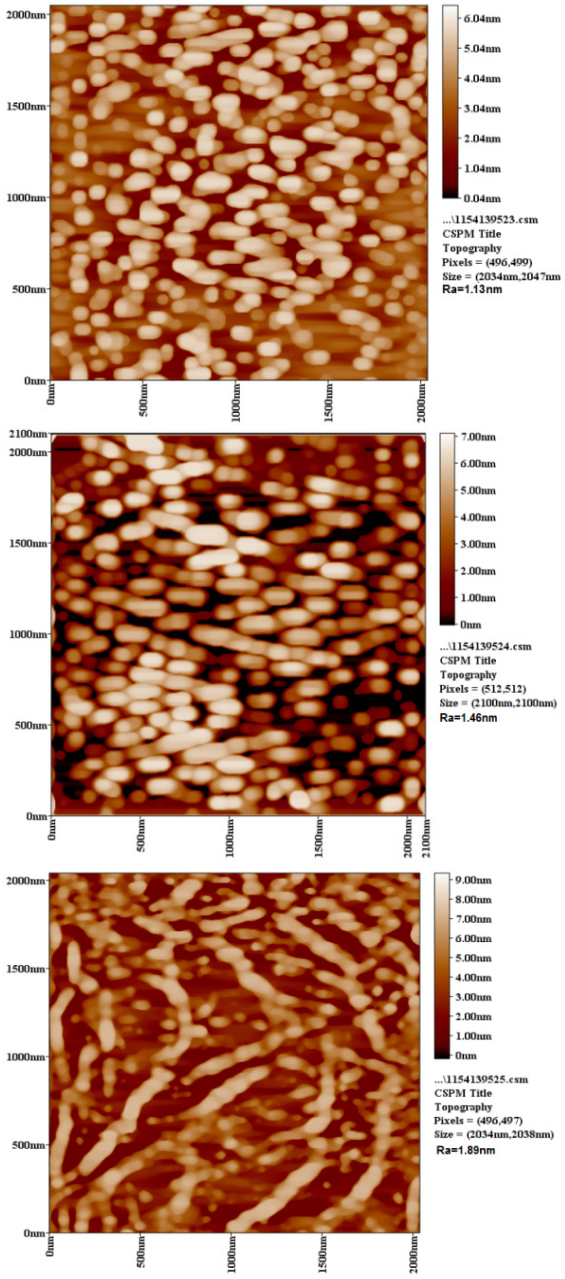

Figure 5. *2-D AFM images PI thin films*

The respective imidization temperatures from (a) to (c) are 150,200 and 250 °C.

Thermal Stability

Figure 6 showed the weight loss of the PI with temperature at a heating rate of 10 °C/min as measured by TGA in air

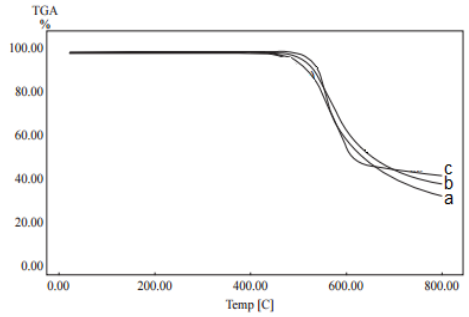

Figure 6. *TGA curves of PI thin films*

The respective imidization temperatures from (a) to (c) are 150, 200 and 250 °C.

The three curves in the figure indicate the thermal stability of PI which had a thermal imidization temperature at 150 °C, 200 °C and 250 °C for a,b and c respectively. It can be observed from Figure 6 that the temperature, at which weight loss of occurred, 490 °C, 520 °C and 542 °C for PI-a, PI-b and PI-c respectively, a continuous weight loss in the initial stage may be attributed to the evaporation of the preabsorbed water and solvent in the film[9]. It was also found that the temperature of thermal weight loss of was raised with the increasing of thermal imidization temperature of PAA. weight loss becomes more marked, indicating the occurrence of imidization.

The result implied that imidization temperature had a significant influence on thermal weight loss [13,14]. At above 580°C, the sample starts to decompose drastically. For the conventional film, as shown in Figure 6, the rapid weight loss at above 490°C may result from ongoing solvent evaporation and imidization until decomposition takes place at 585°C[4,15].

CONCLUSIONS:

In this research polyimide films prepared by the vapor deposition, which are prepared by the reaction of a PMDA-p-PDA mixture, which by solid state reactions is converted to polyimide by different imidization temperature . When temperature increases, a general increase in all the absorption peaks is observed by FTIR. The AFM analysis also provides information on the changes in the surface morphology and roughness introduced by the heat treatment. The thermal stability of polyimide was also improved .The thermal properties of all polyimides were varied, depending on the structure of the monomer and following the stiffness of the polymer backbones makes the polymer thermally stable with increased solubility.

References:

[1.] M. Barikani Polyimides Derived from Diisocyanates 'Iranian Polymer Journal / Vol. I No. 4 (2002).

[2.] G. Danev, E. Spassova, J. Assa vacuum deposited polyimide – a perfect matrix for nanocomposite materials, Journal of Optoelectronics and Advanced Materials Vol. 7, No. 3, pp. 1179 – 1190(2005) .

[3.] E. O. Al-Temimi , M. A.AL-Issa, S. J. Al-Bayat Synthesis and Characterization of New Polyimide by Curing Poly Acryloyl Chloride with Different Amides J. Baghdad for Sci. Vol.10, No.3, pp.686-698(2013).

[4.] J.Jou, C.Chenc, E.Chin-yi, and A.Yyang, Characterization of Vapor Deposition Polymerized Polyimide Thin Films Journal of Polymer Science: Part B: Polymer Physics, Vol. 34,pp.2239-2246 (1996)
[5.] S.Iwamori, R.Sugimoto, K.Osada, M.Kurata, H.Matsumotoand K.Noda, Gas adsorbsion performance of organic thin films prepared by plasma-assisted vacuum evaporation with polyimide precursors: sensor and materials ,vol.22,No.7,pp.347-356(2010)
[6.] M. Putkonen, J.Harjuoja, T.Sajavaara and L. Niinisto , Atomic layer deposition of polyimide thin films, ,J. M Chem, Vol.17, pp.664–669., (2007).
[7.] I. Karamancheva , V. Stefov , B. S˘optrajanov, G. Danev , E. Spasova ,J. Assa, FTIR spectroscopy and FTIR microscopy of vacuum-evaporated polyimide thin films, Vibrational Spectroscopy Vol. 19 pp.369–374(1999).
[8.] S.C.Lee, F.C. Tai, C.H. Weiand J.I Yu, ATR-FTIR and Nanoindentation Measurements of PMDA-ODA Polyimide Film under Different Curing Temperature, Materials Transactions, Vol. 48, No. 6 pp. 1554 - 1557(2007)
[9.] W. Xie, R. Heltsley, H.Li, Ch. Lee, W. Pan Study of the Processing Chemistry of Polyimides with Thermogravimetry/Fourier Transform Infrared/Mass Spectrometry Techniques Journal of Applied Polymer Science, Vol. 83,pp. 2213–2224 (2002)
[10.] C. L. H. Devlin, S. Chiang, T. P. Russell The Effects of Varied Imidization Conditions on Rubbed Polyimide Film Surface Morphology Journal of Applied Polymer Science, Vol. 93, pp.1192–1197 (2004)
[11.] A. Atta Modification of the Surface Properties of Polyimide Films Using Oxygen Plasma Exposure Arab Journal of Nuclear Science and Applications, Vol.46, No.5, pp.115-123 (2013).
[12.] High Performance Polymers – Polyimides Based – From Chemistry to Applications Ed .Marc Jean Médard, Croatia, chapter 2,(2012).
[13.] X. Li, X. Wang, Q.Wang, Q.Wei, Effects of Imidization Temperature on the Structure and Properties of Electrospun Polyimide Nanofibers Journal of Engineered Fibers and Fabrics Vol. 9, Issue 4, pp.33-38, (2014).
[14.] M.B. Ahmad, Y. Gharayebi, M. S. Salit , M. Z. Hussein, S. Ebrahimiasl and A. Dehzangi Preparation, Characterization and Thermal Degradation of Polyimide (4-APS/BTDA)/SiO2 Composite Films International Journal of Molecular Sciences, Vol.13, pp.4860-4872; (2012).
[15.] W. Xie, R. Heltsley, X. Cai, F. Deng, J. Liu, Ch. Lee, W. Pan Study of Stability of High-Temperature Polyimides Using TG/MS Technique Journal of Applied Polymer Science, Vol. 83, pp.1219–1227, (2002).

