II International Conference of Computational Methods in Engineering Science

Lublin, 23-25 November 2017

CMES

CMES.POLLUB.PL

BOOK OF ABSTRACTS

Krajowa Reprezentacja Doktorantów | KRD

PDUT

Porozumienie Doktorantów Uczelni Technicznych

Politechnika Lubelska

2nd International Conference of Computational Methods in Engineering Science (CMES)

II International Conference of Computational Methods in Engineering Science CMES'17 takes place in Lublin, 23-25 November 2017 at Lublin University of Technology, Poland.

The main objective of 2nd CMES conference is development of engineering sciences, numerical and experimental techniques, broaden experience and good practices by representatives of the scientific community and industry. Conference allows exchange of knowledge between different research domestic and foreign centres representing various fields of engineering science and technology.

The organizers of the conference are Department of Thermodynamics, Fluid Mechanics and Aircraft Propulsion, Department of Machine Engineering Fundamentals and Mechatronics, Department of Materials Engineering from Mechanical Engineering Faculty of Lublin University of Technology, Institute of Computer Science of Faculty of Electrical Engineering and Computer Science, Department of Organisation of Enterprise (Faculty of Management), Self-Government of Doctoral Students, as well as Polish Association for Knowledge Promotion.

Scientific Committee:

Maksym Bondarenko
František Brumerčík
Jacek Czarnigowski
Dariusz Czerwiński
Hubert Dębski
Agata Dudek
Gabriel Fedorko
Jakub Gajewski
Arkadiusz Gola
María Hallo
Tadeusz Hejwowski
Józef Jonak
Jerzy Józwik
Yevgenia Katayeva
Ján Král
Jacek Kęsik
Grzegorz Kozieł
Andrzej Kwiecień
Jerzy Lipski
Grzegorz Litak
Paweł Lonkwic
Sergio Luján-Mora
Marek Miłosz
Vieroslav Molnár
Jerzy Montusiewicz
Rosa Navarette
Ali Özer
Małgorzata Plechawska-Wójcik
Anna Rudawska
Sandra Sánchez
Mirosław Skrzewski
Maria Skublewska-Paszkowska
Ondrej Stopka
Barbara Surowska
Branislav Šarkan
Jakub Szabelski
Yassine Tabaa
Ualsher Tukeyev
Yuriy Tryus
David Vališ
Ján Vrábel
Mariusz Walczak
Mirosław Wendeker
Tadeusz Wieczorek
Tomasz Zientarski

Organizing Committee

Monika Kulisz
Mirosław Szala
Marcin Badurowicz
Magdalena Borys
Wojciech Cel
Zbigniew Czyż
Katarzyna Falkowicz
Justyna Kujawska
Tytus Tulwn

Table of Contents:

An inexpensive environmental monitoring system with IoT agents

Dariusz Czerwinski[1],*, and Marek Milosz[1]

[1]*Lublin University of Technology, Institute of Computer Science, Nadbystrzycka 38A, 20-618 Lublin, Poland*

Abstract. Air quality is of great importance for human health and life expectancy. It becomes crucial to monitor atmospheric dust in the air of cities. In connection with the development of mobile networks and low-cost sensory agents, it has become possible to create inexpensive environmental monitoring systems. The paper presents results of studies on the system monitoring dust concentration in city air. The system consists of moving IoT agents placed on vehicles (taxies, busses, private cars) and measure the dust concentration. Agents, using a wireless connection, are sending the data to the recording server. The server application collects the data and visualises them on the map in a certain colour, depending on the dust concentration in the air and the values acceptable by standards. The system architecture, the algorithm of measurements and the agent-server data exchange protocol were presented in the article, as well as the example of data visualisation.

* Corresponding author: d.czerwinski@pollub.pl

Decomposition of business process models into reusable sub-diagrams

Piotr Wiśniewski[1,*]

[1]*AGH University of Science and Technology, Department of Applied Computer Science, al. Mickiewicza 30, 30-059 Krakow, Poland*

Abstract. In this paper, an approach to automatic decomposition of business process models is proposed. According to our method, an existing BPMN diagram is disassembled into reusable parts containing the desired number of elements. Such elements and structure can work as design patterns and be validated by a user in terms of correctness. In the next step, these component models are categorised considering their parameters such as resources used, as well as input and output data. The classified components may be considered a repository of reusable parts, that can be further applied in the design of new models. The proposed technique may play a significant role in facilitating the business process redesign procedure, which is of a great importance regarding engineering and industrial applications.

* Corresponding author: wpiotr@agh.edu.pl

Identification, characterisation, and correction of artefacts in electroencephalographic data in study of stationary and mobile electroencephalograph

Monika Kaczorowska[1,*]

[1]*Lublin University of Technology, Electrical Engineering and Computer Science Faculty, Institute of Computer Science, Nadbystrzycka 36B, 20-618 Lublin, Poland*

Abstract. The present paper covers the review of artefacts of EEG recording, as well as methods to eliminate them, i.e. PCA and ICA. The reviewed artefacts were of various origins: biological (muscle, eye blinking, eyeball moving), as well as technological artefacts caused mainly by the power network with the frequency of 50 Hz. The research has been conducted on a group consisting of 8 students. The research was carried out with the use of two defined models of electroencephalographs: stationary and mobile, then results have been compared. The comparison of two amplifiers combined with various artefact elimination methods has been presented. Presented research has shown that the record performed by the mobile amplifier contains the artefacts of significantly lower amplitude.

* Corresponding author: m.kaczorowska@pollub.pl

Modification of Adaptive Huffman Coding for use in encoding large alphabets

Mikhail Tokovarov[1,*]

[1]*Lublin University of Technology, Electrical Engineering and Computer Science Faculty, Institute of Computer Science, Nadbystrzycka 36B, 20-618 Lublin, Poland*

Abstract. The paper presents the modification of Adaptive Huffman Coding method – lossless data compression technique used in data transmission. The modification was related to the process of adding a new character to the coding tree, namely, the author proposes to introduce two special nodes instead of single NYT (not yet transmitted) node as in the classic method. One of the nodes is responsible for indicating the place in the tree a new node is attached to. The other node is used for sending the signal indicating the appearance of a character which is not presented in the tree. The modified method was compared with existing methods of coding in terms of overall data compression ratio and performance. The proposed method may be used for large alphabets i.e. for encoding the whole words instead of separate characters, when new elements are added to the tree comparatively frequently.

* Corresponding author: m.tokovarov@pollub.pl

Optimisation of milling parameters using neural network

Jerzy Lipski[1,*], and Kazimierz Zaleski[2]

[1]*Lublin University of Technology, Department of Organisation of Enterprise, Nadbystrzycka 38, 20-618 Lublin, Poland*
[2]*Lublin University of Technology, Mechanical Engineering Faculty, Nadbystrzycka 38, 20-618 Lublin, Poland*

Abstract. The purpose of this study was to design and test an intelligent computer software developed with the purpose of increasing average productivity of milling not compromising the design features of the final product. The developed system generates optimal milling parameters based on the extent of tool wear. The introduced optimisation algorithm employs a multilayer model of a milling process developed in the artificial neural network. The input parameters for model training are the following: cutting speed v_c, feed per tooth f_z and the degree of tool wear measured by means of localised flank wear (VB3). The output parameter is the surface roughness of a machined surface R_a. Since the model in the neural network exhibits good approximation of functional relationships, it was applied to determine optimal milling parameters in changeable tool wear conditions (VB3) and stabilisation of surface roughness parameter R_a. Our solution enables constant control over surface roughness parameters and productivity of milling process after each assessment of tool condition. The recommended parameters, *i.e.* those which applied in milling ensure desired surface roughness and maximal productivity, are selected from all the parameters generated by the model. The developed software may constitute an expert system supporting a milling machine operator. In addition, the application may be installed on a mobile device (smartphone), connected to a tool wear diagnostics instrument and the machine tool controller in order to supply updated optimal parameters of milling. The presented solution facilitates tool life optimisation and decreasing tool change costs, particularly during prolonged operation.

* Corresponding author: j.lipski@pollub.pl

Repeatability of the three dimensional kinematics of the pelvis, spine and lower limbs while performing selected exercises

Maria Skublewska-Paszkowska[1]*, Edyta Łukasik[1], Jakub Smołka[1], Magdalena Zawadka[2], Mirosław Jabłoński[3], and Piotr Gawda[4]

[1]*Lublin University of Technology, Faculty of Electrical Engineering and Computer Science, Institute of Computer Science, Nadbystrzycka 38D, 20-618 Lublin, Poland*

[2]*Medical University of Lublin, Faculty of Health Sciences, Jaczewskiego 8 Street, 20-090 Lublin, Poland*

[3]*Medical University of Lublin, Department of Rehabilitation and Orthopedics, Jaczewskiego 8, 20-090 Lublin, Poland*

[4]*Medical University of Lublin, Faculty of Health Sciences, Department of Rehabilitation and Physiotherapy, Magnoliowa 2, 20-143 Lublin, Poland*

Abstract. Three-dimensional optical systems are used for calculating many kinetic and kinematic parameters. The obtained data are precise; however, their repeatability is a very important aspect. The aim of this paper is to verify the range of motion repeatability of one healthy subject in the joints of the pelvis, spine and lower limbs based on the coefficient of variation. The participant performed seven exercises, repeated five times: two-leg squat, single-leg squat, forward bending, forward-step motion, step onto the stair, hip extension in a standing position and tip-toe extension while standing. Motion was recorded using Vicon motion capture system consisting of eight NIR cameras. The participant had 39 markers attached to her body according to the Plug-in Gait model. The coefficient of variation was calculated in three dimensions (X, Y and Z). The greatest repeatability, pursuant to the coefficient, was observed during the two-leg squat and forward bending in the sagittal plane (X coordinate). It was also high during the single-leg squat. The lowest repeatability was observed during the tip-toe extension while standing and the hip extension in a standing position. During the step onto the stair and the forward-step motion, a higher repeatability of measurement occurred in the open kinematic chain than in the closed chain; in the hip extension the reverse occurred. Repeatability of a range of motion is different in two types of kinematic chain and in 7 exercises. Exercises such as tip-toe extension and hip extension, which require a greater ability to balance, indicated more variability in movement.

* Corresponding author: maria.paszkowska@pollub.pl

Segmentation and reconstruction of the 3D geometry of the middle and inner ear

Yanfei Lu [1,*]

[1]*Warsaw University of Technology, Faculty of Production Engineering, Institute of Mechanics and Printing, Department of Construction Engineering and Biomedical Engineering, Narbutta 85, 02-524 Warsaw, Poland*

Abstract. The anatomical model of the ear is of great importance in the design of ossicular prosthesis, cochlear implant electrodes, as well as for the preoperative planning and navigation of surgery. By means of micro-computed tomography (micro-CT) and technology of 3D reconstruction, an anatomical model of the middle and inner ear was built. Region of interest includes the ossicular chain (malleus, incus, and stapes), cochlea (scala vestibule-ST, scala tympani-ST, basilar membrane-BM, spiral ligament-SL and osseous spiral lamina-OSL), tympanic membrane-TM, oval window membrane-OWM, round window membrane-OWM and stapedial annular ligament-SAL. The micro-CT images of a cadaver's temporal bone were acquired by "SkyScan 1076" (Kontich, Belgium, www.skyscan.be) and then reconstructed to cross-section images by SkyScan NRecon™ (v1.6.10.4). The image processing and 3D geometry reconstruction of temporal bone were performed by software Mimics® (v14.0, Materialise NV, Leuven, Belgium). The obtained structures are measured and validated against literature data and the results are in good agreement.

* Corresponding author: y.lu@wip.pw.edu.pl

Artificial neural network modelling of cutting force components in milling

Ireneusz Zagórski[1], Monika Kulisz[2,*], and Aleksandra Semeniuk[3]

[1]*Lublin University of Technology, Faculty of Mechanical Engineering, Department of Production Engineering, Nadbystrzycka 36, 20-618 Lublin, Poland,*
[2]*Lublin University of Technology, Faculty of Management, Department of Organisation of Enterprises, Nadbystrzycka 38, 20-618 Lublin, Poland*
[3]*Lublin University of Technology, Faculty of Mechanical Engineering, Nadbystrzycka 36, 20-618 Lublin, Poland*

Abstract. The following paper will give an account of experimental tests and simulation of the cutting force components Fx, Fy and Fz in down milling of AZ91D magnesium alloy. The milling operation employed two milling cutters with a different helix angle, λs = 20° and λs = 50°, and was conducted with changeable milling machining parameters: cutting speed, feed per tooth, axial depth of cut. The simulation part of the study was conducted in Statistica software environment with the application of Multi-Layered Perceptron neural network architecture, and using a "black box" approach, which guarantees a good fit of input and output data obtained from the experimental tests.

