BOOK OF ABSTRACTS

Editors

Zbigniew Czyż, Mirosław Szala, Monika Kulisz, Wojciech Cel, Katarzyna Falkowicz, Justyna Kujawska, Marcin Badurowicz, Jakub Pizoń

Polish Air Force University
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November 23rd-25th, 2023, Puławy, Poland

Book of Abstracts

Editors:
Zbigniew Czyż
Mirosław Szala
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Katarzyna Falkowicz
Justyna Kujawska
Marcin Badurowicz
Jakub Pizoń

Technical editor:
Zbigniew Czyż

Cover design:
Jakub Pizoń

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ABOUT THE CONFERENCE

The 8th International Conference of Computational Methods in Engineering Science (CMES'2023), held on 23-25 November 2023 in Puławy, Poland, is organized by the Polish Society for the Promotion of Knowledge, the Lublin University of Technology (Faculty of Mechanical Engineering, Faculty of Electrical Engineering and Computer Science, Faculty of Management, and Faculty of Environmental Engineering), and the Polish Air Force University (Faculty of Aviation).

This annual conference has been organized since 2016. This year's conference has attracted 100 participants, including foreign speakers and industry representatives.

The CMES'2023 conference helps develop engineering and numerical and experimental techniques and members of the scientific community and industry representatives can share their best practices and experience here. The conference addresses nine specialized topics:

- analysis of engineering processes,
- application of computer programs in technology,
- artificial and computational intelligence,
- Computational Fluid Dynamics (CFD),
- computer simulations of processes and phenomena,
- Finite Element Method (FEM),
- material properties and structure research methods,
- production engineering and quality control,
- technology management in energy acquisition processes.

The conference is an excellent opportunity to present and learn how computational methods can be applied in scientific disciplines like mechanical, materials, and civil engineering, management, environmental engineering, mining and energy, computer engineering, and innovative products launched by companies. The interdisciplinary nature of the conference facilitates knowledge sharing among Polish and foreign research centers that represent different engineering and technical sciences disciplines. This edition creates opportunities for plenary sessions and presentations of companies that solve engineering problems with modern computational methods and tools.

The conference highlights new trends in computational engineering methods and helps the conference attendees make their research and results more recognizable. The CMES' 2023 conference proceedings are published in the Journal of Physics: Conference Series, and selected full papers are submitted to:

- Advances in Science and Technology Research Journal (ASTRJ),
- Applied Computer Science (ACS),
- Advances in Materials Science (AMS).

For more information about the CMES'2023 conference, including CMES previous editions, visit the website: https://cmes.pl.

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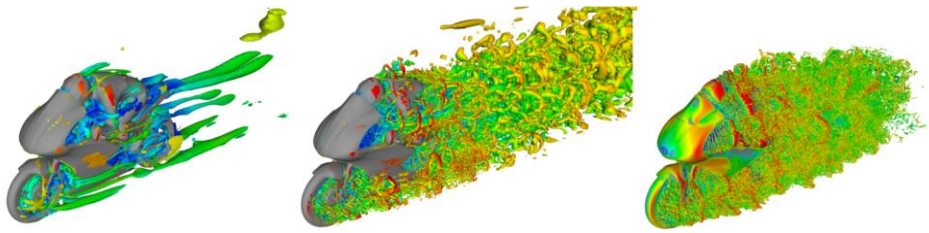
FUNDING

The project was supported by state budget funds granted by the Minister of Education and Science within the framework of the "Doskonała Nauka II" Program (Poland).

Plenary session – Thursday, November 23rd – 13:45

What do a vacuum cleaner, Hussarya and train travel have in common?

Adam **Piechna**, PhD
Symkom sp. z.o.o./Warsaw University of Technology



ABSTRACT

One of the earliest applications of Computational Fluid Dynamics (CFD) methods was external aerodynamics, which remains a fundamental branch of CFD applications to this day. This specific field has significantly contributed to the advancement of turbulence models and high-performance computing (HPC) technologies. The presentation showcases collaborative work conducted with Professor Janusz Piechna's team from the MEiL Department of Warsaw University of Technology, in partnership with the i-CFD group from the Mechatronics Department, the National Center for Nuclear Research, and Symkom company.

The presentation explores the utilization of flow modelling techniques to test various innovative aerodynamic solutions. First of all, the results of a modern implementation of the idea used by Jim Hall's in the legendary Chapparal 2J will be presented. Then, the participants will embark on a train trip, encountering the challenge of calibrating the new tunable GEKO turbulence model for the scenario of a high-speed train in crosswind. Finally, the results of high-performance computing simulations using Delayed Detached Eddy Simulation (DDES) models for student-class motorcycle aerodynamics will be presented. The simulation resolved more than 95% of the turbulence kinetic energy spectrum on a mesh comprising over 230 million elements.

The presentation raises a critical question: what is the trade-off between the accuracy of advanced turbulence models and their associated costs? Is it always

justifiable? The lecture concludes with a brief glimpse into the future, exploring the evolving landscape of CFD methods in both industry and scientific research.

SPEAKER BIOGRAPHY

Dr. Adam Piechna brings over fifteen years of expertise from his work at Symkom, where he is integrating ANSYS software solutions in both industry and Polish Universities. He has conducted more than 200 specialized training courses and is certified annually by ANSYS in technical support. He currently leads a technical team solving problems in fluid mechanics, mechanics, electromagnetism, and system modeling. He passes on his knowledge from his work in industry to students and applies it to scientific topics.

As an alumnus of Professor Krzysztof Cieslicki, Dr. Piechna's primary research focus lies in a biomedical engineering. As part of his doctoral dissertation, in a team with physicians from the Warsaw Medical University, he was involved in unique experimental and modeling studies of the strength of cerebral vessels and aneurysms. His current research endeavors delve into the domain of modeling cerebral blood flows. This includes exploring autoregulation mechanisms and employing computational fluid dynamics methods combined with medical imaging data to facilitate patient-specific blood flow modeling.

Beyond biomedical engineering, Dr. Piechna's scientific pursuits extend to vehicle aerodynamics and its modeling. He has participated in numerous projects, including the numerical simulations of the aerodynamics of the Polish Arrinera Hussarya supercar, the analysis of pressure wave propagation in the Warsaw subway, and the analysis of the effects of crosswinds on the train. He founded the i-CFD group, bringing together specialists in computational fluid dynamics.

Plenary session – Thursday, November 23rd – 16:50

Embracing the Future with Digital Mission Engineering (DME)

Przemysław **Turos**
Topologic Consulting

ABSTRACT

Now when digital transformation continues to revolutionize various sectors, the field of systems engineering remains no exception. The emergence of Digital Mission Engineering (DME) underscores the synergy of digital technology and mission-focused engineering, facilitating implementation of innovative solutions addressing complex challenges. DME is a discipline that has emerged in the defense and aerospace sectors, primarily as a response to the increasing complexity of modern mission systems and the need for rapid innovation. This presentation aims at introducing of the essence, significance, and applications of DME, exploring how it is reshaping the landscape of systems development, mission design, execution, and optimization.

At its core, DME represents a paradigm shift from traditional component-centric engineering to a holistic mission-centric approach. Leveraging the power of comprehensive digital modeling, simulation, and analysis, DME allows stakeholders to conceptualize, test, and refine systems within the digital realm before their real-world implementation. This not only ensures efficient resource allocation but also aids in the identification and mitigation of potential risks at early stages of undertakings.

A critical aspect of DME lies in its emphasis on 'reference missions'. These standardized scenarios serve as benchmarks, encapsulating specific operational challenges and environments. By simulating system performance within these reference missions, DME offers invaluable insights into system capabilities, vulnerabilities, and areas for enhancement. Such a mission-oriented approach ensures that systems are not just theoretically sound but are also optimized for real-world application.