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BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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PERFORMANCE EVALUATION OF WSN TOPOLOGY CONTROL ALGORITHMS THAT CAN BE USED IN SMART CITY CONCEPT

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Abstract: *Smart City concept is a topical issue. The main contribution of this paper is the performance evaluation of topology control algorithms that can be integrated in the Smart City concept. Thus, the following topology algorithms A3, A3 Coverage and EECDS are considered. The parameters evaluated are: the number of active nodes after the topology reduction algorithm is applied, the number of packets sent and the energy consumed for building the topology. From the results we conclude that the topology construction algorithm A3 provides the lowest number of active nodes and is recommended for use in the Smart City concept.*

Keywords: *large-scale, Smart City, WSN*

INTRODUCTION

The Smart City concept is a topical issue. The structure of a WSN network that can be integrated within such a concept is of large-scale type and has a number of characteristics such as in comprising of a very large number of nodes distributed over a wide geographical area (large-scale). Thus, to achieve a high level of performance the optimal network topology construction is an issue that should not be neglected. In the scientific literature, there are a number of specialized algorithms that reduce the initial network topology having as main purpose to increase the lifetime of WSN nodes which are often battery powered.

The main contribution of this paper is the performance level evaluation of the topology control algorithms that can be integrated in a Smart City. In the first part of the paper summarizes the main topology control algorithms which can be integrated in the concept of Smart City, meanwhile the second part presents the results obtained in simulations.

TOPOLOGY CONTROL ALGORITHMS

In this section are presented the most used topology control algorithms that can be integrated in the concept of Smart City. The topology control algorithms presented in this section are used to reduce the initial network topology and don't ensure its maintenance. Because the vast majority of WSN nodes within the concept of Smart City are fixed, we consider only control/construction algorithms to ensure the highest possible performance level.

CDS (Connected Dominating Set) Algorithm

The main goal of the CDS (Connected Dominating Set) algorithm involves determining a backbone type structure by selecting a subset of nodes that can guarantee and provide connectivity while allowing any other nodes in the WSN network to communicate directly with a backbone node. Thus, low delays, packet loss and network capacity are considerably increased.

The determination of the dominant nodes can be achieved by solving the mathematical CDS problem. A set of dominant nodes $D \subset V$ within a graph (V), assures that any other node that do not belong to this subset (D) must have a link with at least one node from the subset. A CDS topology control algorithm is proposed in [1]. The set of dominant components of a graph consists of a set of nodes whose neighbors, together with themselves constitute all nodes in the topology graph. As can be seen from Figure 1 the dominant nodes (N4, N7) are shown in blue and provide a backbone for the entire WSN network.

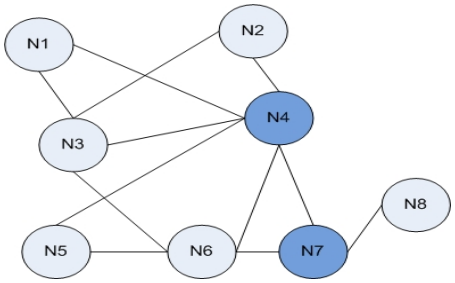

Figure 1. *The set of dominant nodes within the network topology*

The CDS graph can be constructed by determining, step by step, the tree topology which can be established by using Prim's algorithm [2]. Prim's algorithm determines the minimum tree topology for ensuring the connectivity condition within a graph. The construction process is based on a set of nodes that are part of the topology tree at time t. With time, the nodes within the set evaluate all adjacent nodes, in order to expand the tree graph. This process continues until all nodes in the graph are evaluated, some nodes are declared as active, while the other are set to sleep mode. Using this algorithm guarantees connectivity for a new node with at least one active node in the topology tree. However, each branch of the tree topology does not fulfill the condition of reliability. CDS algorithm starts from the sink node and ensures a high performance level

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for hierarchical based routing algorithms.

EECDS Algorithm (Energy Efficient CDS)

In an undirected graph, a set of MIS (Maximal Independent Set) nodes is also a dominating set (DS - Dominating Set). The vast majority of distributed algorithms first determine the MIS set that is then used to determine the CDS set of nodes. The papers [3], [4] propose, for the first time, a series of distributed algorithms that can be used for determining the CDS set of nodes by building UDG (UDG-Unit Disk Graphs). This algorithm consists of two steps: the first step involves the formation of the spanning tree graph that will then be used to determine the MIS set of nodes in the tree.

In [5] is presented an algorithm to ensure efficiency in terms of power consumption EECDS (Energy Efficient CDS) meanwhile determining the CDS nodes. The algorithm uses two steps to determine the CDS optimal set in terms of power consumption by using a coloring process. The algorithm starts with all the nodes colored in white. An initiator node is chosen that is part of the MIS set, it sends messages to neighboring nodes informing them that it's part of the MIS and changes his color to black. Upon receipt of these messages, each node neighbor turns gray. Gray colored nodes send notification messages to the neighboring nodes colored with white to announce their color change. Therefore, all white nodes receiving a message from a gray node are neighbors of a node that doesn't belong to the MIS set. These nodes are then colored to black. Thus, a node sends a request message to all neighboring nodes to know their status. If it doesn't receive a response from a black node becomes himself a black initiator node and the process is resumed. The second part of the EECDS algorithm, is the formation of the CDS by using the nodes that don't belong to the MIS set [6].

A3 Algorithm

In terms of routing protocol in order to achieve a high level of performance the CDS set must contain a low number of nodes, so the retransmission of packets in the network can be achieved with a minimum number of hops and hence a much lower energy consumption.

Therefore Wightman PM in [7] proposed a topology construction algorithm which determines the approximate CDS sub-optimal set of nodes. The A3 (A tree) algorithm uses four types of messages to achieve topology discovery. The CDS construction process is initiated by a pre-defined node which could even be the sink node of the WSN network, which sends hello messages to all nodes within communication range.

The WSN nodes that receive the hello message from the parent node (sink node) send back the information regarding the remaining power and the signal strength of the signal received. This information will be used to calculate a metric. The metric will have a low value in case of timeout or a value that gives priority to the nodes with higher energy which are further from the sink node. This metric is used in the construction of the reduced topology which must incorporate a minimum number of nodes. As soon as the sink node receives confirmation to be a parent node sends back a list of all child type nodes selected by using the metric. This list contains information about all child nodes belonging to a parent node. This procedure is repeated by the neighboring nodes with the purpose of forming the reduced WSN topology. The nodes that don't receive a reply to the hello message go to sleep mode.

A3 Coverage Algorithm

The Coverage A3 algorithm was also developed by Pedro M. Wightman and is presented in [11]. The protocol is a topology construction algorithm which emphasizes the development of the optimal topology aimed at increasing coverage of WSN sensors. Coverage A3 is similar to the A3 algorithm which involves the development of a backbone in the WSN network to ensure guarantee connectivity between nodes.