* Corresponding author: m.kulisz@pollub.pl

Classification of user performance in the Ruff Figural Fluency Test based on eye-tracking features

Magdalena Borys[1,*], Sara Barakate[2], Karim Hachmoud[2], Małgorzata Plechawska-Wójcik[1], Paweł Krukow[3], and Marek Kamiński1

[1]*Lublin University of Technology, Faculty of Electrical Engineering and Computer Science, Institute of Computer Science, Nadbystrzycka 38D, 20-618 Lublin, Poland*

[2]*Abdelmalek Essaâdi University, Polydisciplinary Faculty, Martil Road, Tétouan, Morocco*

[3]*Medical University of Lublin, Department of Clinical Neuropsychiatry, Głuska 1, 20-439 Lublin, Poland*

Abstract. Cognitive assessment in neurological diseases represents a relevant topic due to its diagnostic significance in detecting disease, but also in assessing progress of the treatment. Computer-based tests provide objective and accurate cognitive skills and capacity measures. The Ruff Figural Fluency Test (RFFT) provides information about non-verbal capacity for initiation, planning, and divergent reasoning. The traditional paper form of the test was transformed into a computer application and examined. The RFFT was applied in an experiment performed among 70 male students to assess their cognitive performance in the laboratory environment. Each student was examined in three sequential series. Besides the students' performances measured by using in app keylogging, the eye-tracking data obtained by non-invasive video-based oculography were gathered, from which several features were extracted. Eye-tracking features combined with performance measures (a total number of designs and/or error ratio) were applied in machine learning classification. Various classification algorithms were applied, and their accuracy, specificity, sensitivity and performance were compared.

* Corresponding author: m.borys@pollub.pl

Classifier testing for the brain-machine interface (BCI) based on Steady State Visually Evoked Potential (SSVEP)

Arkadiusz Kubacki[1,*], and Arkadiusz Jakubowski[1]

[1]*Poznan University of Technology, Institute of Mechanical Technology, Skłodowska-Curie Square 5, 60-965 Poznań, Poland*

Abstract. The paper describes the research on the classifiers for brain-computer interface (BCI) based on Steady State Visually Evoked Potential (SSVEP). Authors presented research on the checking the usability of classifiers for recognizing an EEG signal during the stimulus. Three classifiers have been checked: Support Vector Machine (SVM), Linear Discriminant Analysis (LDA) and one based on Artificial Neural Network (ANN). First part is concentrated on brain-computer interfaces and classification of them. The second part describes algorithms of all using classifiers. In the next part, authors present test stand and how the experiment is built. The last part consists of results of these tests. The best was the classifier based on Artificial Neural Network – up to 95% of correct identified. The worst results were obtained from Support Vector Machine – about 70%.

* Corresponding author: arkadiusz.j.kubacki@doctorate.put.poznan.pl

Kohonen network as a classifier of Polish emotional speech

Paweł Powroźnik[1],*

[1]*Lublin University of Technology, Faculty of Electrical Engineering and Computer Science, Institute of Computer Science, Nadbystrzycka 38D, 20-618 Lublin, Poland*

Abstract. The power of speech is a main tool in human communication. There are a lot of factors as age, emotions, gender, pitch of the voice which can influence features of speech. Obviously, information conveyed by voice intonation has more than only textual meaning. The same sentence pronounced in two different ways can have two completely different meanings. This paper describes Kohonen networks as a classifier of Polish emotional speech. The usage of Discrete Wavelet Transform (DWT) as well as an innovative approach to scaleogram processing is also presented in this article. Mexican Hat Wavelet and the Haar Wavelet were used in researches. All simulations were carried out in MatLab 2016 with Neural Network Toolbar. During whole research more than 9000 simulation have been done. Three different speech databases were used in conducted researches. One of them was prepared by professional actors – four women and four men, and contains 240 wav files. Two others are results of researchers works. The structures of used Kohonen networks depend on speech signal decomposition's level and scaleogram division. During conducted researches the following emotional states were considered: anger, joy, sadness, boredom, fear and neutral state. Achieved results were between 68% and 80% depends of used wavelet, speech signal and signal decomposition's level.

* Corresponding author: p.powroznik@pollub.pl

Prediction of monthly electric energy consumption using pattern-based fuzzy nearest neighbour regression

Paweł Pełka[1,*], and Grzegorz Dudek[1]

[1]*Czestochowa University of Technology, Department of Electrical Engineering, Al. Armii Krajowej 17, 42-200 Czestochowa, Poland*

Abstract. Electricity demand forecasting is of important role in power system planning and operation. In this work, fuzzy nearest neighbour regression has been utilised to estimate monthly electricity demands. The forecasting model was based on the pre-processed energy consumption time series, where input and output variables were defined as patterns representing unified fragments of the time series. Relationships between inputs and outputs, which were simplified due to patterns, were modelled using nonparametric regression with weighting function defined as a fuzzy membership of learning points to the neighbourhood of a query point. In an experimental part of the work the model was evaluated using real-world data. The results are encouraging and show high performances of the model and its competitiveness compared to other forecasting models.

* Corresponding author: pavelle50@gmail.com

Reliability and cost optimisation of complex electric power networks using ant colony algorithm

Łukasz Piątek[1,*]

[1]*Częstochowa University of Technology, Institute of Information Technology, 42-200 Częstochowa, Poland*

Abstract. The article presents a new approach towards reducing an overall cost of electric power network with maintaining its reliability. Goals are achieved by implementing an ant colony algorithm with a cut-set method as a method for reliability evaluation. The algorithm solves the problem of multi-objective optimisation, where both the network cost and network reliability index, known as unavailability, should be minimalised. The network cost is considered as a linear function of overall length of network's connections. For reliability evaluation in the cut-set method, real empiric data of hazard rate for overhead power lines are used. Parallel-series network structure, equivalent by means of reliability to analysed network, is generated through the cut-set method to compute unavailability of trial solutions. Sections of the structure are generated on the basis of minimum cut set, found by the algorithm for finding one- and two- minimum cuts. As used algorithm for finding minimum cuts has linear complexity, the evaluation of trial solutions is computationally effective. An example, presented in this article, provides figure of optimal network configurations found by the algorithm.

* Corresponding author: l_piatek@el.pcz.czest.pl

Using methods of the reverse engineering to carry personalised preoperative stabilisers out on the example of vertebrae of human spine

Ewelina Kozłowska[1,*], and Jarosław Zubrzycki[1]

[1]*Lublin University of Technology, Faculty of Mechanical Engineering, Institute of Technological Systems of Information, Nadbystrzycka 38A, 20-618 Lublin, Poland*

Abstract. There is presented the possibility of using modern rapid prototyping methods in the form of reverse engineering on the example of lumbosacral spine of a human spine at the level of L3-L. Reverse engineering techniques were directly used in the generation and processing of point clouds from a real object. The point clouds were generated by using specialised Mimics software and basing on the results of computer tomography and magnetic resonance imaging using. In the next stage of processing, there was the export of the appropriately converted point clouds to STL format, compatible with CAD programs. The reverse engineering process took four steps: digitisation of the real object, using non-invasive imaging techniques (CT, MRI), processing the point clouds from the digitisation stage, construction of a surface model of the real object basing on the processed point clouds, realising of the real object's copy by using rapid prototyping techniques. In the final stage, the model of the complex spinal's part was tested to MES strength analysis.

* Corresponding author: ewelina.kozlowska16@wp.pl

Virtual road concept as a tool for road quality research

Marcin Badurowicz[1,*], and Jerzy Montusiewicz[1]

[1]*Lublin University of Technology, Faculty of Electrical Engineering and Computer Science, Institute of Computer Science, Nadbystrzycka 36B, 20-618 Lublin, Poland*

Abstract. Road quality assessment using crowdsourced data gathered by smartphone users, based on acceleration data, is an interesting subject on using modern technology for improvements of the infrastructure. The algorithms – for both road quality assessment and detection of different elements on the road – need to be tested, especially in the field. To facilitate building sets of different data and sharing them in a standardised way, the authors propose extraction of known road fragments with known types of surface degradation and construction of virtual streams of data, thus "virtual roads". The procedure for data extraction and building a database of segments, combining them into virtual road, as well as testing real-world algorithm using the constructed virtual road are presented in the paper.

* Corresponding author: m.badurowicz@pollub.pl

Web service for solving optimisation problems using swarm intelligence algorithms

Yuriy Tryus[1], Andrii Geiko[1], and Grygoriy Zaspa[1,*]

[1]*Cherkasy State Technological University, Computer Science and Information Technology Department, 460 Shevchenko Blvd, 18006, Cherkasy, Ukraine*

Abstract. In this research the web service which provides a user a possibility to use swarm optimisation algorithms for solving continuous and discrete extreme problems online was created. The web service includes facilities for data input and making numerical experiments related to optimisation problems research with swarm intelligence methods. For swarm intelligence algorithms numerical experiments, the user can tune the following parameters: problem dimension; swarm parts number; inertial, cognitive, and social coefficients. The user can also select algorithm stop criterion and set the number of algorithm iterations. During the optimisation problem solving, the iteration process graphical visualisation is done. Also, the protocol is being formed and it can be exported to .xls file. Checking the algorithms in the web service was made on well-known test functions and conditional and non-conditional optimisation problems; some of them are built into the service.

* Corresponding author: g.zaspa@chdtu.edu.ua

An investigation into multi-domain simulation for a pantograph-catenary system

Paweł Zdziebko[1],*, Adam Martowicz[1], and Tadeusz Uhl[1]

[1]*AGH University of Science and Technology, Department of Robotics and Mechatronics, Al. A. Mickiewicza 30, 30-059 Krakow, Poland*

Abstract. There is a need for modelling various phenomena present in a pantograph-catenary structure, (e.g. wave propagation and its reflections, friction, aerodynamic and electromagnetic forces), which allows for a more reliable study on the dynamic behaviours of a railway pantograph, particularly in the case of high-speed trains. Hence, the creation a complex pantograph-catenary multi-domain model should help to effectively meet the above-mentioned requirements. The work presents a co-simulation approach to investigate the pantograph-catenary dynamic interaction. The elaborated co-simulation algorithm assumes data exchange between multibody models of a pantograph and finite element model of a catenary. The presented approach explores multi-domain phenomena that have an influence on the pantograph-catenary interaction. The nonlinear finite element catenary model takes into account the slackening of droppers, relatively large displacements and contact with the pantograph's slider, while the multibody model of the pantograph considers friction forces and suspension springs. Additionally, aerodynamic forces caused by wind acting on the pantograph were computed using the fluid structure interaction method and implemented in the dynamic simulation. The influence on the pantograph-catenary interaction caused by electromagnetic force acting on the pantograph was investigated, along with the influence of the locomotive's vertical vibrations and tilt.

* Corresponding author: zdziebko@agh.edu.pl

Charging process analysis of an opposed-piston two-stroke aircraft Diesel engine

Łukasz Grabowski[1,*], Konrad Pietrykowski[1], and Paweł Karpiński[1]

[1]*Lublin University of Technology, Faculty of Mechanical Engineering, Department of Thermodynamics, Fluid Mechanics and Aviation Propulsion Systems, Nadbystrzycka 36, 20-618 Lublin, Poland*

Abstract. This paper presents the research results on a 1D model of an opposed-piston two-stroke aircraft Diesel engine. The research aimed at creating a model of the engine in question to investigate how engine performance is affected by the compressor gear ratio. The power was constant at all the operating points. The research results are presented as graphs of power consumed by the compressor, compressor efficiency and brake specific fuel consumption. The optimal range of compressor gear ratio in terms of engine efficiency was defined from the research results.