One of the most profound advantages of DME is its capacity for integration. In an era where multi-domain operations are becoming the norm, the ability to ensure seamless integration across diverse systems is paramount. DME facilitates this by providing a unified digital platform where various systems can be cohesively modeled, ensuring harmonious interoperability.

The iterative nature of DME further sets it apart. As systems are modeled, simulated, and analyzed, feedback loops inform subsequent design and strategy iterations. This dynamic process, underpinned by DME, promotes continuous improvement, adaptability, and resilience.
Yet, as with all technological advancements, DME is not without its challenges. Data security, model accuracy, and the steep learning curve associated with sophisticated DME tools are areas of concern.
In conclusion, Digital Mission Engineering represents the confluence of digital prowess and mission-centric engineering. It offers a vision of the future where complex challenges are addressed through comprehensive digital models, ensuring that systems are not just designed for performance but also for mission success.

SPEAKER BIOGRAPHY

Przemysław Turos, graduated from Warsaw University, the Geography and Regional Studies Department. He completed postgraduate studies in Aviation Management at the National Defense Academy in Warsaw. He has wide, long term experience in Remote Sensing and Geographical Information Systems applications, data mining, processing and analysis, as well as in the field of Digital Mission Engineering.
Previously held the position of the Chief Operating Officer in GEOSYSTEMS Polska. Since 2016 runs Topologic Consulting, specialized in advisory and implementation in the field of aerial and satellite monitoring systems and data fusion in various domains. In 2019 the company become the Polish Agent of Analytical Graphics Inc., producer of DME solutions, currently part of Ansys Inc., a producer of engineering simulation software. Closely cooperates with Symkom Sp. z o.o. an Ansys Channel Partner in Poland as sub-distributor.

Plenary session – Thursday, November 23rd – 17:20

Non-destructive building moisture testing system based on electrical tomography and neural networks

Monika **Kulisz**, PhD
Department of Organisation of Enterprise, Management Faculty, Lublin University of Technology, Lublin, Poland

ABSTRACT

The presentation will introduce a non-destructive system for assessing building moisture using electrical tomography combined with neural networks. Recognizing that traditional destructive approaches are not suitable for historically significant structures, we've adopted a non-invasive technique via electrical tomography. A hybrid tomograph equipped with specialized sensors was created for this purpose. This device captures data that is then reconstructed using advanced methods, allowing detailed spatial analysis of wet buildings. To convert electrical measurements into reconstructed 3D images, we used a neural network with an LSTM layer. This network converts input electrical values into conductance values represented by the pixels of the resulting image. From these conductance values, we can generate images of the interior of building walls, both in 2D slices and in 3D visualizations. The algorithm presented here has significant practical potential. Key advantages of this novel approach include precise imaging, cost-effectiveness, rapid data processing, and adaptability to walls of varying thickness and irregularity.

SPEAKER BIOGRAPHY

Dr. Monika Kulisz is a highly regarded academic and researcher, presently holding the position of Assistant Professor within the Department of Enterprise Organization at Lublin University of Technology. In September 2016, she attained her Doctor of Philosophy degree in the field of mechanical engineering and operations. Dr. Kulisz's scholarly contributions are substantial, reflecting her active involvement in a variety of projects that showcase her expertise in domains such as neural networks, applied mathematics, and complex systems design. Notably, she served as the project manager for a National Science Center project spanning from 2021 to 2022, with a primary focus on magnesium alloy research. Her engagement with the academic community is evident through her ongoing participation in numerous national scientific conferences, where she has served as a committee member. Her role as a co-organizer of the International Conference of Computational Methods in Engineering Science (CMES) since 2016 is of particular significance. Dr. Kulisz is an active member of several professional associations, including the Polish Society of Production Management. Her scholarly output also encompasses the authorship of 21 expert reports and opinions pertaining to innovation within the production and service domains. In

recent years, her research has encompassed the modeling and prediction of phenomena and processes, employing artificial neural networks in contexts where such methodologies are less commonly employed, including quality management in production, analysis, and prediction within manufacturing processes, as well as environmental engineering.

Plenary session – Friday, November 24th – 9:00

Laser micro-texturing as a key technology for development of a new TBCs generation – a numerical and experimental approach

Leszek **Łatka**, PhD, DSc
Department of Metal Forming, Welding and Metrology, Faculty of Mechanical Engineering, Wroclaw University of Science and Technology, Wroclaw, Poland

ABSTRACT

The presented works consider the possibility of the tailoring the columnar microstructure of the top coat in the thermal barrier coating (TBC) system. The main idea of these investigations is using the micro-texturing of the bond coat in order to improve the columns growth. In the first stage of the laser treatment, the numerical analysis were carried out. The 2D axisymmetric time-dependent CFD model was used in the Ansys Fluent 2020/R1 package. Secondly, the series of the experiment were done in order to confirm results from numerical analysis as well as the assistance of the shadowing effect phenomenon. The feedstock material was ZrO2 + 8wt.% Y2O3 (YSZ) and the deposition process was suspension plasma spraying (SPS). The trajectories of the droplets and particles were numerically investigated in the boundary layer of the substrate after micro-texturing treatment. It makes possible to predict the coating material behaviour in the closest proximity of the substrate as well as understand the build-up mechanism of the columnar-like coatings.

SPEAKER BIOGRAPHY

Prof. Leszek Łatka is working at Wroclaw University of Science and Technology in the Department of Metal Forming, Welding and Metrology. He is a graduate of the Faculty of Mechanical Engineering in 2007. After working in the industry, he continued education under Polish - French PhD studies supervised by the French Embassy in Poland. During PhD studies, he has spent several months in various universities or laboratories, mainly in France (Limoges and Lille) and Belgium (Mons). He has received a double PhD title in 2012 (by the Wroclaw University of Science and Technology and by the Lille University of Science and Technology). After PhD defense, he continued his research and started to create his own research group and co-worked with laboratories in Poland (among others: Silesian University of Technology, Lublin University of Technology, Centre of Polymer and Carbon Materials, Polish Academy of Sciences, Gdańsk University of Technology) and abroad (IWS Dresden Fraunhofer Institute, Institute of Plasma

Physics in Prague, University West in Trollhattan). Since 2020 he is an associate professor. His research interests are focused mainly on liquid feedstock thermal spraying, development of welding and hardfacing, as well as novel routes for powders manufacturing for thermal spraying and additive manufacturing. Since 2015 he is co-organizer International Thermal Spraying and Hardfacing Conference, which is 3-years cyclic event in Wrocław.

Plenary session – Friday, November 24th – 9:45

Industry 4.0 - How the CosmoEye system meets the needs of manufacturing companies

Wojciech **Danilczuk,** PhD
CosmoEye, Product Owner/Project Manager

ABSTRACT

The presentation outlines CosmoEye's approach to implementing Industry 4.0 solutions. It discusses the high-level architecture of the CosmoEye System, issues related to the use of artificial intelligence in image analysis and the most common problems and needs related to Industry 4.0 reported by industrial companies. CosmoEye AI System controls the enterprise in real time. Based on specify type incident, which customer what to detect, dedicated neural network is developed. How CosmoEye system works? The image from the cameras of the surveillance system, is directed to a local server, where internal mechanisms stream it to an artificial intelligence engine and save the recordings. Using neural networks, we analyze the image and detect established patterns. Information about the found events goes to the external server. The customer receives notifications about them and he can watch the key moments that the camera recorded. CosmoEye system can work with CCVT cameras and thermal imaging camera. The typical usage of CosmoEye system in area of Industry 4.0 are:

- detection of occupational health and safety incidents,
- detection of violations of prohibited zones,
- visual documentation of packaging processes combined with OCR analysis of courier labels,
- visual documentation of production processes,
- prediction of machine failures based on thermal imaging cameras,
- integration with WMS, ERP, B2B/B2C systems,
- counting OEE and performance indicators, etc.