All the nodes that are part of the backbone will remain active while the remaining nodes can enter sleep mode to save energy. The considerable difference between the two algorithms can be seen in the mode they ensure the growth of coverage. Thus, in the algorithm A3, the coverage of WSN nodes is achieved by ensuring connectivity of the nodes in the sleep mode (passive nodes) by using the communication range of active nodes. In contrast A3 Coverage algorithm uses the sensing range of the active nodes to ensure the coverage condition [11].

TESTS RESULTS

Atarraya is a simulation tool that can be used to assess the performance evaluation of topology control algorithms that can be integrated in a wireless sensor networks (WSN). The application was developed by the University of Florida, USA [8]. Atarraya has the following characteristics:

- *Allows fast integration of topology control and topology maintenance algorithms;*
- *Positioning of the WSN nodes can be achieved by using mathematical distributions;*
- *The simulation environment allows the user to develop, test and implement new topology control algorithms;*
- *The simulator also allows the use of mathematical models to ensure node mobility [9].*

In a previously published paper [10] is presented the performance evaluation of topology control algorithms that can be integrated into a street lighting monitoring and control system which is based on a large-scale, long-thin WSN network.

Figure 2 presents the Atarraya simulator interface.

In order to determine the best topology control algorithms that can be integrated in the Smart City concept were implemented a series of test scenarios. Thus, we consider the following algorithms A3, A3 Coverage and EECDS. One of the simulation parameters evaluated is the number of active nodes after the topology construction algorithm is performed.

Other parameters considered are the number of packets sent and the energy consumed in the topology building process.

Thus, we developed a large-scale sensor network WSN distributed on a large geographical area of 2.5 x 2.5 Km. In the simulation scenarios the number of sensor nodes was varied from 500 to 1000, 1500, 2000 and 2500. Atarraya simulator offers the possibility the node position through the use of mathematical distributions such as uniform distribution, constant, normal or central distribution. In the implemented simulation scenarios the nodes were distributed in the defined geographical area, using the uniform mathematical distribution.

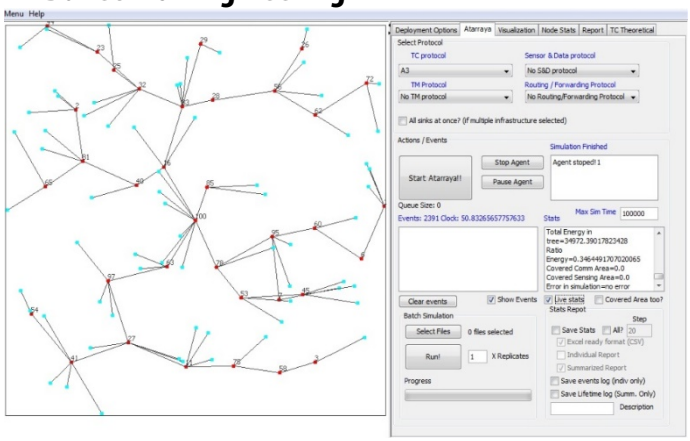

Figure 2. *Atarraya graphical user interface (GUI)*

Figure 3 presents the reduced topology for the network with 2500 nodes using the A3 algorithm.

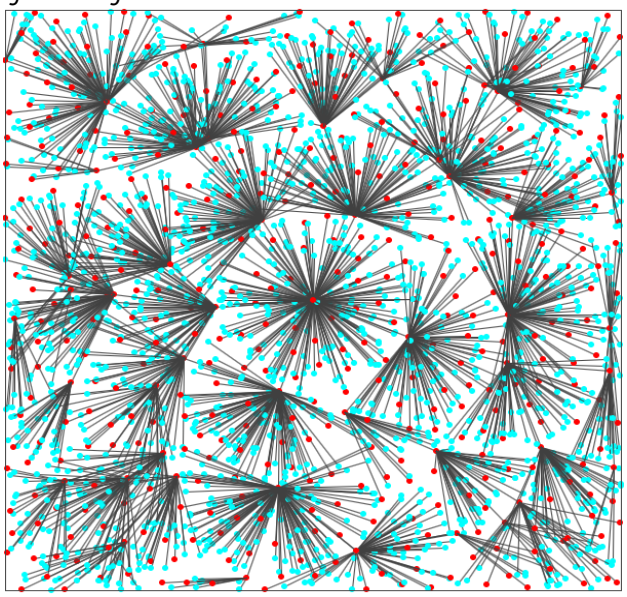

Figure 3. *The reduced network topology by using the A3 algorithm (2500 node architecture)*

In Figure 4 is presented the variation of the active nodes as compared to the total number of nodes. If the standard tree protocol (Just Tree) is used all nodes in the topology, are considered active as can be observed.

The number of active nodes represents the number of nodes that cannot go into sleep mode. Thus, these nodes cannot be supplied from a battery device as they actively participate in the routing and packet forwarding process.

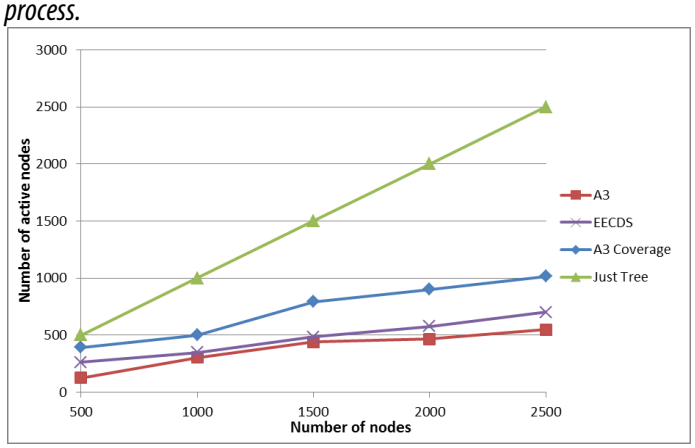

Figure 4. *Number of active nodes*

From the obtained results the topology construction algorithm A3 provides the lowest number of active nodes, i.e. 547 nodes, for the network topology with 2500 nodes and is recommended for use in the Smart City concept.

Figure 5 shows the variation of the number of packets sent inside the network in order to generate the topology when the EECDS algorithm is used.

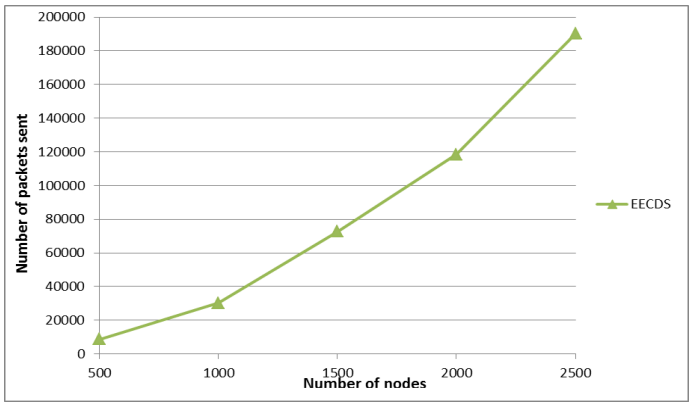

Figure 5. *Number of packets sent by the EECDS algorithm*

Figure 6 shows the variation of the number of packets sent within the network topology when the A3, A3 Covergecast and standard tree algorithms are used to reduce initial network topology.

From the results obtained the EECDS algorithm has the largest number of packets sent (190060 packets for the 2500 node topology) unlike A3 algorithm which sends a number of 7579 packets for the same topology. Thus, the concept of Smart City is recommended A3 algorithm in terms of number of packets sent. The A3 algorithm in terms of the performance of is followed by the algorithms A3 Coverage and Just Tree.