*Corresponding author: l.grabowski@pollub.pl

Comparison of macroscopic descriptions of magnetization curves

Radosław Jastrzębski[1,*] , and Krzysztof Chwastek [1]

[1]*Częstochowa University of Technology, Faculty of Electrical Engineering, 42-201 Częstochowa, Poland*

Abstract. The paper considers a qualitatively different behaviour of two phenomenological hysteresis models. The first one is the widespread Jiles-Atherton description, which is based on the ”effective field” concept. The other model is the proposal by the Brazilian research team GRUCAD. First order reversal curves simulated with the latter formalism do not exhibit negative slopes. This feature is in accordance with the experiment.

* Corresponding author: radoslaw@jastrzebski.info

Discrete Element Method for engineering application: modelling of granular materials transported on conveyor belt

Joanna Wiącek[1,*], Wojciech Sobieski[2], Waldemar Dudda[2]

[1] *Institute of Agrophysics, Polish Academy of Sciences, Doświadczalna 4, 20-290 Lublin 27, Poland*
[2] *University of Warmia and Mazury in Olsztyn, M. Oczapowskiego 11, 10-957 Olsztyn, Poland*

Abstract. Computational techniques are common tools for large scale modelling of devices and elements being a part of technological devices applied for conveying and storage of materials. One of the numerical methods applied for modelling mechanical processes involving granular media is a Discrete Element Method (DEM). Discrete Element Method enables analysis of both, interactions between particles in granular bedding and interactions between grains and structural elements. In the presented project, Discrete Element Method was applied for modelling horizontal transport of granular materials of different geometrical and mechanical properties on belt conveyor. The objective of this study was to analyse the effect of particle shape and size heterogeneity on conveying, trajectory of the material stream and a shape of pile. Simulations were performed for particles with geometrical and mechanical properties of ammonium sulphate, wheat seeds and polyethylene granules. The generated samples were monodisperse or exhibited some degree of polydispersity. Numerical results were found to be in good agreement with theoretical results and experimental data which displays that Discrete Element Method has a high potential for various engineering applications. Application of DEM for engineering design enables optimization of technological processes providing economic benefits.

* Corresponding author: j.wiacek@ipan.lublin.pl

Modelling of the temperature field that accompanies friction stir welding

Przemysław Nosal[1],*, and Artur Ganczarski[1]

[1]*Cracow University of Technology, Institute of Applied Mechanics, Jana Pawła II 37, 31-864 Cracow, Poland*

Abstract. The thermal modelling of the Friction Stir Welding process allows for better recognition and understanding of phenomena occurring during the joining process of different materials. It is of particular importance considering the possibilities of process technology parameters, optimization and the mechanical properties of the joint. This work demonstrates the numerical modelling of temperature distribution accompanying the process of friction stir welding. The axisymmetric problem described by Fourier's type equation with internal heat source is considered. In order to solve the diffusive initial value problem a fully implicit scheme of the finite difference method is applied. The example under consideration deals with the friction stir welding of a plate (0.7 cm thick) made of Al 6082-T6 by use of a tool made of tungsten alloy, whereas the material subjected to welding was TiC powder. Obtained results confirm both quantitatively and qualitatively experimental observations that the superior temperature corresponds to the zone where the pin joints the shoulder.

*Corresponding author: nosal.przemyslaw@student.pk.edu.pl

Stochastic higher order finite element elasto-plastic analysis of the necking phenomenon

Michał Strąkowski[1,*], and Marcin Kamiński[1]

[1]*Łódź University of Technology, Faculty of Civil Engineering, Architecture and Environmental Engineering, Department of Structural Mechanics, Politechniki Avenue 6, 90-924 Łódź, Poland*

Abstract. The principal goal of this work is to investigate an application of the stochastic perturbation technique of the 10th order in coupled thermo-elasto-plastic analysis of tension of the steel elastic bar exposed to fire with thermally dependent material characteristics. An ambient temperature, calculated from the fire curve after ISO 834-1, equivalent to the fire exposure of the steel structure is treated here as the input Gaussian random variable. It is uniquely defined by the constant mean value at outer surfaces of this element, where material parameters of the steel as Young modulus, yield strength, heat conductivity, capacity and thermal elongation are considered all as highly temperature-dependent. Computational implementation known as the Stochastic Finite Element Method is carried out with the use of the FEM system ABAQUS and computer algebra system MAPLE. It uses both polynomial and non-polynomial local response functions of stresses and displacements. The basic probabilistic characteristics of time-dependent structural response are determined (expectations, coefficients of variation, skewness and kurtosis) and verified with classical Monte-Carlo simulation scheme and semi-analytical technique for input coefficient of variation not larger than 0.20. Finally, probabilistic convergence of all three methods versus increasing input uncertainty level is investigated.

* Corresponding author: michal.strakowski@p.lodz.pl

The assessment of water loss from a damaged distribution pipe using the FEFLOW software

Małgorzata Iwanek[1,*], and Paweł Suchorab[1]

[1]*Lublin University of Technology, Faculty of Environmental Engineering, Nadbystrzycka 40 B, 20-618 Lublin, Poland*

Abstract. Common reasons of real water loss in distribution systems are leakages caused by the failures or pipe breakages. Depending on the intensity of leakage from a damaged buried pipe, water can flow to the soil surface just after the failure occurs, much later or never at all. The localization of the place where the pipe breakage occurs is relatively easy when water outflow occurs on the soil surface. The volume of lost water strongly depends on the time it takes to localize the place of a pipe breakage. The aim of this paper was to predict the volume of water lost between the moment of a failure occurring and the moment of water outflow on the soil surface, during a prospective failure in a distribution system. The basis of the analysis was a numerical simulation of a water pipe failure using the FEFLOW v. 5.3 software (Finite Element subsurface FLOW systems) for a real middle-sized distribution system. Simulations were conducted for variants depending on pipes' diameter (80÷200 mm) for minimal and maximal hydraulic pressure head in the system (20.14 and 60.41 m H_2O, respectively). FEFLOW software application enabled to select places in the water system where possible failures would be difficult to detect.

* Corresponding author: M.Iwanek@wis.pol.lublin.pl

The modelling of condensation in horizontal tubes and the comparison with experimental data

Rafał Bryk[1,*], Holger Schmidt [2], Thomas Mull [2], Thomas Wagner [2], Oliver Herbst [2], and Ingo Ganzmann [2]

[1] *Warsaw University of Technology, Institute of Heat Engineering, 00-661 Warsaw, Poland*
[2] *AREVA GmbH, Thermal Hydraulics and Components Testing, 91052 Erlangen, Germany*

Abstract. The condensation in horizontal tubes plays an important role in determining the operation mode of passive safety systems of modern nuclear power plants. In this paper, two different approaches for modelling of this phenomenon are compared and verified against experimental data. The first approach is based on the flow regime map developed by Tandon. Depending on the regime, the heat transfer coefficient is calculated according to corresponding semi-empirical correlation. The second approach uses a general, fully empirical correlation proposed by Shah. Both models are developed with utilization of the object-oriented, equation-based Modelica language and the open-source Open-Modelica environment. The results are compared with data obtained during a large scale integral test, simulating a Loss of Coolant Accident scenario performed at the dedicated Integral Test Facility Karlstein (INKA) which was built at the Components Testing Department of AREVA in Karlstein, Germany. The INKA facility was designed to test the performance of the passive safety systems of KERENA, the new AREVA boiling water reactor design. INKA represents the KERENA containment with a volume scaling of 1:24. Components heights and levels over the ground are in the full scale. The comparison of simulations results shows a good agreement.

* Corresponding author: test-labs@areva.com

The modelling of two DOF joints controlled by elastic inner ties

Dominik Ożóg[1,*]

[1] *Rzeszów University of Technology, Department of Computer and Control Engineering, ul. W. Pola 2, 35-959 Rzeszów, Poland*

Abstract. This paper considers the mathematical model of two types of joints that can be used to connect the arms of two robots. The first of them is a simple revolute joint with one degree of freedom and the second is a universal joint with two degrees of freedom. Each of them is controlled using elastic ties that run in the joints and are connected to the inside of the arm joints. This paper describes a study of kinematics, dynamics properties and Extended Denavit-Hartenberg Notation parameters mentioned joints.

* Corresponding author: dominikozog@wp.pl

The optimisation of a water distribution system using Bentley WaterGEMS software

Karolina Świtnicka[1,*], Paweł Suchorab[1], and Beata Kowalska[1]

[1]*Lublin University of Technology, Faculty of Environmental Engineering, Nadbystrzycka 40 B, 20-618 Lublin, Poland*

Abstract. The proper maintenance of water distribution systems (WDSs) requires from operators multiple actions in order to ensure optimal functioning. Usually, all requirements should be adjusted simultaneously. Therefore, the decision-making process is often supported by multi-criteria optimisation methods. Significant improvements of exploitation conditions of WDSs functioning can be achieved by connecting small water supply networks into group systems. Among many potential tools supporting advanced maintenance and management of WDSs, significant improvements have tools that can find the optimal solution by the implemented mechanism of metaheuristic methods, such as the genetic algorithm. In this paper, an exemplary WDS functioning optimisation is presented, in relevance to a group water supply system. The action range of optimised parameters included: maximisation of water flow velocity, regulation of pressure head, minimisation of water retention time in a network (water age) and minimisation of pump energy consumption. All simulations were performed in Bentley WaterGEMS software

*Corresponding author: karolina2393@wp.pl

Application of neural networks in CRM systems

Agnieszka Bojanowska[1,*]

[1]*Lublin University of Technology, Faculty of Management, Department of Marketing, Nadbystrzycka 38, 20-618 Lublin, Poland*

Abstract. The central aim of this study is to investigate how to apply artificial neural networks in Customer Relationship Management (CRM). The paper presents several business applications of neural networks in software systems designed to aid CRM, *e.g.* in deciding on the profitability of building a relationship with a given customer. Furthermore, a framework for a neural-network based CRM software tool is developed. Building beneficial relationships with customers is generating considerable interest among various businesses, and is often mentioned as one of the crucial objectives of enterprises, next to their key aim: to bring satisfactory profit. There is a growing tendency among businesses to invest in CRM systems, which together with an organisational culture of a company aid managing customer relationships. It is the sheer amount of gathered data as well as the need for constant updating and analysis of this breadth of information that may imply the suitability of neural networks for the application in question. Neural networks exhibit considerably higher computational capabilities than sequential calculations because the solution to a problem is obtained without the need for developing a special algorithm. In the majority of presented CRM applications neural networks constitute and are presented as a managerial decision-taking optimisation tool.

* Corresponding author: a.bojanowska@pollub.pl

Calculation of the number of branches of multi-valued decision trees in computer aided importance rank of parameters

Agnieszka Tiszbierek[1,*]

[1]*Opole University of Technology, Faculty of Production Engineering and Logistics, Sosnkowskiego 31 Str., 45-272 Opole, Poland*

Abstract. An elaborated digital computer programme supporting the time-consuming process of selecting the importance rank of construction and operation parameters by means of stating optimum sets is based on the Quine – McCluskey algorithm of minimizing individual partial multi-valued logic functions. The example with real time data, calculated by means of the programme, showed that among the obtained optimum sets there were such which had a different number of real branches after being presented on the multi-valued logic decision tree. That is why an idea of elaborating another functionality of the programme – a module calculating the number of branches of real, multi-valued logic decision trees presenting optimum sets chosen by the programme was pursued. This paper presents the idea and the method for developing a module calculating the number of branches, real for each of optimum sets indicated by the programme, as well as to the calculation process.

*Corresponding author: a.tiszbierek@po.opole.pl

Cluster analysis to evaluate chemical compounds in the waters of piezometers from a drilling wastes landfill

Justyna Kujawska[*1], and Wojciech Cel[1]

[1]*Institute of Renewable Energy Engineering, Lublin University of Technology 40B Nadbystrzycka Street Lublin, Poland*

Abstract. Storage of drilling wastes threatens the natural environment. Cluster analysis was employed for evaluation of the behaviour of chemical compounds in the water of piezometers from the drilling waste management facility in Luchów. Cluster analysis proved to be an efficient method, enabling the identification of groups of chemical compounds threatening the environment.