SPEAKER BIOGRAPHY

Wojciech Danilczuk is an engineer who realises the needs of industry using information systems. In his career, he has worked his way up from assembler, through automation, business consultant to Product Owner. On a day-to-day basis, he supports industrial companies in the layout of processes and

implementation of IT systems in the ERP, WMS, CRM class and based on artificial intelligence algorithms.
Parallel to his professional career, he is researching and developing his scientific career. His academic achievements culminate in a PhD in the discipline of mechanical engineering.

Plenary session – Friday, November 24th – 9:45

Digital – precision and intelligent agricultural machinery and equipment as a response to climate challenges

Łukasz **Kopiński**, PhD
Ribes Technologies Sp. z o.o., CEO

ABSTRACT

Digital Farming, or Agriculture 4.0, refers to a systems technology that complements existing methods with four further main elements: Internet of Things (IoT) or machine-to-machine (M2M) communication; cloud computing; big data analytics and artificial intelligence (AI); and robotisation using mobile and stationary units. Supporting agricultural production technology 4.0 (including orcharding 4.0) is one of the major challenges for machinery and equipment manufacturers. Startup Ribes Technologies Sp. z o.o. will present, as a case study, its solution proposal in the area of machinery and equipment for agriculture 4.0 as well as 5.0.

SPEAKER BIOGRAPHY

Łukasz Kopiński – scientist, entrepreneur and farmer. CEO at startup Ribes Technologies Sp. z o.o. (R&D), creating technology for agriculture 4.0 and 5.0. Leader of the five-party consortium "Fruits 4.0" within the Operational Group implementing the "Cooperation" project. Researcher at the University of Life Sciences in Lublin, formerly researcher at the H. Kołątaj Agricultural University in Kraków, PhD at the Cracow University of Economics. Member of the Polish Precision Farming Cluster based in Lublin and the National Bioeconomy Hub in Puławy. Owner of a family orchard farm.

ABSTRACTS

ANALYSIS OF ENGINEERING PROCESSES

Estimating the size of a crater after an underwater explosion

Radosław Kiciński, Fundamentals of Ship Machinery Construction Department, Mechanical and Electrical Engineering Faculty, Polish Naval Academy in Gdynia, Smidowicza 69, 81-127 Gdynia, Poland, r.kicinski@amw.gdynia.pl

Abstract: There have been terrorist attacks in the Baltic region that used explosives to destroy underwater infrastructure, including the Nord Stream 1 and 2 gas pipelines. Data from the Danish National Seismic Network indicate that two explosions occurred on September 26, 2022, causing gas leaks from pipelines. While examining the data from September 26, two disturbing events were observed in the Baltic Sea, which caused tremors of magnitude 2.3 and 2.1 on the Richter scale. Both events had high wave energy, indicating an explosion, not an earthquake. Based on the above data, it was decided to analyze the potential effects of underwater explosions in the area of the Nord Stream gas pipelines. From the point of view of ecology, the volume of material torn up from the bottom is essential. Therefore determining the volume of the crater after the explosion is crucial. For this purpose, empirical formulas for explosions on land were used, and then the crater's size was estimated per the physics of the underwater explosion phenomenon. Calculations indicate that the explosion of 750 kg of TNT will raise about 20 m^3 of the bottom volume into the water column. Because of the explosion, a gas bubble will form directly at the bottom, and it will suck the sand and the impurities contained in it and particles of dead organisms, bringing them to the surface and dispersing them in the water column. These attacks pose a serious environmental and safety risk as gas leaks from pipelines can cause harmful effects on marine ecosystems and people. It also violates international law and international agreements, including the United Nations Convention on the Law of the Sea and the Convention on the Protection of the Marine Environment in the Baltic Sea Region.

Keywords: terrorist attacks, Baltic Sea, Nord Stream, underwater explosions, seismic measurements, detonation crater, TNT, environmental impact.

The influence of light Intensity on the operation of vision system in collaborative robot

Adrian Bochen, Lublin University of Technology, adrian.bochen@pollub.edu.pl

Bartłomiej Ambrożkiewicz, Lublin University of Technology, b.ambrozkiewicz@pollub.pl

Abstract: Human-robot collaboration can be a powerful tool for increasing productivity in production systems by combining the strengths of humans and robots. Assembly operations, in particular, have shown great potential for utilizing the unique abilities of both parties. However, for robots to efficiently perform assembly tasks, components and parts must be presented in a known location and orientation, which is achieved through a process called parts feeding. Traditional automation methods for parts feeding, such as vibratory bowl feeders, are limited in their ability to accommodate variations in parts design, shape, location, and orientation, making them less flexible for use in human-robot collaboration. Recent advancements in machine vision technology have opened up new possibilities for flexible feeding systems in human-robot assembly cells. This paper explores the application of vision system in collaborative robot ABB Yumi and its ability in objects detection. In this case the characteristic of vision system was determined experimentally by changing the light intensity on the test rig. The system was validated, if the angle of incidence of light affects the stability of the vision system. The results of the study demonstrate the efficiency of vision system in collaborative robot and provide insights into its industrial application.

Keywords: collaborative robot; vision system, ABB Yumi, robotics.

The influence of the laser cutting process parameters on the quality of the cut edge

Leszek Łatka, Department of Metal Forming, Welding and Metrology, Faculty of Mechanical Engineering, Wroclaw University of Science and Technology, leszek.latka@pwr.edu.pl

Ewa Jonda, Department of Engineering Materials and Biomaterials, Silesian University of Technology, ewa.jonda@polsl.pl

Tomasz Kiełczawa, Department of Metal Forming, Welding and Metrology, Faculty of Mechanical Engineering, Wroclaw University of Science and Technology, tomasz.kielczawa@pwr.edu.pl

Abstract: The article describes the influence of the parameters of laser cutting on the cut edge quality of 10 mm S355J2 structural steel. The cutting process was carried out with a fiber laser. The basic evaluation criteria were measurements of perpendicularity tolerance, average profile height of roughness Rz5, visual evaluation, and measurements of hardness HV10. Moreover, the factorial regression models were prepared to investigate the standardized effects of the process parameters on the cutting quality. The variable process parameters were laser beam power, cutting velocity and working gas pressure. For regression modeling, low and high levels ofthese factors were considered representing the effective range of each parameter. The research presented in this paper proves that there are statistical correlations between the examined factors that have a significant impact on the achieved cutting effect. By the analysis of the process control parameters, it is possible to achieve an optimal level of quality that facilitates further technological operations on a given cutting product.

Keywords: laser cutting, surface quality, hardness, roughness, factorial regression, Pareto diagram.

Analysis of the potential for reducing the energy consumption of a vegetable sprouts production using Flownex Simulation Software

Klaudia Słomczyńska, Faculty of Infrastructure and Environment, Czestochowa University of Technology, klaudia.zolinska@pcz.pl

Paweł Mirek, Faculty of Infrastructure and Environment, Czestochowa University of Technology, pawel.mirek@pcz.pl

Marcin Panowski, Faculty of Infrastructure and Environment, Czestochowa University of Technology, marcin.panowski@pcz.pl

Abstract: Using the waste energy generated in any production process is one way of increasing energy efficiency. In the industrial cultivation of vegetable sprouts for food purposes, significant amounts of low-temperature waste heat are released, the source of which is the metabolic processes taking place inside the seeds. In typical installations, this energy is lost to the environment, while it could be used, for example, to heating the water used to irrigate the plants. This paper presents a method of utilizing waste heat generated during the germination process of seeds using plate heat exchangers and analyses the potential for reducing the energy consumption of installations for vegetable sprout production. For this purpose, transient simulations were conducted using a developed simulation model of the technological line in Flownex Simulation Environment. In order to formulate a reliable simulation model, relevant device parameters and process data were collected. After building the model and calibrating it appropriately, an analysis of the variability of the values of all process parameters was performed, and the potential for recovering waste heat was determined. The results obtained from numerical modelling were verified against the results obtained from the production line. The amount of recoverable waste heat in the entire production cycle amounted to about 5 GJ.