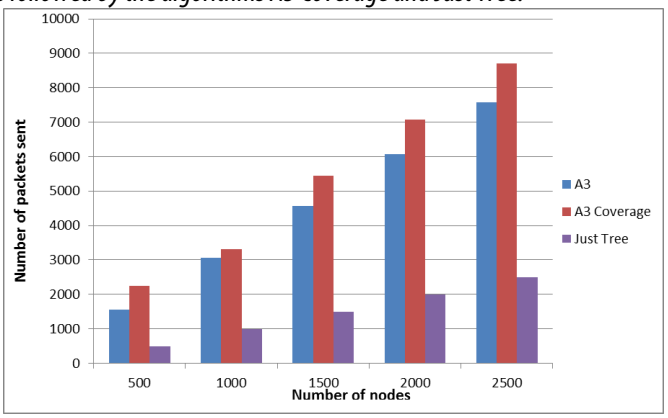

Figure 6. *Number of packets sent*

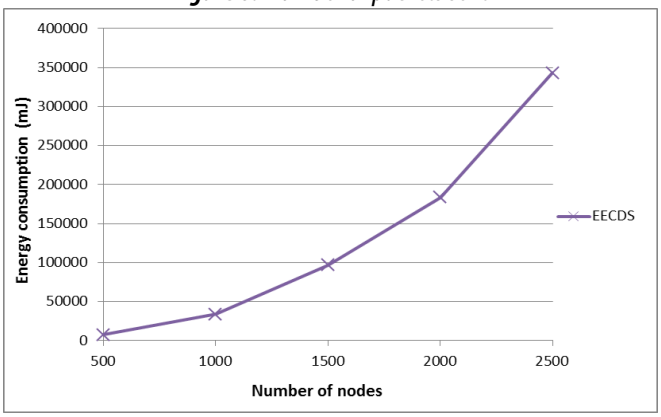

Figure 7. *Total energy consumption in EECDS topology control*

Another aspect that should not be overlooked is the total energy consumed by the network nodes to determine the network topology reduction. In Figure 7 presents the variation of the energy needed to build the network topology by using EECDS algorithm.

In Figure 8 is presented the variation of energy needed for building the network topology. The algorithms used are A3, A3 Coverage and Just Tree.

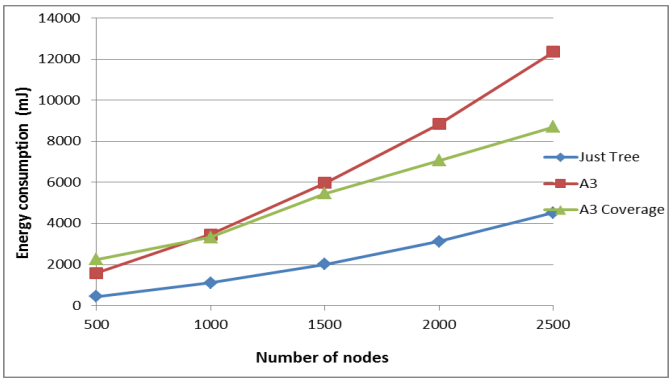

Figure 8. *Total energy consumption in topology control*

From the results obtained the standard tree algorithm provides the lowest energy consumption, which was expected because it has the lowest number of messages sent. The standard tree algorithm is followed in terms of performance by A3 Coverage and A3 respectively.

It can be observed that the most complex EECDS algorithm developed to ensure optimal energy consumption also has the highest energy consumption when the initial network topology is created.

CONCLUSION

In the scientific literature, there are many papers that approach the network topology control problem, but none of these addresses the issue of large scale WSN networks that can be integrated in the Smart City Concept [10].

Thus, the main contribution of this paper is the performance evaluation of the following algorithms A3, A3 Coverage, tree standard and EECDS respectively. From the results obtained we conclude that the topology construction algorithm A3 provides the lowest number of active nodes and is recommended for use in Smart City concept. In terms of the number of packets sent the A3 algorithm ensures the highest level of performance. From the point of view of energy consumption A3 Coverage algorithm is the most efficient algorithm and is being followed by A3, and EECDS.

ACKNOWLEDGMENT

This paper has been financially supported within the project entitled „SOCERT. Knowledge society, dynamism through research", contract number POSDRU/159/1.5/S/132406. This project is co-financed by European Social Fund through Sectoral Operational Programme for Human Resources Development 2007-2013. Investing in people!

REFERENCES

[1] *D. J. Baker, A. Ephremides, "The architectural organization of a mobile radio network via a distributed algorithm", IEEE Transactions on Communications, vol.29, pp. 1694-1701. November, 1981.*

[2] *Prim Robert Clay, "Shortest connection networks and some generalizations", Bell system technical journal 36.6, pp. 1389-1401, 1957.*

[3] *P. J. Wan, K. M. Alzoubi and O. Frieder, "Distributed Construction of Connected Dominating Sets in Wireless Ad Hoc Networks", IEEE Infocom, vol. 3, pp. 1597-1604, November, 2002.*

[4] *K. M. Alzoubi, P. J. Wan, and O. Frieder, "New Distributed Algorithm for Connected Dominating Set in Wireless Ad Hoc Networks", 35th Hawaii International Conference on System Sciences (HICSS 02), vol. 9, pp. 3849-3855, January, 2002.*

[5] *Z. Yuanyuan, X. Jia, and H. Yanxiang, "Energy efficient distributed connected dominating sets construction in wireless sensor networks", ACM International Conference on Wireless Communications and Mobile Computing, pp. 797–802, July, 2006.*

[6] *Qureshi, Hassaan Khaliq, "Graph-theoretic channel modeling and topology control protocols for wireless sensor networks", (Unpublished Doctoral thesis, City University London) pp. 52-70, 2011.*

[7] *Wightman P.M., Labrador M.A, "A3: A Topology Construction Algorithm for Wireless Sensor Network", IEEE Globecom, pp. 1-6, December, 2008.*

[8] *Atarraya Simulator, On-line: www.csee.usf.edu/~labrador/Atarraya/.*

[9] *Wightman, P. M., Labrador M., "Atarraya: a simulation tool to teach and research topology control algorithms for wireless sensor networks", Proceedings of the Second International ICST Conference on Simulation Tools and Techniques, pp. 26-36, 2009.*

[10] *Alexandru Lavric, Valentin Popa, "Performance Evaluation of Topology Control Algorithms", RoEdu International Conference, pp. 111-114, 2013.*

[11] *Wightman, Pedro M., and Miguel A. Labrador. "A3Cov: A new topology construction protocol for connected area coverage in WSN." Wireless Communications and Networking Conference (WCNC), 2011 IEEE.*

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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PROBLEMS CONFRONTING THE HUMANITARIAN WORKERS

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Abstract: The humanitarian aid personnel usually work in complex environments where working conditions are often not favourable, which results in putting these humanitarian staff at risk of experiencing traumatic and daily cumulative stresses. As this field of study is relatively new and least addressed, this paper aims to provide a conceptual overview of common themes that have begun to emerge from recent works. Different areas of risks are proposed that are likely to have applicability across different contexts and situations. This includes individual risk factors, health issues and situational risk factors which require Psychological adjustment, medical health and security in promoting safety and wellbeing of individuals.
Keywords: Job stress, risk factors, psychological distress, Psychological Co morbidity

INTRODUCTION

Psychological distress that may result from repeated exposure to traumatic events experienced as part of a person's every day work, includes symptoms ranging from posttraumatic stress disorder and depression, discontinuity in memory, perception or identity (Koopman, Classen, & Spiegel, 1994) to emotional exhaustion, and low personal accomplishment. A refugee camp is one of the hardest situations that one could find in, because it's so dynamic and horrifying that thousands of people may be there dying and watching their close relatives dying. It is one of the hardest things, in terms of emotions.