* Corresponding author: j.kujawska@pollub.pl

Computer modelling of the influences of a subsystems' interaction on energetic efficiency of biofuel production systems

Andrzej Wasiak[1,*], and Olga Orynycz[1]

[1]*Bialystok University of Technology, Dept. of Production Management, Bialystok, Poland*

Abstract. Energetic efficiency of biofuel production systems, as well as that of other fuels production systems, can be evaluated on the basis of modified EROEI indicator. In earlier papers, a new definition of the EROEI indicator was introduced. This approach enables the determination of this indicator separately for individual subsystems of a chosen production system, and therefore enables the studies of the influence of every subsystem on the energetic efficiency of the system as a whole. The method has been applied to the analysis of interactions between agricultural, internal transport subsystems, as well as preliminary studies of the effect of industrial subsystem.

* Corresponding author: a.wasiak@pb.edu.pl

Equilibrium model of sewage sludge gasification

Grzegorz Gałko[1,*], DanutaKról[1]

[2]*Silesian University of Technology, Faculty of Energy and Environmental Engineering, Konarskiego 18, 44-100 Gliwice, Poland*

Abstract. Pyrolysis, combustion and gasification are thermal processes used for wastes and fuel transformation. Reaction cycle between fuel and gasification agent is the essence of the gasification process. Combustible syngas is the product of gasification, which may be used in combined heat and power technologies. Hazardous wastes, which may be obtained from sewage sludge from municipal sewage sludge treatment plants, are increasingly used in near standard fuels like hard coals as substrates in gasification. High temperature of the process neutralizes microorganisms and pathogens contained in sewage sludge, and oxygen, steam and air are used as gasification agents. Equations that use stoichiometry and constant rate response prove useful in creating simulation models. Compounds formation in reactions between fuel and gasification agent and syngas secondary reactions depend on right selection of coefficient. Shown in this paper is the mathematical model of sewage sludge air gasification process. Mass balance of fuel and gasification agent streams were used in evaluation. Calculations were based on the experiment carried out on countercurrent gas generator. Lower heating value of syngas depends on carbon monoxide, hydrogen and methane concentration. Simulated syngas components are in correlation with components received in the experiment.

* Corresponding author: grzegorz.galko@polsl.pl

Estimation of uncertainty of laser interferometer measurement in industrial robot accuracy tests

Jerzy Józwik[1,*], Elżbieta Jacniacka[1] and Dawid Ostrowski[2]

[1]*Lublin University of Technology, Mechanical Engineering Faculty, Department of Production Engineering, 36 Nadbystrzycka Street, 20-618 Lublin, Poland*
[2]*The State School of Higher Education, The Institute of Technical Sciences and Aviation, 54 Pocztowa Street, 22-100 Chełm, Poland*

Abstract. The subject of this article is the assessment of measurement uncertainty of the Renishaw XL80 laser interferometer in MOTOMAN HP20 industrial robot inaccuracy test. The paper presents the methodology for estimating the measurement uncertainty of the system used in tests. Estimates of standard and extended uncertainty were calculated for the given research method. These uncertainties are based on the information included in the device calibration certificate (method B) but also on the basis of measurements and statistics (method A). The authors proposed their own research methodology, taking into account measurement capabilities of the applied system and the specific character of the robot work. Calculations employed universal computing systems based on standard algorithms. The results obtained from the research and calculations precisely defined key uncertainties allowing for objective evaluation of industrial robot errors identified by the Renishaw XL80 system.

* Corresponding author: j.jozwik@pollub.pl

Experimental investigation of the degree of weakening in structural notch area of 7075-T6 aluminum alloy sheet welded with the RFSSW method

Andrzej Kubit[1,*], Magdalena Bucior[1], Dawid Wydrzyński[1],and Łukasz Bąk[2]

[1] *Faculty of Mechanical Engineering and Aeronautics, Department of Manufacturing Processes and Production Engineering, Rzeszow University of Technology, Powstańców Warszawy 8, 35-959 Rzeszów, Poland*

[2] *Faculty of Mechanical Engineering and Aeronautics, Department of Materials Forming and Processing , Rzeszow University of Technology, Powstańców Warszawy 8, 35-959 Rzeszów, Poland*

Abstract. The paper presents the methodology of the research determining the degree of weakening of the welded sheet obtained by the refill friction stir spot welding (RFSSW) method. The considered weakness is the effect of a structural notch resulting from penetration by the tool. RFSSW technology is a relatively new method of joining metals, which can successfully provide an alternative to resistance welding or riveting - traditionally used methods of joining thin-walled structures in the aerospace and automotive industries. The study presented in the paper focuses on the overlapping of sheet metal with 7075-T6 aluminum alloy combined in the configuration: 1.6 mm top sheet and 0.8 mm bottom sheet. Joints were assembled following the following process parameters: Welding time 1.5 s, the tool plunge depth in the range of 1.5 ÷ 1.9 mm, and the spindle speed of 2600 rpm. The analysis of the microstructure of joints revealed that along the edge of the tool path a structural notch is formed, the size and shape of which depend on the parameters applied. The paper describes the study consisting in punching the welded area along the formed notch in the upper sheet. The punching process was performed on a universal testing machine and the punching force was measured during the test. Based on the force value, the degree of sheet weakening in the notched area was determined. The smallest weakening was observed in joints made with the smallest tool depth, i.e. 1.5 mm, whereas the biggest weakening was obtained for tool depth of 1.9 mm. The load applied to the joints was equal to 5290N and 7585N respectively.

* Corresponding author: akubit@prz.edu.pl

IT solutions supporting project management processes and the choice of software

Anna Kaczorowska[1,*], Jolanta Słoniec[2], and Sabina Motyka[3]

[1]*University of Lodz, Faculty of Management, Department of Computer Science, Matejki 22/26, 90-237 Łodz, Poland*

[2]*Lublin University of Technology, Faculty of Management, Department of Enterprise Organization, Nadbystrzycka 38, 20-618 Lublin, Poland*

[3]*Cracow University of Technology, Faculty of Mechanical, Department of Manufacturing Processes, M6 Institute, Jana Pawła II 37 Avenue, 31-864 Cracow, Poland*

Abstract. The article aims to present both the theoretical contents and proposed solutions to practical problems perceived in the support of project management. The process' approach was recommended as the basis of project management. The classification of instruments due to the implemented functions and structure of information systems, which support project management, was included, in conjunction with the type of projects handled. The maturity of project management information support was analysed. Project management areas that have the highest possibilities of information support were indicated, and a list of advantages of the use of information instruments was drawn up. Both the main criteria of software selection and the basic requirements presently formulated with reference to project management supporting systems were determined.

* Corresponding author: annak@wzmail.uni.lodz.pl

Milling gate vibrations analysis via Hilbert-Huang transform

Grzegorz Litak[1,*], Marek Iwaniec[1], and Joanna Iwaniec[2]

[1]*AGH University of Science and Technology, Faculty of Mechanical Engineering and Robotics, Department of Process Control, Mickiewicz Alley 30, 30-059 Krakow, Poland*

[2]*AGH University of Science and Technology, Faculty of Mechanical Engineering and Robotics, Department of Robotics and Mechatronics, Mickiewicz Alley 30, 30-059 Krakow, Poland*

Abstract. The study aimed at identification of the milling gate modal parameters: natural frequencies and mode shapes, in order to establish the working range free from resonant areas. The evaluation was performed under exploitation loads, generated in the course of the milling process. System responses, in the form of the acceleration time histories, were analysed with the application of the Hilbert-Huang method data analysis. Selection of this method was motivated by the fact that it does not require stationarity of the analysed and provides information about nonlinearities in vibration empirical modes. In contrast to classical nonlinear system identification methods, the Hilbert-Huang method does not require measurements of excitations acting on the system of interest nor linear system dynamic behaviour in a broad frequency range around any operating point.

* Corresponding author: g.litak@pollub.pl

Scalability conditions of the measuring points network in a production system using the RFID selective gate technology

Monika Łobaziewicz[1,*]

[1]*DataConsult Sp. z o. o., 30-614 Kraków, Poland*

Abstract. The aim of paper is to present results of the research work in development conducted to define the scalability conditions for the measuring points network at production cells in the resistant to the electromagnetic disturbances system based on the patented selective RFID gate technology. This is a conceptual paper that includes research results of the selective RFID gate and its place in a production system, a communication model between two measuring points in a complex production system that was the input to do further analysis required to define its scalability conditions. The proposed approach provides the following results: order and speed of data reading from measurement points, data transfer between measurement points, access to database, communication between the database and measurement points, data archiving, procedures of changing the measurement point configuration in the system, including error handling and network re-configuration. It is believed that both practitioners and researchers will benefit from it.

* Corresponding author: ml@un.pl

Selected aspects of the technological processes of the aircraft engine washing

Anna Rudawska[1], Przemysław Wrona[1], Izabela Miturska[1,*], and Miroslav Müller[2]

[1]*Lublin University of Technology, Faculty of Mechanical Engineering, Department of Production Engineering, Nadbystrzycka 36, 20-618 Lublin, Poland*
[2]*Czech University of Life Sciences Prague, Faculty of Engineering, Agricultural Engineering, Kamýcká 129, 165 21 Prague, Czech Republic*

Abstract. In production, treatment or operation of selected components it is not possible to avoid dirtiness. Given the fact that impurities significantly affect the quality, functionality and service life of a part, the surface preparation of such an element is a key aspect in the regeneration process. The choice of contaminant removal method will depend on the type of impurity. This operation is often treated as a separate technological process, during which the type and properties of the removed dirt are determined, along with assessing the degree of purity required to ensure the correctness of subsequent operation or operations. Rising expectations regarding specific effects of purification have led to massive improvement of traditional methods, and development of new processes that require the use of complex technologies. The present research was to prepare the technological process of washing selected parts of the aircraft turbine engine. The preliminary assumption was to use the LUA-1000 automatic washing processing line, which selecting and modifying particular parameters of the process in order to comply with the technological assumptions. The elaborated process includes the following stages: preparing the selected parts for washing, washing the engine parts and the quality control of washing. The primary objective of the study was to achieve the most beneficial parameters possible and, at the same time, to minimise the costs of the machine's work, as well as to preserve high quality and to comply with environmental standards.

* Corresponding author: i.miturska@pollub.pl

Supporting the climate of innovation in the SME sector - an application for SMEs

Sabina Motyka[1,*], Jolanta Słoniec[2], Anna Kaczorowska[3] and Elżbieta Łaciak[4]

[1]*Cracow University of Technology, Faculty of Mechanical Engineering, Department of Manufacturing Processes, M6 Institute, Jana Pawła II 37 Avenue, 31-864 Cracow, Poland*
[2]*Lublin University of Technology, Faculty of Management, Department of Enterprise Organization, Nadbystrzycka 38 Str., 20-618 Lublin, Poland*
[3]*University of Lodz, Faculty of Management, Department of Computer Science, Matejki 22/26 Str., 90-237 Lodz, Poland*
[4]*Ericsson sp. z o.o., Czerwone Maki 87 A Str., 30-392 Cracow, Poland*

Abstract. The ability of contemporary organizations to create innovative solutions in the areas of products, processes, organization and marketing requires proper technical and managerial skills and the skill of continuous learning. The pursuit and efforts of companies to upgrade their competitive position through innovation requires active involvement and improvement from all employees of an organization. Large organizations and international corporations usually have significant resources for developing and supporting management processes. SMEs are struggling with a range of economic, legal and psychosocial barriers, and difficulties in accessing innovative financing sources. Innovation management in smaller businesses, supported by recent data and analytical tools, has a potential for more effective and faster implementation. The aim of this article is to show the determinants and proposals of actions (organizational innovations) supporting the creation of a specific climate and culture of innovation in enterprises from the SME sector. In addition, the article presents an original solution in the form of a developed web application supporting innovation management in an enterprise. The presented utility tool is a proposal for organizational innovation dedicated to companies from the SME sector.