Keywords: industrial waste heat recovery, low-temperature waste heat, transient simulation.

Analysis of the applicability of thermal imaging measurements for early detection of arteriovenous malformations

Magdalena Matysiak, Lublin University of Technology, m.marchewka@pollub.pl

Jarosław Zubrzycki, Lublin University of Technology, j.zubrzycki@pollub.pl

Magdalena Przybylska-Fronc, Lublin University of Technology, magdalena.przybylska@pollub.edu.pl

Abstract: The demand for thermal imaging today is of high quality, both in the complementary examination at X-ray, tomography, mammography and ultrasound, as well as in the study of the detection of product, piping, and insulation and the survey during the detection of heat loss from a building - the more profound the temperature range of thermal imaging equipment, the greater can be its application in various industries, with a properly selected range of delivery of results. Interpretation of the information received could be more helpful. It does not require specialised knowledge, which affects the effects of the application of this technique, and the benefits to determine the continued development of this type of equipment. Accurate methods are non-contact measurements of the sending infrared test, which emits any body with a temperature higher than 0 K and non-invasiveness of the test. This work applies the use of thermography in medicine. The rationale between selected pathologies and the test method used was demonstrated. The activities carried out with thermograms were distinguished. Examples of thermograms at exact temperatures were presented. The final part summarises how thermography can identify selected pathologies. It turned out that thermograms with selected abnormalities and lesions were created with thermograms of healthy patients.

Keywords: thermovision, thermal imaging, medical imaging.

Research on the distribution of axial excitation of mobile overpressure fans in the aspect of stability safety of the load-bearing frame

Bartosz Wieczorek, Institute of Machine Design, Faculty of Mechanical Engineering, Poznan University of Technology, Piotrowo 3, 60-965 Poznań, Poland, bartosz.wieczorek@put.poznan.pl

Piotr Kaczmarzyk, Institute of Machine Design, Faculty of Mechanical Engineering, Poznan University of Technology, Piotrowo 3, 60-965 Poznań, Poland/ Scientific and Research Centre for Fire Protection, National Research Institute, Nadwiślańska 213, 05-420 Józefów, Poland, pkaczmarzyk@cnbop.pl

Łukasz Warguła, Institute of Machine Design, Faculty of Mechanical Engineering, Poznan University of Technology, Piotrowo 3, 60-965 Poznań, Poland, lukasz.wargula@put.poznan.pl

Marcin Giedrowicz, Institute of Architecture and Spatial Planning, Poznan University of Technology, Piotrowo 3, 60-965 Poznań, Poland, marcin.giedrowicz@put.poznan.pl

Damian Bąk, Scientific and Research Centre for Fire Protection, National Research Institute, Nadwiślańska 213, 05-420 Józefów, Poland, dkbak@cnbop.pl

Łukasz Gierz, Institute of Machine Design, Faculty of Mechanical Engineering, Poznan University of Technology, Piotrowo 3, 60-965 Poznań, Poland, lukasz.gierz@put.poznan.pl

Grigor Stambolov, Technical University of Sofia, Kliment Ohridski 8, 1756 Studentski Kompleks, Sofia, Bulgaria, gstamb@gmail.com

Boris Kostov, Angel Kanchev University of Rousse, Studentska 8, 7017 Studentski grad, Ruse, Bulgaria, bkostov@uni-ruse.bg

Abstract: Positive pressure ventilators are exposed to self-shifting during their operation. The aim of the article was to perform research analysing dynamic excitations resulting from vibrations caused by the operation of the drive system. The tests included four different fans, including one with an electric drive. The tests carried out made it possible to determine the effective RMS R value of vibrations, which is a maximum of 0.970 G, and the direction of the excitation relative to the vertical and horizontal axes. In addition, the values of vibration amplitudes on individual axes of the adopted reference system were determined. In this case, the highest values were measured on the vertical axes for combustion-powered ventilators (vibration value from 20 to 35 m/s^2) and in the axis along the fan rotor for electric-powered ventilators (vibration value from 1.1 m/s^2).

Keywords: positive pressure ventilators, rescue operation, machine vibration, vibration of internal combustion engine, vibration of electric drive, occupational safety.

An application of orifice hydrodynamic cavitation reactor for tertiary treatment of wastewater treatment plant effluents

Aleksandra Szaja, Faculty of Environmental Engineering, Lublin University of Technology, a.szaja@pollub.pl

Agnieszka Montusiewicz, Faculty of Environmental Engineering, Lublin University of Technology, a.montusiewicz@pollub.pl

Magdalena Lebiocka, Faculty of Environmental Engineering, Lublin University of Technology, m.lebiocka@pollub.pl

Jan Skrzypiec, Faculty of Environmental Engineering, Lublin University of Technology, jan.skrzypiec@pollub.edu.pl

Abstract: In this paper, a multi-orifice hydrodynamic cavitator (HC) has been applied as an effective device for water reclamation. Municipal wastewater after mechanical and biological treatment has been applied as a medium. The effectiveness of using this device has been evaluated on the basis on the microbiological indicators. Moreover, optimization of operating parameters was evaluated. Two experiments with different inlet pressure of 0.4 and 0.6 MPa were performed. The samples for analyses were taken at the following time intervals: 0, 15, 30, 60 and 90 min. The application of HC reactor provided the effective destruction of microorganisms, thus allowing for subsequent use of reclaimed water. With regard to Escherichia coli and Coliform bacteria destruction, the longest time of 90 min and higher pressure of 0.6 MPa might be considered as the most advantageous conditions to perform cavitation. In both cases, the microbes were deactivated in over 50%. In the case of Enterococci, Pseudomonas aeruginosa and colony count, more beneficial results were found at lower pressure of 0.4 MPa and 90 min. Therein, the high level of microorganisms destruction was achieved varied between 81 and 92%. The applied HC allowed for selecting optimal operating parameters and process control through the application of gauge system.

Keywords: hydrodynamic cavitation, cavitation number, municipal wastewater, water reuse, optimization of cavitational parameters.

Comparison of software development solution implementations in Lightning Flow Builder and Apex programming language in Salesforce technology

Michał Grabowski, Lublin University of Technology,
michal.grabowski1@pollub.edu.pl

Małgorzata Plechawska-Wójcik, Lublin University of Technology,
m.plechawska@pollub.pl

Abstract: The rapid development of the Salesforce platform in recent years has induced an expansion of no-code solutions to make automation available for less technical audience. This study examines similarities and differences between Apex programming and one of the no-code solutions on the Salesforce platform, Flow Builder. The research includes the implementation of the same applications in Apex language and using Flow Builder, comparing the time of work to fulfill the requirements (first part) and the time of execution of both applications (second part). The applications were divided into two regarding the complexity of the solution: simple and intermediate, so that the research would thoroughly verify the impact of the amount of code and the simplification of programming concepts that Flow Builder allows. In the first part of the research, for the majority of the developers, who took part in the research, the implementation of Apex simple application was much quicker than using Flow Builder. The intermediate application needed much more Apex code and made use of concepts like bulkification of records which are automated in Flow Builder, so it was much easier to develop the second application in Flow Builder than using Apex. In the second part of the research, which included an execution time comparison of both Apex and Flow Builder applications, the results uncovered the impact of Flow Builder "behind the scenes" automation which were the root cause of its more complex solutions slowdown.

Keywords: Salesforce, Apex, flows, no-code solutions.