It is commonly acknowledged that humanitarian aid efforts are increasingly associated with a rising number of civil conflicts and with countries suffering from prolonged poverty and disaster (International Federation of Red Cross and Red Crescent Societies, 1998; Minear & Weiss, 1995). During these complex emergencies, humanitarian staff is at risk of experiencing acute potentially traumatic stressors and ongoing cumulative daily stresses. At times these staff may themselves become victims of disasters. Secondary traumatic stress is an experience of trauma that comes from behaviour and emotions resulting from helping or wanting to help a suffering person (Figley, 1995). Incidents such as catastrophic injury to a co-worker, gruesome victim incidents, aiding seriously injured victims of a disaster, vulnerable victims, and exposure to death and dying, have been rated as being the most stressful (Beaton, Murphy, Johnson, Pike & Corneil, 1998).

Academic research and clinical knowledge about the wellbeing of humanitarian aid workers remains in its infancy. Due to early stage of development of this field, this paper aims to provide a conceptual overview of common patterns that have begun to emerge from recent works and to set forth a preliminary examination of areas that are likely to carry risks for the psychological adjustment of international and national humanitarian staff that have applicability across different contexts, countries and people.

INDIVIDUAL RISK FACTORS AND PSYCHOLOGICAL DISTRESS

= Job Expectations

International aid workers have expectations about the ideals of humanitarianism and the conduct of colleagues was often met with disappointment (McFarlane, 2003b). Inexperienced aid workers wanting simply to help can become targets for anger and rejection. Most of the national aid workers work with international aid organizations for their own survival and for their good name.

= Risk Taking Tendency

Risk taking tendency has been reported as prevalent among humanitarian staff (Smith, 2002). Sheik et al. (2000) reported that workers who were parents are more careful and therefore were significantly less likely to die from unintentional violence (accidents), implying that individuals without such responsibilities were more likely to engage in risk-taking behaviour.

= Negligence in Self-Care

Several authors have reported that despite being briefed, aid workers did not follow preventive measures for their health (Blacque-Belair, 2002; Lange et al., 1994). Sharp et al. (1995) and Blacque-Belair (2002) both reported that some relief workers felt uncomfortable utilizing medical prevention strategies that were not available to the local population.

HEALTH ISSUES IN HUMANITARIAN AID WORK

The health consequences associated with humanitarian aid work include death, physical illness and psychological distress.

= Loss of Life

There has been a documented rise in mortality rates of humanitarian aid workers over the past decade, which has indicated the serious risks humanitarian staff faces (Sheik et al., 2000). Intentional violence related

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to the use of weaponry (Sheik et al., 2000), infectious disease (Peytremann, Baduraux, O'Donovan, & Loutan, 2001) and accidents (Hurlburt, 2002) are the major reasons for deaths in humanitarian staff.

= ***Sickness***

Physical sickness experienced by humanitarian staff can have serious consequences in countries where the availability of health services may be limited. Preventable infectious diseases and accidents have been reported as the main medical problems which result in the majority of medical evacuations (Peytremann et al., 2001).

= ***Psychological Comorbidity***

Investigations have revealed that the international humanitarian staff is at risk of developing significant mental health problems. Cardozo & Salama (2002) reported high levels of depression (15%), anxiety (10%) and alcohol abuse (15%) in international aid workers. Reports from multiple sources have repeatedly documented the related distress, culture shock and burnout that humanitarian staff experience (Agger, 1995; Danieli, 2002; Lovell, 1997).

Studies suggest that nationals are also at increased risk of psychological distress. Holtz, Salama, Lopes Cardozo, & Gotway (2002) suggested that human rights workers in Kosovo experienced elevated levels of depression and anxiety associated with longer duration of employment. Ahmad (2002) outlined a unique range of personal and professional difficulties that national staff faced, including problems with accommodation, finances, safety, job security and family dislocation.

SITUATIONAL RISK FACTORS AND PSYCHOLOGICAL DISTRESS

These factors may carry risk for death and illness and are as follows:

= ***Timing of Employment***

For both international and national humanitarian staff, the critical periods during the first job with non-governmental organizations (NGOs) and for the beginning of subsequent jobs thereafter have reported increased psychological distress and physical health complaints. Sheik et al. (2000) reported that a third of all deaths occurred within the first three months of arrival and were unrelated to previous experience. Cardozo & Salama (2002) recommended the use of a formal mentoring system to support newcomers under such conditions. Cardozo & Salama (2002) also noted that experienced personnel who had completed multiple assignments were at risk of increased exposure to more traumatic experiences. Recreational breaks between assignments may be important for mediating the effects of traumatic stress allowing staff to ease their stress, rejuvenate and readjust (Eriksson, 1997).

= ***Organizational Preparation***

The role of the organization in preparing their humanitarian staff for aid work is very critical in mitigating or preventing psychological distress. Preliminary results from Cardozo & Salama (2002) suggest, "There is a relationship between organizational support policies and mental health outcomes in humanitarian aid workers". Studies of organizational practices have shown that pre-departure training in stress-management, conflict resolution, media handling, working cross-culturally and team building have been neglected aspects of training (Macnair, 1995; McCall & Salama, 1999). Simmonds et al. (1998) reported that many staff were not systematically briefed or covered by comprehensive medical examinations. For international staff, comprehensive knowledge and training about the country, security, medical care, psychological stress management, team building and cultural differences of the host country are important to reduce the potential for psychological distress.

= ***Country Violence***

Violence and the perceived threat to one's life constitute important risk factors in the wellbeing of both international and local staff. They include bombings, shootings, assaults, kidnappings, rape and accidents. The lack of legal and military protection for humanitarian staff exacerbates the problems of violence. Threats of violence may be in the following forms; the general layout of the host community and its phase of conflict and development, threats of violence targeted at particular groups (i.e. foreigners, women, ethnic groups) and threats of violence targeted at particular individuals. In humanitarian work, ongoing concerns about personal safety to oneself, colleagues, family and friends are common (Cardozo & Salama, 2002; McFarlane, 2003b). Eriksson (1997) found that the severity of exposure and high frequency of these occurrences were associated with higher levels of distress upon return home.

Unfortunately national staff may be more at risk because they are often not evacuated from countries in extreme danger, are not afforded the special status of Western aid workers while in-country and have limited access to resources. Although it is very difficult to prevent such situations of violence but, well-planned security procedures and psychological support that encourage individual health and security-promoting behaviour could be practiced.

= ***Cultural and Physical Context***

For international staff, social, cultural and geographical isolation are often an inherent part of the overseas experience. A combination of social, cultural and geographical isolation can evoke feelings of abandonment, despair and fear (McFarlane, 2003b). Moreover isolation is aggravated by placement in countries where cultural differences are greatest. There should be cultural training methods to improve cultural empathy, interpersonal problem-solving techniques and reinforcement of self-efficacious behaviour. Increasing access to electronic communication technology and the ability of international staff to integrate with local people are examples of ways in which feelings of loneliness and isolation may be ameliorated (Hullett & Witte, 2001; McFarlane, 2003b).

National staff may also find themselves working with minority, disadvantaged or marginalized community groups where they are considered outsiders. These groups may be culturally and linguistically different, thus posing difficulties with intercultural communication and trust for national staff. National staff can also benefit from intercultural training programs.

= ***Organizational Support***

It has been observed that sometimes there is a culture of denial among some aid organizations as well as a legitimate lack of organisational capacity to cope with the psychosocial challenges their staff face (Ager, Flapper, van Pietersom, & Simon, 2002). Macnair (1995) reported an

overall lack of training resources available for personnel, particularly nationals, while in the field.