* Corresponding author: motyka@mech.pk.edu.pl

The effects of welding parameters on the tensile shear strength of refill friction stir spot welding of 7075-T6 aluminium alloy joints

Dawid Wydrzyński[1,*], Magdalena Bucior[1], and Andrzej Kubit[1]

[1]*Faculty of Mechanical Engineering and Aeronautics, Department of Manufacturing Processes and Production Engineering, Rzeszow University of Technology, Powstańców Warszawy 8, 35-959 Rzeszów, Poland*

Abstract. The paper presents the results of an analysis of the effect of welding parameters on the load capacity of joints obtained by the refill friction stir spot welding (RFSSW) method. This technology has a prospective application in aerospace and automotive industries, especially for aluminium alloys. The research was conducted for the overlapping joints made of two 7075-T6 aluminium alloy sheets with thicknesses 1.6 mm and 0.8 mm. Strength tests were conducted for two variants of loading the joint. The experiments were conducted according to statistical Hartley's plan PS/DS-P:Ha3. The welding times *t* was varied in the range of 1.5 ÷ 3.5 s, the tool plunge depth *g* in the range of 1.5 ÷ 1.9 mm, and the tool rotational speed *n* in the range of 2000 ÷ 2800 rpm. For these parameters the analysis of experiment reproducibility, impact significance and adequacy of equations were made. The results of analysis according to the design of the experiment (DOE) indicate that all analyzed parameters have significant influence on the load capacity of joints. The biggest load capacity of joints in the case of the first variant was gained at the maximum spindle speed of 2800 rpm, the minimum tool plunge depth of 1.5 mm and welding time of 1.5 s. For the second variant, the maximum load capacity of joints was gained at the spindle speed of 2400 rpm, tool plunge depth of 1.5 mm and welding time of 2.5 s.

*Corresponding author: magdabucior@prz.edu.pl

Uncertainty measurement with the kinematic telescopic bar during industrial robot inaccuracy tests

Jerzy Józwik[1,*], Elżbieta Jacniacka[1] and, Dawid Ostrowski[2]

[1]*Lublin University of Technology, Mechanical Engineering Faculty, Department of Production Engineering, 36 Nadbystrzycka Street, 20-618 Lublin, Poland*
[2]*The State School of Higher Education, The Institute of Technical Sciences and Aviation, 54 Pocztowa Street, 22-100 Chełm, Poland*

Abstract. The subject of this article is the assessment of measurement uncertainty with the kinematic telescopic bar QC20-W in the accuracy test of MOTOMAN HP20 industrial robot. The measurements were performed to determine the statistical uncertainty of error measurement using the system applied. Analysed in tests was the robot's ability to recreate a circular outline through standard, complex and extended measurement of uncertainty measurement. The obtained results were served to perform rapid evaluation of robot inaccuracy. These uncertainties were based on the information included in the device calibration certificate (estimated with method B) but also on the basis of measurements and statistical data (estimated with method A). These components of the uncertainty budget take relatively small values ($u_c = 0.818 \div 4.130$; $U = 1.636 \div 8.260$ for $k = 2$, which proves that a properly selected method was applied to the research task. The method of research and calculation precisely identified key uncertainties allowing for an objective assessment of the industrial robot errors carried out with Renishaw the kinematic telescopic bar.

* Corresponding author: j.jozwik@pollub.pl

An attempt to use FMEA method for an approximate reliability assessment of machinery

Krzysztof Przystupa[1,*]

[1]*Lublin University of Technology, Mechanical Engineering Faculty, Department of Automation, Nadbystrzycka Street 36, 20-618 Lublin, Poland*

Abstract. The paper presents a modified FMEA (Failure Mode and Effect Analysis) method to assess reliability of the components that make up a wrench type 2145: MAX Impactol TM Driver Ingersoll Rand Company. This case concerns the analysis of reliability in conditions, when full service data is not known. The aim of the study is to determine the weakest element in the design of the tool.

* Corresponding author: k.przystupa@pollub.pl

Analysis of a planetary gear modelled with a contour graph considering the decision making complexity of game-tree structures

Adam DEPTUŁA[1,*], Józef DREWNIAK[2], and Marian A. PARTYKA[1]

[1]*Opole University of Technology, Faculty of Production Engineering and Logistics, Institute of Processes and Products Innovation, Ozimska 75, 45-370 Opole, Poland,*

[2]*University of Bielsko-Biala, Faculty of Machine Building and Computer Science, Department of Mechanical Engineering Fundamentals, Willowa 2, 43-309 Bielsko-Biała, Poland*

Abstract. Analysis and synthesis of mechanisms is one of the fundamental tasks of engineering. Mechanisms can suffer from errors due to versatile reasons. Graph-based methods of analysis and synthesis of planetary gears constitute an alternative method for checking their correctness. Previous applications of the graph theory concerned modelling gears for dynamic analysis, kinematic analysis, synthesis, structural analysis, gearshift optimization and automatic design based on so-called graph grammars. Some tasks may be performed only with the methods resulting from the graph theory, *e.g.* enumeration of structural solutions. The contour plot method consists in distinguishing a series of consecutive rigid units of the analysed mechanism, forming a closed loop (so-called contour). At a later stage, it is possible to analyze the obtained contour graph as a directed graph of dependence. This work presents an example of the application of game-tree structures in describing the contour graph of a planetary gear. In addition, complex parametric tree structures are included.

* Corresponding author: a.deptula@po.opole.pl

Assessing the damage importance rank in acoustic diagnostics of technical conditions of the internal combustion engine with multi-valued logical decision trees

Adam DEPTUŁA[1,*], Wojciech MACEK[2], and Marian A. PARTYKA[1]

[1]*Opole University of Technology, Faculty of Production Engineering and Logistics, Institute of Processes and Products Innovation, Ozimska 75, 45-370 Opole, Poland,*

[2]*Opole University of Technology, Faculty of Production Engineering and Logistics, Department of Engineering and Work Safety, Generała Kazimierza Sosnkowskiego 31, 45-272 Opole, Poland*

Abstract. This paper presents possible applications of acoustic diagnostics in inspecting the technical condition of an internal combustion engine with autoignition on the example of the Fiat drive unit with the common rail system. As a result of measuring the sound pressure level for specific faults and comparing the noise generated by the motor running smoothly, the detailed maps of changes in the acoustic spectrum may be generated. These results may be helpful in future diagnostics of internal combustion engines. In the paper, we present the results from the scientific works in the area of research, design and operation of internal combustion engines, conducted at the Department of Automotive Engineering, in cooperation with the Laboratory of Hydraulic Drives & Vibroacoustics of Machines at the Wroclaw University of Technology. The broader study has so far allowed us to develop an authoritative method of identifying the type of engine damage using game-tree structures. The present works assess the possibility of using multi-valued logic trees.

* Corresponding author: a.deptula@po.opole.pl

Calculating an electromechanical torque of a squirrel cage motor based on an axial flux obtained by the FEM

Janusz Petryna[1], Jarosław Tulicki[1], and Maciej Sułowicz[1,]

[1]*Cracow University of Technology, Faculty of Electrical and Computer Engineering, Institute of Electromechanical Energy Conversion, Warszawska Street 24, 31-155 Cracow, Poland*

Abstract. This article presents a method of calculating an axial flux signal and how to use this signal to determine an electromagnetic torque for a squirrel cage induction motor in a steady state. Numerical analyses were performed using a two-dimensional field-circuit model for the squirrel cage induction motor. Most of analyses were performed for a symmetric motor and to estimate a magnitude of the electromagnetic torque, an algorithm was developed. The electromagnetic torque estimation method proposed in the article is easy to implement and does not require any interference into the drive system transmission. The analysis shows that it is possible for the induction motor to determine a load torque based on the axial flux measurement using a measuring coil applied to the motor, for example from the fan side.

* Corresponding author: msulowicz@pk.edu.pl

Chamber stapes prosthesis with an improved fastening of the membrane

Małgorzata Pudlik[1,*], Henryk Skarżyński[2], and Monika Kwacz[3]

[1]*Institute of Radioelectronics, Warsaw University of Technology, Nowowiejska 15/17, 00-665 Warsaw, Poland*
[2]*Institute of Physiology and Pathology of Hearing, Mochnackiego 10, 02-042 Warsaw, Poland*
[3]*Institute of Micromechanics and Photonics, Warsaw University of Technology, św. Andrzeja Boboli 8, 02-525 Warsaw, Poland*

Abstract. Stapes prostheses are dedicated to assisting patients with otosclerosis. Currently used stapes prostheses have the form of a piston and are called piston prostheses. However, the perilymph excitation by piston prosthesis is not perfect so a new chamber stapes prosthesis (ChSP) has been proposed. The ChSP allows for a more effective stimulation of the cochlea than the piston. A crucial element of the ChSP is a flexible membrane. The membrane transmits vibrations from the plate to the fluid that fills the chamber and then to the inner ear. In the first prototype, the membrane was glued to the chamber, which is an unacceptable solution in a real medical device because of a risk to patient's health. Therefore, there is a need to improve the membrane fastening. In this study, we present a new improved method for attaching the membrane to the chamber. A modified 3D model of the ChSP was build and an additional fastening element was designed. The design process of the fastening element was based on the analysis of deformation conducted for elements made of different materials. As a result the optimal geometry of the element was determined. The new fastening has been experimentally tested using the 3D printed model. Fastening the membrane to the prosthesis was a success and assessed as efficient. The results of the experimental tests confirmed that presented modification can be used in the ChSPs intended for clinical trial

* Corresponding author: mgpudlik@gmail.com

Control and data acquisition system for rotary compressor

Marcin Buczaj[1], and Andrzej Sumorek[2,*]

[1]*Lublin University of Technology, Inst. of Electrical Engineering and Electrotechnologies, Nadbystrzycka 38A, 20-618 Lublin, Poland*
[2]*Lublin University of Technology, Department of Structural Mechanics, Nadbystrzycka 40, 20-618 Lublin, Poland*

Abstract. The rotary compressor (crimping machine) is a machine designed for making hollow forgings. The rotary compressor is a prototype device designed and built at the Technical University of Lublin. The compressor is dedicated to perform laboratory tests related to the hollow forgings of various shapes using different materials. Since the rotary compressor is an experimental device, there is no control and acquisition data system available. The article presents the concept and the capabilities of the computer control and data acquisition system supporting rotary compressing process. The main task of software system is acquisition of force and kinetic parameters related to the analysed process of the rotary forging compression. The software allows the user to declare the course of the forming forgings. This system allows current recording and analysis of four physical values: feed rate (speed of working head movement), hydraulic oil pressure at inlet and outlet of hydraulic cylinder and the torque of engine. Application functions can be divided into three groups: the configuration of the pressing process, the acquisition and analysis of data from the pressing process and the recording and presentation of stored results. The article contains a detailed description about hardware and software implementation of mentioned functions.

* Corresponding author: a.sumorek@pollub.pl

Description of anisotropy of magnetic properties for chosen grades of electrical steels

Piotr Borowik[1], and Krzysztof Chwastek[1,*]

[1]*Częstochowa University of Technology, Faculty of Electrical Engineering, Aleja Armii Krajowej 17, 42-201 Częstochowa, Poland*

Abstract. Magnetic properties of electrical steels, either grain-oriented or non-oriented ones, are significantly affected by anisotropy. The paper considers two descriptions for the dependence: power losses versus angle. The first one is based on the theoretical studies on texture from materials science. The other one is purely phenomenological, and based on an equation of ellipse in a rotated coordinate system.

* Corresponding author: krzysztof.chwastek@gmail.com

Digital signal processing in ultrasonic based navigation system for mobile robots

Paweł Stączek[1,*]

[1]*Lublin University of Technology, Mechanical Engineering Faculty, Department of Automation, Nadbystrzycka Street 36, 20-618 Lublin, Poland*

Abstract. A system for estimating the coordinates of automated guided vehicles (AGV) was presented in this article. Ultrasonic waves for distance measurement were applied. Used hardware was characterised, as well as signal processing algorithms. The system was tested on wheeled mobile robot in model 2D environment. The results of working range and errors of position estimation were discussed.

* Corresponding author: p.staczek@pollub.pl

Implementation of PID autotuning procedure in PLC controller

Marcin Daniun[1], Michał Awtoniuk[1,*], and Robert Sałat[1]

[1]*Warsaw University of Life Sciences, Faculty of Production Engineering, Nowoursynowska 164, 02-787 Warsaw, Poland*

Abstract. In this paper, we present the automatic PID tuning procedure based on the Method of Moments and AMIGO tuning rules. The advantage of the Method of Moments is that the time constant and transport delay are estimated at the areas rather than on the individual points. This results in high resistance to the measurement noises. The sensitivity to measurement noises is a serious problem in other autotuning methods. The second advantage of this method is that it approximates plant during identification process to first order model with time delay. We combined the Method of Moments with the AMIGO tuning rules and implemented this combination as a stand-alone autotuning procedure in Siemens S7-1200 PLC controller. Next, we compared this method with two built-in PID autotuning procedures which were available in Siemens S7-1200 PLC controller. The procedure was tested for three types of plant models: with lag-dominated, balanced, and delay-dominated dynamics. We simulated the plants on a PC in Matlab R2013a. The connection between the PC and PLC was maintained through a National Instruments data acquisition board, NI PCI-6229. We conducted tests for step change in the set point, trajectory tracking, and load disturbances. To assess control quality, we used IAE index. We limited our research to PI algorithm. The results prove that proposed method was better than two built-in tuning methods provided by Siemens, oscillating between a few and even a dozen percent in most cases. The proposed method is universal and can be implemented in any PLC controller.