Implementation of Type-2 Fuzzy Controller in Matlab Software

Ireneusz Dominik, Faculty of Mechanical Engineering and Robotics, Department of Process Control, AGH University of Krakow, al. Mickiewicza 30, 30-059 Kraków, Poland, dominik@agh.edu.pl

Stanisław Flaga, Faculty of Mechanical Engineering and Robotics, Department of Process Control, AGH University of Krakow, al. Mickiewicza 30, 30-059 Kraków, Poland, stanislaw.flaga@agh.edu.pl

Abstract: The purpose of this work is to create a Matlab toolbox that makes it easy and accessible to get acquainted with a novel control method called type-2 fuzzy controller. A toolbox for working with type-1 controllers can be found in the Simulink package, while there is only few, simple toolboxes for type-2 fuzzy controllers. The article describes the details of the created software, which allows you to work both with simulation objects, but also enables you to create program code for an PLC industrial controller. This gives you the opportunity to work in a simulation environment with a model of the control object and then, after tuning the controller, to automatically implement the controller to control the real object. In the literature, you can find many methods for reducing type-2 to type-1 fuzzy logic, but most often they are compared to several well-known classical reduction methods, such as the KM algorithm. There is no compilation of the most popular methods and a comparison of their performance. With the new toolbox it was possible to quickly create and add new reduction methods so in the article an analysis of 16 reduction methods is also presented.

Keywords: Matlabtype-2 fuzzy controllertoolboxreduction types.

The impact of applying universal design principles on the usability of online accommodation booking websites

Katarzyna Kurek, Lublin University of Technology, katarzyna.kurek@pollub.edu.pl

Maria Skublewska-Paszkowska, Lublin University of Technology, maria.paszkowska@pollub.pl

Mariusz Dzienkowski, Lublin University of Technology, m.dzienkowski@pollub.pl

Pawel Powroznik, Lublin University of Technology, p.powroznik@pollub.pl

Abstract: One of the concepts of human-computer interaction is the usability of websites, consisting of features such as efficiency, satisfaction, memorability, and learnability. Usability is particularly important in the case of websites that the user is expected to learn on their own. The main aim of this study was to evaluate the usability of user interfaces of websites and, based on this, to find how this evaluation is affected by the application of universal design principles. The object of the study was two websites, one complying with the principles of universal design - created for the purpose of the study, and the other – an existing commercial website operating in the market, which does not follow these principles. Three hypotheses were defined: 1) effectiveness and efficiency of analyzed websites were higher for a service that followed the principles of universal design than a website that did not comply with these rules; 2) the quality of the user interface was greater for the service fulfilling the principles of universal design; 3) the satisfaction with the interaction with the interface was greater in case of websites conformed to the principles of universal design. The study used two methods: eye tracking and questionnaires. The experiment involved 10 participants who had to perform a scenario consisting of 10 instructions that involved locating various elements in each of the tested GUI interfaces. The eye activity was recorded using a Gazepoint GP3 HD desktop eye tracker, which made it possible to determine the effectiveness and efficiency values of using the analyzed interfaces. Each participant was also asked to fill out two questionnaires: the Lublin University of Technology one and the Questionnaire for User Interaction Satisfaction. The study proved the truth of the hypotheses, that is, the positive impact of universal design on the usability evaluation of user interfaces.

Keywords: accessibility, usability, universal design, eye tracking, WCAG.

Prediction tools as an element aiding decission processes at an airport – The case of Facebook Prophet library

Sylwester Korga, Lublin University of Technology, s.korga@pollub.pl

Kamil Żyła, Lublin University of Technology, k.zyla@pollub.pl

Jerzy Józwik, Lublin University of Technology, j.jozwik@pollub.pl

Jarosław Pytka, Lublin University of Technology, j.pytka@pollub.pl

Kamil Cybul, Lublin University of Technology, k.cybul@pollub.pl

Abstract: Prophet is a quite fresh and promising open-source library for machine learning, developed by Facebook, that gains some significant interest. It could be used for predicting time series taking into account holidays and seasonality effects. Its possible applications and deficit of scientific works concerning its usage within decision processes convinced the authors to state the research question, if the Prophet library could provide reliable prediction data for the purpose of aiding decision processes at an airport. The case of Radawiec airport (located near Lublin, Poland) was chosen. Official measurement data (from the last 4 years) published by the Polish Governmental Institute was used to train the neural network and predict average daily wind speed, average daily temperature, mean daily pressure, average daily relative humidity, mean daily pressure, total precipitation during the day and night. It was revealed that most of the predicted data points were within the acceptance threshold, computations were fast and highly automated. Although the authors find the Prophet library not especially useful in relation to decision making processes at an airport as the way of handling additional regressors and vulnerability for unexpected phenomena negatively influence the reliability of prediction outcomes.

Keywords: weather prediction; Facebook Prophet; aviation; machine learning; data analysis.

Accessibility assessment of visual programming tools for novice programmers - The case of App Inventor, Scratch and StarLogo

Kamil Żyła, Lublin University of Technology, k.zyla@pollub.pl

Kinga Chwaleba, Lublin University of Technology, kinga.chwaleba@pollub.edu.pl

Dominik Choma, Lublin University of Technology, dominik.choma@pollub.edu.pl

Abstract: The current state of the labor market requires modern engineers to acquire programming skills on different levels of advancement and to apply them in multidisciplinary environments. Not all of modern engineers will become full-fledged programmers, but sometimes the possibility to use low-code programming environments like LabView or MIT App Inventor will be sufficient. In order to give good foundations in adulthood, schools use elements of visual programming, e.g. Scratch or StarLogo to enhance critical and algorithmic thinking of future engineers. This article attempts to answer the question whether anyone cares about following general accessibility and usability guidelines in the case of solutions like Scratch, App Inventor and StarLogo. Another goal is to show a set of tools that is successful in such assessment. The authors used Nielsen's heuristics, followed by analysing WAVE output and Web Content Accessibility Guidelines compliance. Especially the last one provides insights usually omitted when evaluating low-code environments. It was found that Scratch and App Inventor are leading solutions in terms of look and feel, functionality, documentation, interface navigation and memorization. The StarLogo interface, on the other hand, is less friendly in terms of aesthetics and functionality.

Keywords: visual programming, accessibility assessment, App Inventor, Scratch, StarLogo.

REDUCE: A Python module for reducing inconsistency in multiplicative pairwise comparisons

Paweł Kuraś, Department of Complex Systems, The Faculty of Electrical and Computer Engineering, Rzeszow University of Technology, ul. MC Skłodowskiej 8, 35-036 Rzeszów, Poland, p.kuras@prz.edu.pl

Dominik Strzałka, Department of Complex Systems, The Faculty of Electrical and Computer Engineering, Rzeszow University of Technology, ul. MC Skłodowskiej 8, 35-036 Rzeszów, Poland, strzalka@prz.edu.pl

Bartosz Kowal, Department of Complex Systems, The Faculty of Electrical and Computer Engineering, Rzeszow University of Technology, ul. MC Skłodowskiej 8, 35-036 Rzeszów, Poland, b.kowal@prz.edu.pl

Jiří Mazurek, School of Business Administration in Karvina, Silesian University in Opava, Univerzitní nám. 1934, Fryštát, 733 40 Karviná, Czech Republic, mazurek@opf.slu.cz