Conflict with the aid organization, or staff members therein, role ambiguity, the remoteness of the office and the functional capacity of the NGO all increase the risk that humanitarian staff will feel unsupported organizationally (McFarlane, 2003b). These difficulties were particularly evident during critical incidents in which staff was faced with acute stressors and when direct requests for assistance were not met with constructive responses. National staff on the other hand has stresses associated with working for a western-based aid organization. These stresses arise due to cultural difference with the Western organizational style, language and communication barriers, an increased sense of insecurity about job loss, socioeconomic differences and enhanced power differentials (Ahmad, 2002; McFarlane, 2003b). Ahmad (2002) claimed that national staff were discontented with the amount of training they received by the organization. Similar difficulties arise for nationals when they see foreigners enjoying higher salaries and additional lifestyle benefits (McFarlane, 2003b). Careful culturally based research needs to address these important parameters in order for the wellbeing of national staff to be effectively addressed.

= ***Difficult Working Situations***

Humanitarian staff while working towards their job can work in antithesis to governments that may be noticeably corrupt, factional or dictatorial, beneficiaries that sometimes appear to make superficial or self-interested funding decisions and at worst, the very act of war. Assessing and reality-orienting staff expectations prior to their work, as well as allowing ventilation, encouragement and support while on the job, will assist in safeguarding the wellbeing of humanitarian staff. Peer support and job satisfaction are likely to have protective effects for these difficulties.

= ***Interpersonal Relations***

The interpersonal relationships of international staff can experience change and disruption when they work overseas, increasing the potential for stress. Furthermore, international aid workers may leave others at home (spouse, children, elderly parents) that create worry because of the distance and difficulties of attending to their concerns (Hurlburt, 2002; McFarlane, 2003a). Those at home may have difficulties in understanding what the aid worker is going through. Rejection by the local population has also been noted to place international staff at risk for distress (Danieli, 2002). Moreover there are difficulties in intercultural communication, conflict and adjustments.

Similarly, national staff faces intercultural relationship difficulties with international humanitarian staff. They can experience frustration and conflict with foreigners who appear not to understand their culture and which can be compounded by power differentials. Interpersonal conflict may also be exacerbated by different cultural norms regarding the expression of conflict and negative emotions (McFarlane, 2003b). These situations have the potential to impact work performance, security and wellbeing.

CONCLUSIONS

Numerous situational risk factors along with individual risk factors have been outlined, that identify areas in which humanitarian aid workers are likely to experience psychological adjustment difficulties. This lead into an overall negative impact on humanitarian efforts. Generally, humanitarian staff is able to adapt to the acute and chronic stressors of their work. Overall as a group they demonstrate considerable resilience and reap many personal rewards from their work such as job satisfaction, personal meaning and improved wellbeing (McFarlane, 2003a). Indeed the active and constructive pursuit of rebuilding communities and nations may be protective for their wellbeing. However, acknowledgement, awareness and support for the potential difficulties they face are imperative in order to preserve such resilience. An implication of this study is that the humanitarian staff should be monitored for signs for developing psychological distress and necessary remedial actions must be taken to prevent the situation from getting aggravated.

This paper has outlined a number of situational and individual risk factors that can further advance the field of humanitarian aid towards a health promoting model of active support for staff. Difficulties in providing support for aid workers are intimately connected to the geographical and cultural distances between aid organizations and their employees that make this a complex task. Clinical and research programs must take into account the specific cultural and situational factors of each country in order to be effective. The prevailing forces of civil unrest and globalization amongst people, means that there is an imperative to advance timely, appropriate and coordinated academic and applied activities. Moreover, because this is a relatively new field, therefore much attention and effort is required to ensure effective output.

REFERENCES

[1.] Ager, A., Flapper, E., van Pietersom, T., & Simon, W. (2002). Supporting and equipping national and international humanitarian non-governmental organizations and their workers. In Y. Danieli (Ed.), Sharing the front line and the back hills: Peacekeepers, humanitarian aid workers and the media in the midst of crisis. (pp. 194-200). Amityville, NY: Baywood.

[2.] Agger, I. (1995). Theory and practice of psychosocial projects under war conditions in Bosnia-Herzegovina and Croatia (pp. 27-33). Zagreb: European Community Humanitarian Office.

[3.] Ahmad, M. M. (2002). Who cares? The personal and professional problems of NGO fieldworkers in Bangladesh. Development in Practice, 12(2), 2002.

[4.] Beaton, R., Murphy, S., Johnson, C., Pike, K., & Corneil, W. (1998). Exposure to duty-related incident stressors in urban firefighters and paramedics. Journal of Traumatic Stress, 11 (4), 821-828.

[5.] Blacque-Belair, M. (2002). Being knowledgeable can help enormously. In Y. Danieli (Ed.), Sharing the front line and the back hills: Peacekeepers, humanitarian aid workers and the media in the midst of crisis (pp. 201-202). Amityville, NY: Baywood.

[6.] Cardozo, B. L., & Salama, P. (2002). Mental health of humanitarian aid workers in complex emergencies. In Y. Danieli (Ed.), Sharing the front line and the back hills: Peacekeepers, humanitarian aid workers and the media in the midst of crisis (pp. 242-257). Amityville, NY: Baywood.

[7.] Danieli, Y. (Ed.). (2002). Sharing the front line and the back hills: international protectors and providers: peacekeepers, humanitarian aid workers and the media in the midst of crisis. Amityville, NY: Baywood.

[8.] Eriksson, C. B. (1997). Traumatic exposure and reentry symptomatology in international relief and development personnel (Doctoral dissertation, Fuller Theological Seminary, 1997). Dissertation Abstracts International, 58(04B).

[9.] Figley, C. R. (1995). Compassion fatigue as secondary traumatic stress disorder. An overview. In C. R Figley (Ed.), Compassion fatigue (pp. 1-20). New York: Brunner Mazel.

[10.] Holtz, T. H., Salama, P., Lopes Cardozo, B., & Gotway, C. A. (2002). Mental health status of human rights workers, Kosovo, June 2000. Journal of Traumatic Stress, 15(5), 389-395.

[11.] Hullett, C. R., & Witte, K. (2001). Predicting intercultural adaptation and isolation: Using the extended parallel process model to test anxiety/uncertainty management theory. International Journal of Intercultural Relations, 25, 125-139.

[12.] Hurlburt, K. (2002). Precious lives honored to serve. In Y. Danieli (Ed.), Sharing the front line and the back hills: Peacekeepers, humanitarian aid workers and the media in the midst of crisis (pp. 161-169). Amityville, NY: Baywood.

[13.] International Federation of Red Cross and Red Crescent Societies. (1998). World Disasters Report. Oxford, England: Oxford University Press.

[14.] Koopman, C., Classen, C., & Spiegel, D. (1994). Predictors of posttraumatic stress symptoms among survivors of the Oakland/Berkeley, Calif., firestorm. American Journal of Psychiatry, 151 (6), 888-894.

[15.] Lovell, D. M. (1997). Psychological adjustment amongst returned overseas aid workers. Unpublished D.Clin.Psy. thesis, University of Wales, Bangor.

[16.] Macnair, R. (1995). Room for improvement: The management and support of relief and development workers (Relief and Rehabilitation Network No. Network Paper 10.). London, UK: Overseas Development Institute.

[17.] McCall, M., & Salama, P. (1999). Selection, training, and support of relief workers: an occupational health issue. British Medical Journal, 318, 113-116.