* Corresponding author: michal_awtoniuk@sggw.pl

Indoor mobile robot attitude estimation with MEMS gyroscope

Radosław Cechowicz[1,*]

[1]*Lublin University of Technology, Mechanical Engineering Faculty, Department of Automation, Nadbystrzycka 36, 20-618 Lublin, Poland*

Abstract. A method of attitude estimation with a low-cost, strap-on MEMS sensor was proposed in the article. The method relies on dynamic gyroscope bias change estimation and updates during detected stops of the robot. The algorithm has been tested in laboratory with iRobot Roomba robot and should be improved to be useful in an industrial environment. The measurement of attitude of a mobile platform is necessary for correct navigation, especially in autonomous vehicles, which use dead reckoning between position updates from external sources. Since the system is intended to operate indoors, in industrial halls and shops, it cannot avail of GPS and Earth magnetic field sensors because of anomalies, which are common inside the steel constructions. Therefore, the accuracy of the gyroscope-based attitude estimation is significant. The proposed method aims to address the common problem of gyroscope bias drift, by dynamic update of sensor bias and simultaneous use of all gyroscope axes, to improve the quality of the measurements. A popular 3-axial gyroscope and 3-axial accelerometer sensors were used during the test runs. Obtained results suggest that it is possible to improve short-term accuracy of inertial dead reckoning, to get a system that could be of practical use in industrial AGV systems or intelligent vehicles.

* Corresponding author: r.cechowicz@pollub.pl

Measurement system analysis for one-sided tolerance

Szemik Kamil[1,*], Bogacz Pawel[1]

[1]*AGH University of Science and Technology, Faculty of Mining and Geoengineering, Department of Economics and Management in Industry, Al. Mickiewicza 30, 30-059 Cracow, Poland*

Abstract. Measurement system analysis is carried out in order to determine if a capability to perform measurements in terms of product and process control is sufficient, indicating that the type I and the type II appraisal errors probability are acceptable. Statistical analyses for measurement system evaluation presented in the literature and the industrial manuals are not applicable for all complex and unusual applications. Therefore, the purpose of this study was to develop a robust statistical analysis method for measurement system variability analysis, in terms of product control scenario applied to one-sided tolerance. In the hereby presented study, the authors presented the theoretical principles of statistical techniques for measurement variations evaluation. Subsequently, the formula of gauge repeatability and reproducibility in terms of lower specification limit was proposed. The research hypothesis was tested using the statistical analysis

* Corresponding author: szemik@agh.edu.pl

Modelling and simulation of a hydraulic active heave compensation system

Arkadiusz Jakubowski[1],*, and Arkadiusz Kubacki[1]

[1]*Institute of Mechanical Technology, Poznan University of Technology, Skłodowska-Curie Square 5, 60-965 Poznań, Poland*

Abstract. The following work presents modelling, simulation and results of hydraulic motor and hydraulic cylinder position measurement for a hydraulic active heave compensation system (AHC). In order to perform experimental research the authors developed a test stand. A hydraulic cylinder is used to carry out a simulation of sea waves. The development of a test stand made it possible to compare the simulation with the experimental results. A hydraulic motor is used for compensation of sea waves. Optimization of design parameters for such systems can be done by analysing a model simulation. The main components of this system were modelled. This model was implemented in simulation software Mathlab Simulink and its dynamic performance was tested. The Authors presented the simulation and the experimental results for main components of a hydraulic active heave compensation system.

* Corresponding author: arkadiusz.z.jakubowski@doctorate.put.poznan.pl

Recurrence analysis of regular and chaotic motions of a superelastic shape memory oscillator

Joanna Iwaniec[1], Grzegorz Litak[2,*], Davide Bernardini[3], and Marcelo A. Savi[4]

[1]*AGH University of Science and Technology, Faculty of Mechanical Engineering and Robotics, Department of Robotics and Mechatronics, Mickiewicz Alley 30, 30-059 Krakow, Poland*

[2]*AGH University of Science and Technology, Faculty of Mechanical Engineering and Robotics, Department of Process Control, Mickiewicz Alley 30, 30-059 Krakow, Poland*

[3]*University of Rome Sapienza, Department of Structural and Geotechnical Engineering, via Antonio Gramsci 53, 00192, Rome, Italy*

[4]*Universidade Federal do Rio de Janeiro, COPPE – Mechanical Engineering, Centre for Nonlinear Mechanics, Rio de Janeiro - RJ - Brazil*

Abstract. The recurrence analysis is a promising tool for diagnostics of periodic and chaotic solutions, as well as identifying bifurcations. This paper deals with the application of this analysis for the first time to identify regular and non-regular motions of a superelastic shape memory alloy oscillator. The numerical analyses show that the method is capable of distinguishing periodic and chaotic trajectories. Recurrence quantities are applied, showing that different approaches are possible to establish the distinction between periodic and chaotic signals. Basically, recurrence entropy, trapping time, and characteristic recurrence time are considered.

* Corresponding author: g.litak@pollub.pl

An experimental study of exploitation of materials used for prosthetic temporary restorations

Leszek Szalewski[1],*, Elżbieta Celej-Piszcz1, Małgorzata Stodółkiewicz[2], Radosław Cechowicz[3], Marcin Bogucki[3], Janusz Borowicz[1], and Jacek Szkutnik[1]

[1]*Medical University of Lublin, Department of Dental Prosthetics, Karmelicka 7, 20-081 Lublin, Poland*

[2]*Medical University of Lublin, Department of Functional Masticatory Disorders, Karmelicka 7, 20-081 Lublin, Poland*

[3]*Lublin University of Technology, Mechanical Engineering Faculty, Department of Automation, Nadbystrzycka 36, 20-618 Lublin, Poland*

Abstract. Temporary restorations more often play their role for a definitely longer period of time, than the time necessary for implementation of final prosthetic work. Therefore, they are subjected to adverse effects of chemical, physical and thermal factors in a patient's oral cavity. Since loss of temporary prosthetic work can have negative consequences for an entire treatment process, it is important to identify a potential risk of damaging temporary restorations by factors derived from the diet of patients. The aim of this study was to evaluate the influence of components of the beverages, such as coffee and tea, consumed daily by the patients, on the mechanical properties of materials used in temporary restorations. The experimental design applied, as well as gained results, were justified by appropriate, chosen statistical methods. The conducted research demonstrated the change of mechanical properties of studied materials for their flexural strength, as well as microhardness. The tendency of changes in both result variables, compared with the samples kept in neutral environment – distilled water, indicates the decrease in mechanical strength and microhardness of materials conditioned in coffee and tea. It can be claimed that the components of beverages present in an everyday diet of patients have a considerably adverse effect on the quality of materials used for provisional crowns and bridges.

* Corresponding author: leszek.szalewski@umlub.pl

Analysis of fracture roughness parameters of S355J2 steel and EN AW-2017A-T4 aluminium alloy

Wojciech Macek[1],*, and Tomasz Wołczański[1]

[1]*Opole University of Technology, Faculty of Production Engineering and Logistics, Sosnkowskiego 31, 45-272 Opole, Poland*

Abstract. This article presents an analysis of fracture surface for steel S355J2 and EN AW-2017A-T4 aluminium subjected to fatigue bending, torsion, and bending with torsion. Fracture surfaces were observed using the focus variation microscope, which allows for the acquisition of data sets with large depth of focus. The authors focus on presenting the features of profile roughness parameters on the example of differences between fracture propagation and rupture areas. The researchers are looking for a correlation or ratio between different profile roughness parameters, especially arithmetical mean deviations of the roughness profile Ra and maximum height of the roughness profile Rz, for this case.

* Corresponding author: w.macek@po.opole.pl

Application of computer image analysis software for determining incubation period of cavitation erosion – preliminary results

Mirosław Szala[1,*]

[1]*Lublin University of Technology, Mechanical Engineering Faculty, Department of Materials Engineering, Nadbystrzycka 36, 20-618 Lublin, Poland*

Abstract. The paper discusses the application of image analysis software ImagePro Plus and MetIlo for assessing cavitation erosion wear. The investigation of cavitation damage is performed on a vibratory test rig in compliance with the ASTM G32 standard using the stationary specimen method. Low-alloy steel grade 34CrNiMo6 is used as the test material. Cavitation wear is evaluated by gravimetric and roughness measurements, microscopic observations and computer image analysis in specified exposure times. The computer image analysis of selected surface areas during a predetermined exposure to cavitation time is performed using images captured with a metallographic microscope. Based on the results of scanning electron and stereoscope microscopic observations, the cavitation worn surfaces are qualitatively described. The relations between surface topography, gravimetric measurements and the microscopic results are discussed. The findings obtained by gravimetric and roughness measurements, image processing and microscopic observations are complementary. The results prove the suitability of image analysis for investigating incubation period of cavitation erosion. The quantification of cavitation erosion damage indicates that the incubation period of cavitation erosion of the tested steel lasts for 20 minutes. The results demonstrate that cavitation-worn surfaces at the initial stage of cavitation erosion can be examined using both ImagePro Plus and MetIlo.

* Corresponding author: m.szala@pollub.pl

Computational image analysis of Suspension Plasma Sprayed YSZ coatings

Monika Michalak*[1], Leszek Łatka[1], Patrycja Szymczyk[1] and Paweł Sokołowski[1]

[1]*Faculty of Mechanical Engineering, Wroclaw University of Science and Technology, Łukasiewicza 5, 50-371 Wrocław, Poland*

Abstract. The paper presents the computational studies of microstructure- and topography- related features of suspension plasma sprayed (SPS) coatings of yttria-stabilized zirconia (YSZ). The study mainly covers the porosity assessment, provided by ImageJ software analysis. The influence of boundary conditions, defined by: (i) circularity and (ii) size limits, on the computed values of porosity is also investigated. Additionally, the digital topography evaluation is performed: confocal laser scanning microscope (CLSM) and scanning electron microscope (SEM) operating in Shape from Shading (SFS) mode measure surface roughness of deposited coatings. Computed values of porosity and roughness are referred to the variables of the spraying process, which influence the morphology of coatings and determines the possible fields of their applications.

*Corresponding author: monika.michalak@pwr.edu.pl

Effect of porosity on physical properties of lightweight cement composite with foamed glass aggregate

Marzena Kurpińska[1,*] and Tomasz Ferenc[1]

[1]*Gdansk University of Technology, Faculty of Civil and Environmental Engineering, Narutowicza 11/12, 80-233 Gdańsk, Poland*

Abstract. This paper reports on a study of physical properties of lightweight cement composite. We investigate the possibility of replacing traditional aggregate with Granulated Ash Aggregate (GAA) and above all with Granulated Expanded Glass Aggregate (GEGA). For this purpose, 15 specimens of different percentage share of each aggregate in total aggregate volume were tested: 0%, 25%, 50%, 75% or 100% of foam glass aggregate (GEGA) partially replaced by ash aggregate (GAA) content in the cement composite. The water-cement ratio was constant and equal to w/c=0.5. Three grain sizes were analyzed: 2mm, 4mm (both GEGA) and 8mm (GAA). Numerical simulations of concrete specimen behavior under static loading were conducted with the implementation of elastic plastic model of each component. The study shows a significant impact of grain type and size on physical properties of lightweight concrete. Due to lower density of foamed glass aggregate, specimens shows various apparent density and porosity, which affect concrete properties. Compressive strength of concrete decreases with the increase in foam glass aggregate content; however specimens show different workability and in consequence porosity of lightweight concrete.