Abstract: This paper introduces REDUCE, a Python module designed to minimize inconsistency in multiplicative pairwise comparisons (PC), a fundamental technique in Multi-Criteria Decision Making (MCDM). Pairwise comparisons are extensively used in various fields, including engineering science and numerical simulation methods, to compare different options based on a set of criteria. However, human errors in perception and judgment often lead to inconsistencies in pairwise comparison matrices (PCM). REDUCE addresses this issue by implementing several algorithms that identify and correct inaccurate data in PCMs, thereby reducing the inconsistency ratio. These algorithms do not require expert intervention, making REDUCE a valuable tool for both scientific research and small to medium enterprises that may not have access to costly commercial software or dedicated decision-making experts. The main functionality of the module is incorporating iterative algorithms for inconsistency reduction. The REDUCE library, written in Python and utilizing auxiliary libraries such as NumPy, SciPy, and SymPy, offers 21 functions categorized into data input helpers, consistency ratio (CR) reduction algorithms, PCM indexes, and support functions. Performance testing indicates that the library can efficiently handle matrices of varying sizes, particularly those ranging from 3x3 to 10x10, and its use significantly accelerates the process compared to spreadsheets, especially when dealing with large quantities of matrices. The library has already been used in several research papers and application tools, and its availability as a free resource opens up opportunities for small and medium-sized enterprises to leverage multi-criteria decision-making methods. Currently, there are no publicly available libraries for this solution. The authors believe that the proposed module may contribute to do better decision-making process in pairwise comparisons, not only for the circle of scientists but also for small and medium enterprises that usually cannot afford expensive commercial software and do not employ full-time experts in decision-making as they rely on the experience of their employees and free online resources. It should also contributes to the transition to Industry 4.0 and advances research in fields such as fuzzy logic, preference programming, and constructive consistent approximations.

Keywords: inconsistencydecision making supportpairwise comparison sinconsistency indexinconsistency reduction

A comparative analysis of image segmentation using classical and deep learning approach

Arsen Plaksyvyi, Department of Computer Science, Lublin University of Technology, arsen.plaksyvyi@pollub.edu.pl

Maria Skublewska-Paszkowska, Department of Computer Science, Lublin University of Technology, maria.paszkowska@pollub.pl

Pawel Powroznik, Department of Computer Science, Lublin University of Technology, p.powroznik@pollub.pl

Abstract: Segmentation is one of the image processing techniques, widely used in computer vision, to extract various types of information represented as objects or areas of interest. The development of neural networks has influenced image processing techniques, including creation of new ways of image segmentation. The aim of this study is to compare classical algorithms and deep learning methods in RGB image segmentation tasks. Two hypotheses were put forward: 1) "The quality of segmentation applying deep learning methods is higher than using classical methods for RGB images, and 2) The resolution of the RGB image affects the segmentation quality. Two traditional segmentation algorithms (thresholding and k-means) were compared with deep learning approach (U-Net, SegNet and FCN 8) to verify RGB segmentation quality. Two resolutions of images were taken into consideration: 160x240 pixels and 320x480 pixels. Segmentation quality for each algorithm was estimated based on four parameters: accuracy, precision, recall and Sorensen-Dice ratio (Dice score). In the study the Carvana dataset, containing 5,088 high-resolution images of cars, was applied. The initial set was divided into training, validation and test subsets 3056/1024/1008, respectively. As a result, average accuracy was obtained ranging from 69.05% to 99.42% depending on the applied segmentation method and used image resolution. The results confirm the first hypothesis, while the second one is confirmed only for methods using deep learning networks and rejected for classical algorithms.

Keywords: image segmentation, U-Net, SegNet, FCN 8, thresholding, k-means.

Dual attention graph convolutional neural network to support mocap data animation

Maria Skublewska-Paszkowska, Department of Computer Science, Lublin University of Technology, maria.paszkowska@pollub.pl

Pawel Powroznik, Department of Computer Science, Lublin University of Technology, p.powroznik@pollub.pl

Marcin Barszcz, Department of Computer Science, Lublin University of Technology, m.barszcz@pollub.pl

Krzysztof Dziedzic, Department of Computer Science, Lublin University of Technology, k.dziedzic@pollub.pl

Abstract: Human Action Recognition is a challenging task used in many applications. It interacts with many aspects of computer vision, machine learning, deep learning and image processing in order to understand human behaviours as well as identify them. Among various applications of computer animation, the analysis of recorded movements can be mentioned. Sophisticated motion capture techniques allow to acquire motion and store it in a digital form for further analysis. The combination of these two aspects of computer vision enables the presentation of data in an accessible way for the user.

The main aim of this study is to propose a system for animation of tennis motion capture data involving pattern recognition as well as 3D modeling. A new classifier, the Dual Attention Graph Convolutional Network, was created. Its unique approach consists of two attention modules, one for body analysis and the other for tennis racket alignment. The input to the classifier is a sequence of images generated from the Mocap data and containing an object of a player holding a tennis racket and presenting basic tennis strokes. Tennis forehand, backhand, volley forehand and volley backhand are classified with great success, reaching a maximum accuracy over 95%.

The recognized movements are further processed using MotionBuilder. Movement sequences are assigned to the tennis player's 3D digital model. In this way, realistic character animations are obtained, reflecting the recognised moves that can be further applied in movies, video games and other visual projects.

Keywords: Tennis strokes pattern recognition, Dual Attention Graph Convolutional Neural Network, computer modelling.

Efficiency comparison of networks in handwritten Latin characters recognition with diacritics

Edyta Łukasik, Lublin University of Technology, e.lukasik@pollub.pl

Wiktor Flis, Lublin University of Technology, wiktor.flis@pollub.edu.pl

Abstract: The aim of the article is to analyze and compare the performance and accuracy of architectures with a different number of parameters on the example of a set of handwritten Latin characters from the Polish Handwritten Characters Database (PHCD). It is a database of handwriting scans containing letters of the Latin alphabet as well as diacritics characteristic of the Polish language. Each class in the PHCD dataset contains 6,000 scans for each character. The research was carried out on six proposed architectures and compared with the architecture from the literature. Each of the models was trained for 50 epochs, and then the accuracy of prediction was measured on a separate test set. The experiment thus constructed was repeated 20 times for each model. Accuracy, number of parameters and number of floating-point operations performed by the network were compared. The research was conducted on subsets such as uppercase letters, lowercase letters, lowercase letters with diacritics, and a subset of all available characters. The relationship between the number of parameters and the accuracy of the model was indicated. Among the examined architectures, those that significantly improved the prediction accuracy at the expense of a larger network size were selected, and a network with a similar prediction accuracy as the base one, but with twice as many model parameters was selected.

Keywords: convolutional neural network, model efficiency, handwritten text recognition.

Prediction of river salinity with artificial neural networks

Justyna Kujawska, Faculty of Environmental Engineering, Lublin University of Technology, j.kujawska@pollub.pl

Monika Kulisz, Faculty of Management, Lublin University of Technology, m.kulisz@pollub.pl

Zulfiya Aubakirova, School of Architecture and Construction, D. Serikbayev East Kazakhstan Technical University, 69 Protozanov Street, Ust-Kamenogorsk, Kazakhstan, Aubakirova.zulfiya@mail.ru

Edyta Wojtaś, Faculty of Environmental Engineering, Lublin University of Technology, Nadbystrzycka 40B, Lublin, Poland, e.wojtas@pollub.pl

Abstract: This paper presents the development and evaluation of an Artificial Neural Network (ANN) based on the model for predicting the salinity of the Warta River. The study focused on the prediction of river water salinity, expressed in terms of electrical conductivity (EC), using the proposed ANN structure of 7-10-1. The network showed a satisfactory ability to capture the interrelationships between the input data: sulphates, chlorides, calcium, magnesium, total hardness, pH, and total dissolved solids. The correlation coefficient (R) values for the training, validation and test sets were 0.99444, 0.96988 and 0.97174, respectively. From the results, it can be concluded that the developed model is suitable for predicting the EC of the river.

Keywords: artificial neural network, prediction.