[18.] McFarlane, C. (2003a). The balance of trauma, stress and resilience by international aid workers: A longitudinal qualitative investigation. Paper presented at the 10th Annual Conference of The Australasian Society for Traumatic Stress Studies, Hobart, Australia.

[19.] McFarlane, C. (2003b). (McFarlane, 2003b). Unpublished raw data.

[20.] Minear, L., & Weiss, T. G. (1995). Humanitarian Politics. New York, NY: Foreign Policy Association.

[21.] Peytremann, I., Baduraux, M., O'Donovan, S., & Loutan, L. (2001). Medical evacuations and fatalities of United Nations High Commissioner for Refugees field employees. Journal of Travel Medicine, 8(3), 117-121.

[22.] Sheik, M., Gutierrez, M. I., Bolton, P., Spiegel, P., Thieren, M., & Burnham, G. (2000). Deaths among humanitarian workers. British Medical Journal, 321, 166-168.

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ISSN:2067-3809

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ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 4 [October – December]
ISSN: 2067 – 3809

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ANN (ARTIFICIAL NEURAL NETWORK) APLICABILITY FOR MODELING AL 6061 ALLOY PROPERTIES

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Abstract: *The majority of newly developed techniques in the aluminum industry are sometimes destined to make special products which require an elaborate investigation of alloy properties, therefore wasted time and additional costs. In the end, the new techniques cannot specify or simulate the required microstructure, optimal parameters, optimal alloy composition in order to improve the new processes which include Al6061. The majority of Al6061 (Al6xxx series) improvements are closely related to their mechanical properties (which also depend on the microstructural characteristics). Therefore, we can use the process-structure-properties simulation methods for the Al6061 alloy, with good results over the physico-mechanical characteristics or in the recycling process. In this article, using ANN (Artificial Neural Network), we have analyzed the implications which the chemical composition of Al6061-T6 has over the mechanical properties and elaboration temperature. This correlation between the mechanical properties and chemical composition has a high importance for establishing the right path for a product, without additional costs or wasted time, but also improving certain characteristics of the alloy.*
Keywords: *Artificial Neural Network , Al6061-T6, mechanical properties*

1.INTRODUCTION

The majority of newly developed techniques in the aluminum industry are sometimes destined to make special products which require an elaborate investigation of alloy properties, therefore wasted time and additional costs. In the end, the new techniques cannot specify or simulate the required microstructure, optimal parameters, optimal alloy composition in order to improve the new processes which include Al6061. The majority of Al6061 (Al6xxx series) improvements are closely related to their mechanical properties (which also depend on the microstructural characteristics). Therefore, we can use the process-structure-properties simulation methods for the Al6061 alloy, with good results over the physico-mechanical characteristics or in the recycling process.

The thermic treatment has an important role in obtaining the desired alloy, with desired physico-mechanical characteristics. It is important to know the fact that the solutions of the thermic treatments are important in order to establish the characteristics of the alloy but also to optimize the process parameters according to a specific path.

The European Union has a high number of Al alloys, each one of them with specific structure which can undergo ANN simulative – predictive techniques. The idea of ANN applicability is optimizing the process parameters and Al6061 alloy composition in order to obtain a separate combination which can be used on a large scale.

In this article ANN is used to predict the correlation between the mechanical properties of the Al6061-T6 alloy. The objective is developing an ANN method which can provide data related to process parameters and Al-6061-T6 composition influence over the mechanical properties in order to use the alloy for new purposes.

The aluminum is an important element with a complex applicability in several industries, nationally and internationally. Al6061 is used on a large scale for different purposes because of its properties: 2.71g/cm^3 density, Young: 68.9GPa, Poisson: 0.33μL. It is the most commonly used aluminum, although it is split in different categories: 6061, 6061-T4, 6061-T6 (each one having physico-mechanical properties which differ based on elaboration and destination). The maximum resistance is somewhere at 300MPa, 8% elongation, 77°F conductivity at 152W/m·K, endurance limit up to 100MPa.

Al6061 is used in building certain aircraft parts (wings, fuselage), passenger planes, sometimes Al2024 is more resistant, but Al6061 has a better machinability and high corrosion resistance. It is also used for building yachts, boats, engine and wagon parts, bicycle parts, fishing products.

2. ANN MODELING

Using ANN requires determining the relationship between the Al6061-T6 properties, alloy composition and process variables. Generally, ANN is characterized by: architecture, activation functions, used algorithms and transfer functions.

In order to describe the ANN model we can consider a black box in which we input data and based on defined criteria it offers us information correlated to the processes-structure-properties line. ANN structure is characterized by the number of inputs and number of neurons in each input (Figure 1). Simplified, ANN consists of: inputs, hidden data (processing) and outputs.

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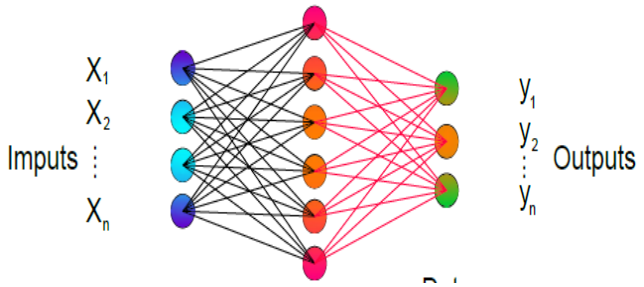

Figure 1. *ANN general architecture*

Table 1*. Al6061 parameters used for ANN (input parameters for the 6xxx series)*

Alloying elements	*Mg*	*Si*	*Cu*	*Zn*	*V*	*Ti*	*Fe*	*Mn*	*Cr*
Number of alloys containing this elements	*40*	*30*	*21*	*14*	*0*	*12*	*16*	*13*	*12*
Range, (%weight)	*0-1.4*	*0-1.8*	*0-1.2*	*0.0 25*	*0*	*0-0.2*	*0-0.7*	*0-1.1*	*0-0.5*

Modeling and simulating ANN for Al6061-T6 alloy present the following steps: data collecting, processing, NN training, testing NN training model and predicting simulation used build NN models.

It is also important to limit the errors of approximation and specific input data adjusting, and the whole process repeats until we obtain a criterion or error-free function. Inside ANN a valid function transforms the input data in output values (which have a $y = ax + b$ linear variation).

The input parameters in order to study the processes-structure-properties system for Al6061 are directly related to the chemical composition, quantity, element combination for alloying. For each element of Al6$x_1x_2x_3$ series, the first number indicates the series, x_1 – alloy element modified in a pre-existent alloy, x_2x_3 – special alloy element.

Table 2*. Physical and elastic parameters of Al6061-T6*

Al6061	*Elastic*							
	E		*G*			*v*		
	70000		*26300*			*0.33*		
	Physical							
	T_{sol}	T_{liq}	*Cp*	*a*	*ρ*	ρ_{el}	*λ*	*EC*
	580	*650*	*895*	*23.3*	*2700*	*40*	*166*	*43*

Key to Parameters:

E	Modulus of elasticity	MPa
G	Modulus of rigidity	MPa
v	Poisson's ratio	
T_{sol}	Solidus temperature	°C
T_{liq}	Liquidus temperature	°C
C_p	Specific heat capacity	J kg^{-1} K^{-1}
α	Coefficient of thermal expansion	µm m^{-1} K^{-1}
ρ	Density	kg m^{-3}
ρ_{el}	Resistivity	nΩ m
λ	Thermal conductivity	W m^{-1} K^{-1}
EC	Electrical conductivity	%IACS

Major alloying elements for Al6061-T6 are Mg and Si, and the chemical composition for the analyzed alloy is presented in Table 1. Physical and elastic characteristics are highlighted in Table 2. They have been taken from specialized articles, analyzed and used in the simulation.