* Corresponding author: marzena.kurpinska@pg.edu.pl

Evaluation of scratch resistance of nitride coatings on Ti grade 2

Kamil Pasierbiewicz[1,*], Anna Rzepecka[1], and Mariusz Walczak[1]

[1]*Lublin University of Technology, Faculty of Mechanical Engineering, Department of Material Science, Nadbystrzycka 36, 20-618 Lublin, Poland*

Abstract. Hard coatings limiting direct contact of material susceptible to wear are applied in order to improve resistance to abrasive wear. The key importance in using anti-wear coatings has their adhesion to substrate and differences in mechanical properties of the coating and substrate, particularly their Young's module. Studies have analyzed merits of applying nitride coatings TiAlN, AlTiN and hybrid coating TiAlN/TiSiN on titanium substrate ASTM grade 2. For that purpose, nanohardness and scratch tests for each coating were conducted. Apparatus of Anton Paar Company was used in these studies – ultra-high resolution nanoindenter and micro combi tester. Due to the fact, that surface roughness is a significant parameter affecting properties of the surface layer, the first appointed parameters were Sa roughness with a use of optical profilometer Bruker Contour GT. Obtained results suggest the best adhesive grip of hybrid coating TiAlN/TiSiN compared with other tested. The weakest adhesion to titanium grade 2 has TiAlN coating, on which in scratch test has been observed significantly faster total damage, in comparison with other tested. Research results will provide the input data for numerical analysis, enabling fast receiving effects of applying tested coatings without the need to carry out time-consuming research.

* Corresponding author: pasierbiewicz.k@gmail.com

Experimental and numerical assessment of the characteristics describing superelasticity in shape memory alloys – influence of boundary conditions

Jakub Bryła[1] and Adam Martowicz[1*]

[1]*AGH University of Science and Technology, Faculty of Mechanical Engineering and Robotics, Department of Robotics and Mechatronics, Mickiewicza 30, 30-059 Krakow, Poland*

Abstract. Relatively recent discovery of shape memory alloys (SMA) justifies ongoing research on their properties and an attempt to explain the physical phenomenon responsible for the characteristic behaviour of SMA. Moreover, there have been reported many successful commercial SMA applications to medical cases, mostly based on superelasticity. Even though a wide application range is confirmed, its further contribution growth is currently not seen - mostly due to deficiency of reliable modelling techniques. Recently, lively discussion in the SMA academic community is observed, which deals with modelling issues and numerical implementation.

Considering the current trends, the authors of the work make an attempt at qualitative analysis of the material properties for superelasticity. The material characteristics – found using static stretching tests – are sensitive to the variation of local stresses induced in the area where a SMA sample is mounted in a fatigue testing machine. As shown, the phenomena present at the clamping area seem to initiate and govern the process of the solid phase transformation within the entire SMA body. The overall objective of the presented research is to assess the influence of the above stated boundary conditions on the properties of selected types of SMA, using both experimental and numerical results.

[*]Corresponding author: adam.martowicz@agh.edu.pl

Structure and tribological properties of MoS_2 low friction thin films

Agnieszka Paradecka[1,*], Krzysztof Lukaszkowicz[1], Jozef Sondor[2], and Mieczysław Pancielejko[3]

[1]*Silesian University of Technology, Institute of Engineering Materials and Biomaterials, 44-100 Gliwice, Poland*
[2]*LISS, a.s., Dopravni 2603, 756 61 Roznov p.R., Czech Republic*
[3]*Koszalin University of Technology, Department of Technical Physics and Nanotechnology, 75-453 Koszalin, Poland*

Abstract. The main aim of the studies was the deposition of the AlCrN film, covered by molybdenum disulphide (MoS2) – based lubricant, on the austenitic steel substrate. The AlCrN and MoS2 layers were deposited by PVD lateral rotating ARC-cathodes (LARC) and magnetron sputtering technology on the X6CrNiMoTi17-12-2 respectively. Structural characterizations of the MoS_2 thin films have been carried out using SEM (scanning electron microscopy) and AFM (atomic force microscopy) to determine the surface topography as well as HRTEM (high-resolution transmission electron microscopy) and Raman spectroscopy for structural investigations. The tribological wear relationships using ball-on-disc test were specified for surface layers, determining the friction co-efficient and mass loss of the investigated surfaces. Tests of the coatings' adhesion to the substrate material were made using the scratch test. HRTEM investigation shows an amorphous character of the MoS_2 layer. In sliding dry friction conditions, the friction co-efficient for the investigated elements is set in the range between 0.4-0.5. The investigated coating reveals high wear resistance. The coating demonstrated a dense cross-sectional morphology as well as good adhesion to the substrate. The good properties of the PVD AlCrN+MoS_2 coatings make them suitable in various engineering and industrial applications.

* Corresponding author: agnieszka.paradecka@polsl.pl

The tensile strength test of thermoplastic materials based on poly(butylene terephtalate)

Anna Rzepecka[1]*, and Monika Ostapiuk[1]

[1]*Lublin University of Technology, Department of Materials Engineering, Nadbystrzycka St. 36, 20-618 Lublin, Poland*

Abstract. Thermoplastic composites go toward making an increasingly greater percentage of all manufacturing polymer composites. They have a lot of beneficial properties and their manufacturing using injecting and extrusion methods is a very easy and cheap process. Their properties significantly overtake the properties of traditional materials and it is the reason for their use. Scientists are continuously carrying out research to find new applications of composites materials in new industries, not only in the automotive or aircraft industry. When thermoplastic composites are manufactured a very important factor is the appropriate accommodation of tensile strength to their predestination. Scientists need to know the behaviour of these materials during the impact of different forces, and the factors of working in normal conditions too. The main aim of this article was macroscopic and microscopic analysis of the structure of thermoplastic composites after static tensile strength test. Materials which were analysed were thermoplastic materials which have poly(butylene terephthalate) – PBT matrix reinforced with different content glass fibres – from 10% for 30%. In addition, research showed the necessary force to receive fracture and set their distinguishing characteristic down.

* Corresponding author: annarzepecka92@gmail.com

Analysis of dynamic stiffness of arch bridges by means of the first natural frequency

Slawomir Karas[1,*], and Radoslaw Wrobel[2]

[1]*Road and Bridge Department, Lublin University of Technology, Nadbystrzycka 40, 20-814 Lublin, Poland*
[2]*Budimex S.A., Stawki 40, 01-040 Warszawa, Poland*

Abstract. Arch bridges have always boasted a strong aesthetic value. However, their design is challenging due to dynamic excitations. It regards, above all, an area up to ¼ of a bridge length. In bridge dynamics numerical analyses, the basic importance is attached to the natural vibration frequency corresponding to the first bending mode. The multiple first mode is connected to the horizontal shift of a platform or arches, additionally coupled with the deformation corresponding to torsion. In the bridge standards, the first bending mode was adopted as default followed subsequently by higher rank modes of torsional or transversal shapes which do not always occur. This paper describes fourteen numerical models of various arches used in bridge design. The arch bridge, of vertical arches, constitutes a reference. Other models are their varieties through a change of the arch height, a method of connecting platforms and arches at a head and their resulting interaction. Furthermore, variability of arch tilts from a vertical plane was discussed. Conclusions are not unanimously final from the technical point of view; nevertheless, certain beneficial solutions, corresponding to the models of structures of higher natural frequencies, can be indicated.

* Corresponding author: s.karas@pollub.pl

Dental implant stress analysis with selected prosthetic crown overhangs sizes

Agnieszka Łagoda[1*], and Adam Niesłony[2]

[1]*Opole University of Technology, Faculty of Mechanical Engineering, Department of Machine Technology and Production Automation, Mikołajczyka 5, 45-271 Opole, Poland*
[2]*Opole University of Technology, Faculty of Mechanical Engineering, Department of Mechanics and Machine Design, Mikołajczyka 5, 45-271 Opole, Poland*

Abstract. Dental implantology is one of burgeoning methods of teeth loss reconstruction. Because each patient is different, there are still many problems to be solved. One of them is occurrence of prosthetic crown overhangs. The overhangs increase the stress value and risk of the glue shattering, causing a crown fall out and requiring another implantologist's appointment. The aim of the study is to assess the stress value generated in the dental implant using Finite Elements Method and simplified models.

* Corresponding author: a.lagoda@po.opole.pl

Dynamic diagnostics of moving ferromagnetic material with the linear induction motor

Krzysztof Szewczyk[1,*], and Tomasz Walasek[2]

[1] *Częstochowa University of Technology, Faculty of Electrical Engeneering, Str. Armii Krajowej 17,42-200 Częstochowa, Poland*
[2] *Częstochowa University of Technology, Faculty of Mechanical Engineering and Computer Science, Str. Armii Krajowej 17,42-200 Częstochowa, Poland*

Abstract. The paper presents the application of a three-phase induction motor as a sensor measuring the force of the electromagnetic field connection between the engine and produced sheet steel. The force interaction between the engine and the manufactured sheet metal treated as a treadmill for a linear motor may be an indicator of damage to the material. Detection of places where the sheet does not meet the quality requirements may be very useful in the production process. FEM calculations were performed in the ANSYS MAXWELL environment. The results suggest the possibility of using this type of construction to test the quality of produced materials. The computational results and their analysis are presented in this article.

[*] Corresponding author: szewczyk500@gmail.com

FEM simulation research of natural frequency vibration of crankshaft from internal combustion engine

Magryta Paweł[1*], Pietrykowski Konrad[1] and Skiba Krzysztof[1]

[1]*Faculty of Mechanical Engineering, Department of Thermodynamics, Fluid Mechanics and Aviation Propulsion Systems, Lublin University of Technology, ul. Nadbystrzycka 36, 20-618 Lublin, Poland.*

Abstract. The article presents vibration simulation studies of a crankshaft used in internal combustion engine. The simulation was performed using FEM method. The study was conducted in Abaqus software, and a shaft model was implemented in Catia v5. The influence of a mesh element size on the results of obtained calculations was analysed. A shaft which will be used in the ultralight aircraft engine was the subject of research. Results show the first 10 frequency modes and 12 grid examples for various element sizes, from 9 to 1.3 mm. Moreover, the effect of mesh size on the obtained results is presented. It has been proven that the maximum error for two extreme results (the densest and sparsest grid) is approximately 1.4%; therefore, it is justified to carry out calculations of own vibration on a fatal grid. Results presented herein will be used in the future work on the crankshaft geometry modifications.

* Corresponding author: p.magryta@pollub.pl

Influence of gas inlet angle on the mixing process in a Venturi mixer

Mathias Romańczyk[1,*],

[1]*Czestochowa University of Technology, Institute of Thermal Machinery, al. Armii Krajowej 21, 42-201 Czestochowa, Poland*

Abstract. In this paper numerical analysis were performed to investigate the influence of gas inlet angle on mixing process in a Venturi mixer. Performance of an industrial gas engine depends significantly on the quality of mixing air and fuel; therefore, on the homogeneity of the mixture. In addition, there must be a suitable, adapted to the current load of fuel, air ratio. Responsible for this fact, among others, is the mixer located before entering the combustion chamber of the engine. Incorrect mixture proportion can lead to unstable operation of the engine, as well as higher emissions going beyond current environmental standards in the European Union. To validate the simulation the Air-Fuel Ratio (AFR) was mathematically calculated for the air-fuel mixture of lean combustion gas engine. In this study, an open source three-dimensional computational fluid dynamics (CFD) modelling software OpenFOAM has been used, to investigate and analyse the influence of different gas inlet angles on mixer characteristics and their performances. Attention was focused on the air-fuel ratio changes, pressure loss, as well as improvement of the mixing quality in the Venturi mixer.

* Corresponding author: mathias@imc.pcz.czest.pl

Influence of patient position and implant material on the stress distribution in an artificial intervertebral disc of the lumbar vertebrae

Robert Karpiński[1,*], Łukasz Jaworski[2], Mirosław Szala[3], and Monika Mańko[4]

[1]*Lublin University of Technology, Faculty of Mechanical Engineering, Department of Machine Design and Mechatronics Nadbystrzycka 36, 20-618, Lublin, Poland*

[2]*Poznan University of Technology, Faculty of Mechanical Engineering and Management, Piotrowo 3, 60-965, Poznań, Poland*

[3]*Lublin University of Technology, Faculty of Mechanical Engineering, Department of Materials Engineering, Nadbystrzycka 36, 20-618 Lublin, Poland*

[4]*Lublin University of Technology, Faculty of Electrical Engineering and Computer Science, Nadbystrzycka 38A, 20-618, Lublin, Poland*

Abstract. The aim of this paper was to determine the effect of using cobalt and titanium-based alloys as implant materials for the lumbar vertebrae with an artificial intervertebral disc on the stress distribution. The lumbar vertebrae were chosen for the study because they carry considerably higher loads, especially while standing or sitting. Finite element method (FEM) simulations were conducted for three standard loads reflecting three patient's positions: recumbent, standing and sitting. The FEM analysis was performed using the SolidWorks Simulation module. Artificial units containing a pair of vertebrae with a prosthesis between them were designed by the Solid Edge software, based on micro-computed tomography CT scans of the patient's spine. The implant model was designed with its shape based on the geometry of surrounding vertebrae, consisting of an upper pad, a bottom pad and an insert (intervertebral disc). Two implant material configurations were studied. One involved the use of titanium alloy for the upper and bottom pads, while in the other, these pads were made of cobalt alloy. In both cases, a polyethylene insert was used. The FEM results demonstrate that both material configurations meet the requirements for prosthesis design. In both material configurations, the maximum stresses in each prosthesis element are almost twice higher in a sitting posture than in a recumbent position.