Application of deep learning neural networks for automatic image analysis in microscopic studies of activated sludge

Marcin Dziadosz, Faculty of Mathematics and Information Technology Lublin University of Technology, m.dziadosz@pollub.pl

Dariusz Majerek, Faculty of Mathematics and Information Technology Lublin University of Technology, d.majerek@pollub.pl

Marcin Dudziński, Faculty of Mathematics and Information Technology, Lublin University of Technology, m.dudzinski@pollub.pl

Grzegorz Łagód, Faculty of Environmental Engineering, Lublin University of Technology, g.lagod@pollub.pl

Abstract: This paper presents a performance comparison of the YOLOv4 and the YOLOv8 deep learning networks based on an automatic image analysis. YOLO is a detector belonging to the family of one-stage object detection models, the idea of which is to look only once at the analyzed image. A single neural network divides the image into a grid of cells and then predicts the bounding boxes and object class probabilities for each box. With single-stage detection, YOLO enables real-time detection with little loss of accuracy. For the analysed task the organisms of the Arcella vulgaris species were chosen. Their size varies from 50 to 150 μm. It can be found in waters rich in organic substances. However, it is often present in wastewater treatment plants using the activated sludge method. It is generally easy to observe and count under a microscope due to its characteristic appearance, large number and sedentary lifestyle of the species. Therefore, it is a good object to perform the detection task. The YOLO models were trained on a sample of images containing the mentioned protists. To create a proper training data set the images needed to be firstly manually labelled. For the comparison, metrics such as accuracy, precision and recall were calculated.

Keywords: deep learning, automatic image analysis, *Arcella vulgaris*, activated sludge.

Numerical calculations of water drop using a firefighting aircraft

Zbigniew Czyż, Polish Air Force University, z.czyz@law.mil.pl

Paweł Karpiński, University of Life Sciences in Lublin, pawel.karpinski@up.lublin.pl

Krzysztof Skiba, Lublin University of Technology, k.skiba@pollub.pl

Szymon Bartkowski, Polish Air Force University, s.bartkowski4718@wsosp.edu.pl

Abstract: The study involved a numerical analysis of the water dropping process by fixed-wing aircraft. This method, also known as air attack, is used for aerial firefighting, primarily in green areas such as forests and meadows. The conducted calculations allowed for the analysis of the process over time. The calculations were performed based on a SolidWorks model of the M18B Dromader aircraft. After defining the computational domain and setting the boundary conditions, the simulations were carried out using the ANSYS Fluent software. The resulting water dropping area was used to analyze the intensity of water distribution. The volumetric distribution and airflow velocity distribution were analyzed for specified time steps. The boundary layer where air no longer mixes with water during the final phase of water dropping was also determined. The obtained results provide an important contribution to further analyses aimed at optimizing the water dropping process by fixed-wing aircraft.

Keywords: aerial firefighting, fixed-wing aircraft, CFD analysis, waterbombing.

CFD studies of a wind vertical axis turbine with a variable swept area

Konrad Pietrykowski, Lublin University of Technology, k.pietrykowski@pollub.pl

Paweł Magryta, Lublin University of Technology, p.magryta@pollub.pl

Idzi Pędzisz, Lublin University of Technology, idzi.pedzisz@pollub.edu.pl

Abstract: The article presents the results of CFD (Computational Fluid Dynamics) research on a wind vertical axis turbine with a variable swept area. The tested turbine has four sets of blades, each of which consists of two moving parts. By changing the angle between these parts, it is possible to change the swept area of the turbine wheel. Thanks to this, it is possible to adjust the characteristics of the turbine to the current wind speed. In case of strong wind, it is possible to fold the blades to protect the rotor against damage. The 3D-CFD model was tested using the ANSYS Fluent software. Four rotors differing in the angle of the blades were analyzed. The tests were carried out for different wind speeds. The results are presented in the form of pressure and velocity distributions as well as streamlines around the rotor. In addition, the waveforms of the torque acting on a single blade and on the entire rotor are shown. The average rotor torque was also calculated. Thanks to this characteristics of the power factor for different rotational speeds of the rotor were also demonstrated. The results show that thanks to the adjustment of swept area, the z-turbine has a flexible operating range.

Keywords: wind turbine, CFD, variable area, vertical axis.

Aerodynamic performance of the XGyro hybrid unmanned aerial vehicle – a numerical investigation

Zbigniew Czyż, Polish Air Force University, z.czyz@law.mil.pl

Abstract: The article presents the results of a numerical analysis of a newly designed unmanned aerial vehicle (UAV) with electric propulsion. The research encompassed a wide range of angles of attack and sideslip angles, and it was conducted at an airflow velocity corresponding to a cruising speed of v=20 m/s. Specialized software based on the finite volume method ANSYS Fluent was employed for the numerical analysis. The article outlines the methodology of the conducted research. The results of the aerodynamic analysis are depicted in graphs, illustrating the components of aerodynamic force and moment as functions of the angle of attack and sideslip angle. Additionally, qualitative results of the airflow around the UAV are presented. The obtained findings demonstrate that the adopted methodology is sufficient for solving problems of this nature.

Keywords: aerodynamic characteristics, unmanned aerial vehicle (UAV), Computational Fluid Dynamics, CFD, autogyro, hybrid aircraft, multicopter, aerodynamics.

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Computational fluid dynamics analysis of an influence of icing on airfoil aerodynamic characteristics

Robert Szczepaniak, Polish Air Force University, r.szczepaniak@law.mil.pl

Robert Bąbel, Polish Air Force University, r.babel@law.mil.pl

Grzegorz Kowaleczko, Polish Air Force University, g.kowaleczko@law.mil.pl

Wit Stryczniewicz, Łukasiewicz Research Network—Institute of Aviation, Wit.Stryczniewicz@ilot.lukasiewicz.gov.pl

Abstract: The paper presents application of numerical simulations for analysis of an influence of icing on NACA 23012 airfoil aerodynamic characteristics. The analysis was performed with use of CFD solver with ANSYS FENSAP-ICE module. The numerical model was developed and proper boundary conditions was set in order to simulate icing. Numerical solution of Navier-Stokes fluid flow equations coupled with icing accretion numerical models allowed to simulate three types of leading edge icing: horn, runback and spanwise ride. Icing is extremely dangerous in aviation and might cause fatal accidents. The most threatening to aviation safety effects of icing are:

- decrease in aerodynamic performance
- lift reduction
- decrease in engine power
- increase of weight
- increase of aerodynamic drag

Ice accretion process is governed by energy transfer. Multiphysics character of the phenomena makes modelling of icing a difficult task. The results depend strongly on proper determination of the environmental conditions during the flight.

The lift and drag coefficients variation with change of AoA for various leading edge icing types are presented in this work. The clean configuration characteristics is shown as a reference. The following conclusions can be drawn:

- icing reduce the lift coefficient at high angles of attack;
- the flow separation for an airfoil with icing is less abrupt;
- the drag is increased in the whole range of investigated angles of attack.

Keywords: influence of icing on airfoil, aerodynamic characteristics, drag coefficent, lift coefficient.

Computational and Experimental Investigation of Inert Gas Flow Field in DMLM Printer Build Chamber

Pawel Czekalowski, GE Company Poland Sp. z.o.o., Pawel.Czekalowski1@ge.com

Wit Stryczniewicz, Łukasiewicz Research Network—Institute of Aviation, Wit.Stryczniewicz@ilot.lukasiewicz.gov.pl

Abstract: Additive manufacturing methods are becoming more and more popular in today's production market. These methods became a useful and flexible alternative to traditional manufacturing approach. One of the most popular methods in this family is Direct Metal Laser Melting. It can achieve high quality prints, however, numerous parameters need to be established, to achieve a good quality product. One of the aspects of printing process is inert gas flow. The goal of presented study is to quantitatively assess inert gas flow field using both experimental and numerical methods. Flow field parameters have been measured with anemometry and Particle Image Velocimetry. Additionally Computational Fluid Dynamics tools were used to investigate flow phenomena occurring inside the build chamber. PIV measurements give good insight into the flow field, but they are costly and require significant time for preparation. For this reason, CFD analysis is widely used as a design tool, giving reasonable turnaround time. In addition, every design tool to be reliable need to be validated against test data. In this study the team was able to collect both experimental and numerical data and finally conduct the validation. Work allowed to determine the most suitable approach for predictions in given problem. Different turbulence models have been tested. Simulation results were validated against collected experimental data.