3. RESULTS AND DISCUSSIONS

ANN procedure has been used for predicting the correlation between the processes and the mechanical characteristics of Al6061-T6 alloy. We can analyze the process at different temperatures because the alloy can present different microstructures, therefore it has different mechanical properties.

According to Figure 2 we can analyze the predicted and experimental values of the Al6061-T6 alloy depending on the mechanical resistance properties. The differences are very subtle, approximately 0.214 (statistically, there are no major differences between the two methods).

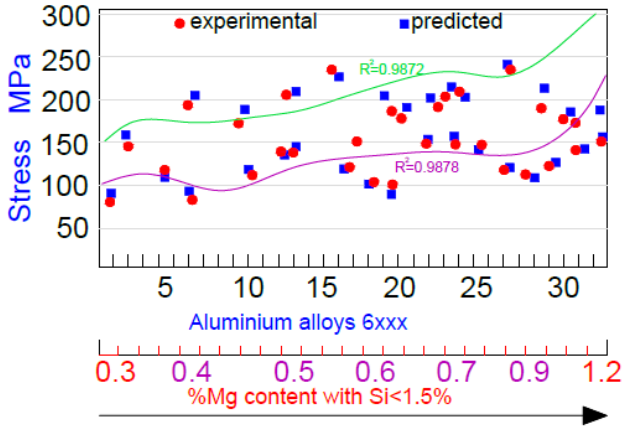

Figure 2*. Experimental data variation as opposed to the predicted ones and evolution towards Mg alloying*

Figure 3 presents the influence of alloying elements from the chemical composition of the Al6061-T6 alloy over stress distribution. The calculated radius of the graphics R^2_1=0.9872 and R^2_2=0.9878, close to 1, show a high precision of tension and stress values from the graphic. Practically, these curves can be used to approximate the desired chemical composition and to achieve certain mechanical properties. Costs and work time are also very important, therefore they must be minimized. Additionally, Figure 4 presents the area based on ductility evolution depending on alloy composition. The most important areas are rendered for unidirectional and alternative tests.

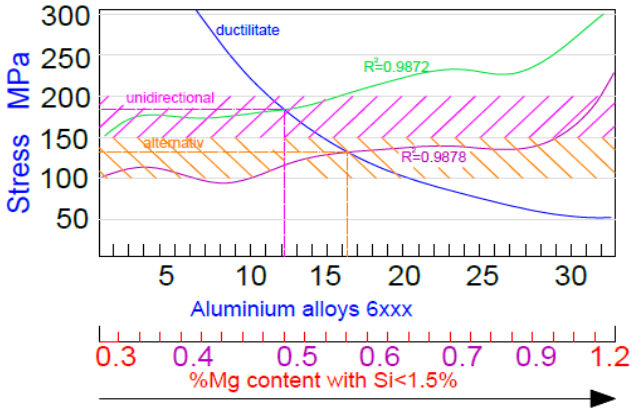

Figure 3*. Influence of alloying elements from Al6061-T6 chemical composition.*

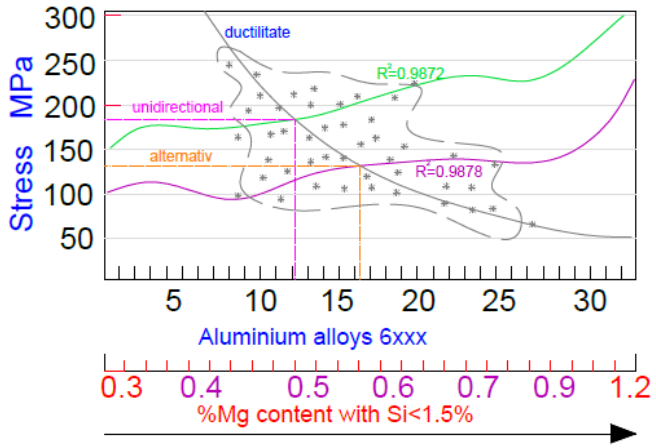

Figure 4. *Ductility variation based on alloying elements for Al6061-T6*

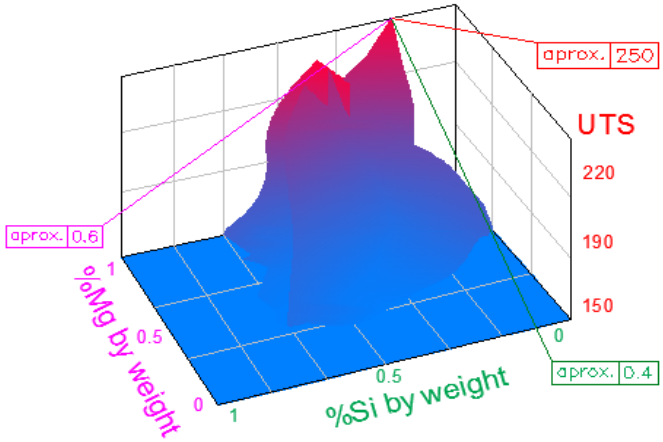

Figure 5. *ANN simulation models for chemical composition (alloying elements) influence over mechanical properties*

Figure 5 proves that using ANN for Al6061-T6 we can predict the influence of the chemical composition over the mechanical properties. Maximum values are rendered on the graphic.

4. CONCLUSIONS

ANN models are used to correlate characteristics such as: structure-processes-properties used for Al6061-T6 material. Therefore, we can remind the following:

- *ANN modeling is important for developing pieces and structures made of Al6061-T6 using product mechanical properties information.*
- *the results of the simulation can be used to determine the optimal composition for Al6061-T6 in accordance with the destination of the final product.*
- *the ANN method has been used to obtain approximate solutions without additional costs or wasted time.*
- *ANN predictions, such as the ones in this article, can be used as inspiration source for various design and elaboration projects, reducing production costs to 0.*
- *the results from this article can be used in different industries for choosing Al6061 alloy domain used based on parameters such as ductility, alloying elements.*
- *the research in this article can be extended therefore obtaining information related to temperature and chemical composition*

Acknowledgement:

This work is supported by the Sectoral Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and the Romanian Government under the POSDRU 2014/ Cod Contract: 134398.

Bibliography

[1.] R.A. Sielski, Research Needs in Aluminum Structures, 10th International Symposium on Practical Design of Ships and Other Floating Structures, Houston, Texas, USA, 2007.

[2.] J. Buha, R.N. Lumley, A.G. Crosky, K. Hono, Secondary precipitation in an Al-Mg-Si-Cu alloy, Acta Mater 55 (2007) 3015-3024.

[3.] S. P. Ringer and K. Hono, Microstructural Evolution and Age Hardening in Aluminum Alloys: Atom Probe Field-Ion Microscopy and Transmission Electron Microscopy Studies, Materials Characterization 44 (2000) 101–131.

[4.] AluMatter Electronic Database, http://aluminium.matter.org.uk accessed July 10 2010

[5.] J. Buha, R.N. Lumley, A.G. Crosky, Microstructural development and mechanical properties of interrupted aged Al-Mg-Si-Cu alloy, Journal of Metallurgical and Materials Transactions A 37A (2006) 3119-3130.

[6.] F. Musharavati, A.S.M. Hamouda, "Application of artificial neural networks for modelling correlations in age hardenable aluminium alloys" JAMME 2010.

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

ISSN:2067-3809

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BULLETIN OF ENGINEERING
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Edited by:

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with kindly supported bythe Associate Editor:

GENERAL ASSOCIATION OF ROMANIAN ENGINEERS (AGIR) – branch of HUNEDOARA

Editor / Technical preparation / Cover design:
Assoc. Prof. Eng. KISS Imre, PhD.
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Commenced publication year: 2008

fascicule 4
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