* Corresponding author: r.karpinski@pollub.pl

Numerical analyses of adhesive-bonded joints in steel I-beams reinforced with CFRP strips

Maciej Kowal[1,*], Mateusz Hypki[2]

[1]*Lublin University of Technology, Faculty of Civil Engineering and Architecture, Poland*
[2]*Lublin University of Technology, Faculty of Civil Engineering and Architecture, Poland*

Abstract. Numerical analyses represent a useful structure-dimensioning tool and are indispensable for the analyses of structures featuring varied materials or complex geometric layouts. Modelling reinforced structures by gluing their elements is complicated as frequently at least two elements, made of different materials, are joined. This influences their behaviour under a load. Numerical analyses can provide invaluable support in this respect. To compare the laboratory test results obtained by the authors referring to reinforcing bent steel I-beams with adhesive-bonded composite-CFRP strips, and theoretical analyses (which are not the subject of this study), a preliminary FEM analysis was carried out. FEM analysis models were created with the same geometries and material parameters of the strengthening composite strip, the adhesive, and the reinforced I-beam, as in the laboratory tests. The distribution of stresses along the bond end, and their maximum values at the strip end, were specified in detail. ABAQUS®6.12-3 software was used to verify the results. The compliance of the FEM analysis with the laboratory measurements was confirmed in terms of the identified values and shearing-stress diagrams.

* Corresponding author: m.kowal@pollub.pl

Numerical analysis of the influence of particular autogyro parts on the aerodynamic forces

Zbigniew Czyż[1,*], Paweł Karpiński[1], Tomasz Łusiak[2], and Tomasz Szczepanik

[1]*Lublin University of Technology, Faculty of Mechanical Engineering, Department of Thermodynamics, Fluid Mechanics and Aviation Propulsion Systems, Nadbystrzycka 36 Str., 20-618 Lublin, Poland*
[2]*Polish Air Force Academy, Department of Airframe and Engine, 35 Dywizjonu 303 Str., 08-521 Dęblin, Poland*
[3]*Institute of Aviation, Aerodynamics Department, Krakowska 110/114, 02-256 Warsaw, Poland*

Abstract. This paper describes the research gyrocopter and presents the methodology of numerical calculations for this type of research objects. There are also the results of an ANSYS Fluent three-dimensional simulation of an airflow around a gyrocopter, excluding an airflow around its main rotor and propeller blades. The calculations enabled basic aerodynamic characteristics. The analysis of the numerical calculations focuses on the impact of gyrocopter individual sections like a fuselage, tail, tail boom, etc., on aerodynamic forces and moments, as well as coefficients of aerodynamic forces and moments. The research scope covers an angle of attack α ranging between -20° and 25° at a sideslip angle equal to 0.

* Corresponding author: z.czyz@pollub.pl

Numerical simulations of crashworthiness performance of multi-cell structures considering damage evolution criteria

Quirino Estrada[1*], Dariusz Szwedowicz[2], Alejandro Rodriguez-Mendez[3], Jesús Silva-Aceves[1], Javier S. Castro[1], Lara C. Wiebe[1], Elifalet Gonzalez[1], Julio Vergara-Vazquez[2] and Andrea E. Chavez[1]

[1]*Institute of Technology and Engineering, Autonomous University of Juarez City (UACJ), Ciudad Juárez, Chihuahua, México.*
[2]*Mechanical Engineering Department, National Centre for Research and Technological Development, Cuernavaca, Morelos, México.*
[3]*Department of Mechanical Engineering, University of California, Berkeley, CA 94720, USA.*

Abstract. In this paper finite element software Abaqus was used to analyse the effect of cross-sectional shape on the crashworthiness performance of multi-cell profiles. An emphasis was placed on the modelling of the damage initiation criteria and its evolution during the crash event. The structures evaluated included square and circular multi-cell cross-sections fabricated with aluminium alloy EN AW-7108 T6. During the crash simulations, the structures were subjected to axial impact loads using a 500-kg rigid body striker with an initial velocity of 10 m/s. Accordingly to our results, profiles with circular cross-section base presented better crashworthiness performance than square profiles. An increase in crush force efficiency to 36.9 % and specific energy to 35.4% was observed when a circular cross-section has been reinforced in the transversal and longitudinal directions. Finally, it was corroborated that the addition of the damage initiation criteria allowed for more reliable crash simulations of the structures.

* Corresponding author: quirino.estrada@uacj.mx

Open-end tube dynamic flow model with an oscillatory extortion

Tytus Tulwin[1,*], Monika Klimek[2], and Piotr Piech[2]

[1]*Lublin University of Technology, Mechanical Engineering Faculty, ul. Nadbystrzycka 36., 20-618 Lublin, Poland*
[2]*Medical University of Lublin, Department of Human Anatomy, al. Racławickie 1, 20-059 Lublin, Poland*

Abstract. This paper presents a derivation of dynamic 2d mathematical model for open end tube with oscillatory extortion in the region of the closed end. The aim the research is to investigate possible uses of the increased pressure in the enclosed tube chamber, especially for energy efficient lift generation. The mathematical model allows to test and predict how flow modifications impact the resultant lifting force. A derivation of the proposed mathematical model is shown. The mathematical model is then compared to the computational fluid dynamics discrete model. The results prove the accuracy of the mathematical physical model.

* Corresponding author: t.tulwin@pollub.pl

Optimisation of liquid flow in cavitation tunnel using CFD method

Robert Jasionowski[1,*], and Waldemar Kostrzewa[1]

[1]*Maritime University of Szczecin, Institute of Basic Technical Sciences, 2-4 Willowa Str., 71-650 Szczecin, Poland*

Abstract. Computational Fluid Dynamics CFD is a type of software using a numerical modelling (finite element methods and finite volume methods) based on Navier-Stokes equations. This approach allows determining distributions of pressure, velocity, temperature and other features of a flowing media. In the present work. CFD software was used to a development of three-dimensional model of a cavitation tunnel, used for an examination of cavitation resistance of structural materials, as well as to simulate a liquid flow through the tunnel. The simulation was carried out for various assumed flow rates, to determine an optimal value leading to a more extensive area of low pressure assisted by a cavitation phenomenon.

* Corresponding author: r.jasionowski@am.szczecin.pl

Selection of appropriate concrete model in numerical calculation

Krzysztof Śledziewski[1,*]

[1]*Lublin University of Technology, Faculty of Civil Engineering and Architecture, Department of Road and Bridges, Nadbystrzycka 40, 20-618 Lublin, Poland*

Abstract. Modelling of composite and reinforced concrete structures requires very precise determination of material parameters and constitutive relations between strain and stress. Erroneous selection of the dependencies and incorrect modelling, in particular, of the performance of concrete in tension may generate results in finite element method programs, that are far from the results obtained in an experiment. Using the example of a concrete damage plasticity model, based on fracture mechanics, this paper describes the physical interpretation and the method of the selection of parameters necessary for the appropriate modelling of concrete in a complex stress state. The correctness of the assumed description of concrete was verified on the basis of results of laboratory tests. A comparative analysis of the experimental and numerical results showed that the application of the concrete damage plasticity model allowed correct determination of the concrete element damage mechanisms for each level of strain.

* Corresponding author: k.sledziewski@pollub.pl

Stability of rectangular plates with notch using FEM

Katarzyna Falkowicz[1]

[1]*Faculty of Mechanical Engineering, Department of Machine Design and Mechatronics, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland*

Abstract. Buckling behaviour analysis of thin-walled composite plate under an axial compressive force is presented. The plate with central notch is made of a carbon-epoxy composite – a laminate consisting of eight symmetrically oriented plies. This paper addresses an influence of notch on buckling behaviour of laminated composite plates. In this analysis, FEM was applied to perform parametric studies on various plates based on stacking sequences, shape of notch, and its size. Buckling behaviour of laminated composite plates under an axial compression load is studied using ABAQUSS software.

* Corresponding author: k.falkowicz@pollub.pl

The analysis of distributions of effective strain and flow stress in longitudinal sections of cold backward extruded copper cans for different punch-face shapes

Tomasz Miłek[1,*]

[1]*Kielce University of Technology, Faculty of Mechatronics and Mechanical Engineering, Department of Applied Computer Science and Armament Engineering, al. Tysiąclecia Państwa Polskiego 7, 25-314 Kielce, Poland, UE*

Abstract. The paper presents computer modelling results of researches on cold backward extrusion of copper cans. The calculations were carried out using the commercial code QFORM-2D, based on the Finite Element Method (FEM). The simulation of cold backward extrusion process was performed for different punch-face shapes (flat; flat and conical with conical angle 90^0 and 150^0; as well as concave). On the basis of obtained results, the analysis of distributions of effective strain and flow stress in longitudinal sections of cold backward extruded copper cans was conducted.

* Corresponding author: tmatm@tu.kielce.pl

The design and structural analysis of the endoprosthesis of the shoulder joint

Robert Karpiński[1], Łukasz Jaworski[2], Jarosław Zubrzycki[1,*],

[1]*Lublin University of Technology, Faculty of Mechanical Engineering, Department of Machine Design and Mechatronics, Nadbystrzycka 36, 20-618, Lublin, Poland*

[2] *Poznan University of Technology, Faculty of Mechanical Engineering and Management, 60-965 Poznań, Poland*

Abstract. The shoulder joint is a crucial element of the upper limb and is necessary to maintain full mobility during daily activities. Similar as in the hip, it is an example of a ball and socket joint, enabling articulation between the head of the humerus and the glenoid cavity of the scapula. By studying kinematics of upper limbs, it is possible to distinct several possible movements in the shoulder joint. Due to many painful diseases and medical conditions, it may be crucial to perform a pain reducing procedure, like shoulder joint replacement. In order to preserve the function of the joint, the endoprosthesis should be designed exclusively for the patient. To assess a scale of damage in the joint or its specific structure, the shoulder was scanned using the computed tomography procedure. Results of the scan were processed with the use of Materialise Mimics software, which converts standard 2D images into 3D CAD models. Necessary analysis and measurements were taken leading to the beginning of the designing process. The prosthesis was created using Solid Edge software, developed especially for the purpose of rapid prototyping. After determining the physical properties of structural materials, the Finite Elements Analysis of the model was conducted using SolidWorks Simulation software under various load conditions

* Corresponding author: robert.karpinski@pollub.edu.pl

The dual-fuel CFD combustion model with direct and indirect CNG injection

Tytus Tulwin[1,*], and Rafał Sochaczewski[2]

[1]*Lublin University of Technology, Mechanical Engineering Faculty, ul. Nadbystrzycka 36, 20-618 Lublin, Poland*
[2]*Pope John Paul II State School of Higher Education, Department of Mechanical Engineering, ul. Sidorska 95/97, 21-500 Biala Podlaska, Poland*

Abstract. A proper design of the compression ignition engine fuel system requires various fuel injection methods analysis. Direct and indirect CNG injection process simulation research was conducted. The results allow a mixture homogeneity analysis and its impact on combustion process and heat transfer. For an indirect injection the injector is placed in intake channel and the injection is performed during an intake stroke. For a direct injection the specially designed injector is installed in the glow plug position. The analysed case is set for 20% energetic ratio of diesel fuel and 80% of methane fuel. In order to perform the calculations a special combustion model has been implemented that allows duel-fuel combustion in a compression ignition engine

* Corresponding author: t.tulwin@pollub.pl