Keywords: Particle Image Velocimetry, CFD, inert gas flow, 3D printing.

Computational analysis of PEM fuel cell under different operating conditions

Tomasz Seredyn, Polish Air Force University, t.seredyn@law.mil.pl

Małgorzata Skawińska, Polish Air Force University, m.skawinska@law.mil.pl

Abstract: PEM fuel cells are one of the most promising sources of electrical energy and also have interesting properties. This research is purely theoretical and based on ANSYS Fluent software. Thus, the next step of the research should be the comparison of the solutions to other models and experimental results. The PEM fuel cell can be used as an energy source in the near future in a much more common way, although there are few modifications required, such as increasing efficiency and reducing production costs.

In general, a three-dimensional steady-state model of the polymer electrolyte membrane fuel cell implemented in Fluent was used to study a single channel flow inside such a PEMFC. The analysis concerns an aspect, that seems to be overlooked in this type of analysis, namely the influence of the substrate flow rate on the quality and efficiency of the chemical reaction, and thus on the value of the generated current for a given voltage. It is clearly visible that there is a rather narrow range in the amount of hydrogen fuel fed that is optimal for a given fuel cell. Such theoretical research is very useful and very much needed to design a new PEM fuel cells, utilizing Computational Fluid Dynamics (CFD) tool to statically monitor its performance for different boundary conditions.

Keywords: PEMFC, CFD, fuel cell, hydrogen, polarization curve.

Autonomous mobile robot implementation strategy to support intralogistics auxiliary processes using modern technologies of Logistics 4.0 – case study

Jakub Pizoń, Faculty of Management, Lublin University of Technology j.pizon@pollub.pl

Łukasz Wójcik, BORG Automotive, lwoj@pl.borgautomotive.com

Arkadiusz Gola, Faculty of Mechanical Engineering, Lublin University of Technology a.gola@pollub.pl

Łukasz Kański, Institute of Management and Quality Sciences, University of Maria Curie-Skłodowska, lukasz.kanski@mail.umcs.pl

Izabela Nielsen, Aalborg University, izabela@mp.aau.dk

Abstract: The article focuses on the role of modern logistics 4.0 technologies and lean management in optimizing ancillary processes in intralogistics. The literature review presents critical aspects of intralogistics, including the use of autonomous mobile robots (AMR) and the challenges associated with their successful implementation. The article also discusses the concepts of Industry 4.0 and Industry 5.0. highlighting the importance of synergies between workers and advanced technologies. In optimizing logistics processes, the authors emphasize the importance of lean management and tools such as 5S and Kaizen. The authors analyze the research gap related to the organization of auxiliary processes intralogistics and the introduction of modern technologies. The lack of good practices and strategies for implementing new technologies for ancillary processes makes this an important and critical issue for both managers and production engineers. The article provides practical strategy that can be implemented in companies. It is a valuable resource for managers seeking to manage intralogistics and effectively improve support processes in manufacturing plants.
In summary, the article provides a comprehensive look at modern approaches to optimizing support processes in internal logistics. It highlights the importance of integrating modern logistics technologies with lean management principles, which can increase companies' efficiency and competitiveness.

Keywords: internal logistics, Industry 5.0, autonomous mobile robots, intralogistics, lean management, automotive industry, simulation.

Investigation on the limits of type 1 diabetes therapy automation using insulin pumps

Tomasz Nowicki, Department of Computer Science, Lublin University of Technology, t.nowicki@pollub.pl

Robert Piekarski, Medical University of Lublin, robert.piekarski@umlub.pl

Abstract: Type 1 diabetes is an incurable chronic disease that usually has its onset in childhood. The disease means that the patient's body irreversibly loses its ability to produce the insulin hormone. Since the lack of insulin in the organism always leads to death, the therapy primarily consists in supplying the hormone from the outside inright doses and in the right time. Administration errors can result in poor mood, health complications or even death. The introduction of insulin pumps for common use as basic devices for insulin delivery has significantly improved the quality of the therapy, and what follows, the physical and mental comfort of patients. It is still easy to get an opinion that these devices completely automate the therapy process, but this is not true. The aim of this research was to determine the possible level of the automation of the type 1 diabetes therapy solely based on an insulin pump. First, the principle of operation of typical modern insulin pumps was described. This became the basis for the development of a special biocybernetic model of a patient with diabetes. Then, the model was used in numerous computer simulations whose output was confronted with historical data obtained from real patients. The research confirms that the use of a typical modern insulin pump alone does not fully automate the therapy of type 1 diabetes. Nevertheless, possible methods could be identified to achieve a higher quality of treatment and to find opportunities for additional automation. These methods can be considered as an alternative to the socalled artificial pancreas.

Keywords: type 1 diabetes, insulin pump, computer simulation, therapy automation.

Using fuzzy logic to make decisions based on data from Customer Relationship Management systems

Agnieszka Bojanowska, Faculty of Management, Department of Marketing, Lublin University of Technology, a.bojanowska@pollub.pl

Monika Kulisz, Faculty of Management, Department of Organization of Enterprise, Lublin University of Technology, m.kulisz@pollub.pl

Abstract: The purpose of the article is to propose a fuzzy logic solution for decision-making based on data from CRM (Customer Relationship Management) systems to evaluate banking customer attractiveness. The article is based on theory about management IT systems, especially the CRM type. Based on the literature research, nine identified factors were proposed that can influence whether the relationship with the customer will be profitable for the bank. Factors that affect banking customer attractiveness are considered, including the share of the customer's wallet and the customer's tendency to express a positive opinion of the bank. Data allowing for the identification of these factors is collected in the bank's IT systems, among other CRMs. Based on the research, a model prepared in Simulink using a Mamdani-type Fuzzy Inference System was made. It is a decision model that provides a result in the form of a binary value of 0 or 1, where 1 means it is worth investing in a customer, while 0 means it is not. After considering the subjective opinions, competence and experience of specialists and confronting them with the results from the developed model, it can be confirmed that the model works as expected.

Keywords: manufacturing knowledge management, knowledge management, CRM, SCM, SRM, management systems, supply chain, customer, food service, restaurant, logistics.

Simulation model of a patient with type 1 diabetes using fuzzification

Tomasz Zientarski, Department of Computer Science, Faculty of Electrical Engineering and Computer Science, Lublin University of Technology, t.zientarski@pollub.pl

Marek Miłosz, Department of Computer Science, Faculty of Electrical Engineering and Computer Science, Lublin University of Technology, m.milosz@pollub.pl

Tomasz Nowicki, Department of Computer Science, Faculty of Electrical Engineering and Computer Science, Lublin University of Technology, t.nowicki@pollub.pl

Adam Kiersztyn, Department of Computer Science, Faculty of Electrical Engineering and Computer Science, Lublin University of Technology, a.kiersztyn@pollub.pl

Piotr Wójcicki, Department of Computer Science, Faculty of Electrical Engineering and Computer Science, Lublin University of Technology, p.wojcicki@pollub.pl

Dariusz Gutek, Megatech Dariusz Gutek, ul Energetyków 45, 20-468 Lublin, darek@megatech.pl

Abstract: Type 1 diabetes is one of the most common diseases. The disease is caused by a lack of insulin secretion from the beta cells of the pancreas, which leads to improper regulation of blood glucose levels. The article presents a simulation model for determining changes in glucose-insulin levels using fuzzy logic techniques. The work concerns a quite simple deterministic simulation model of a digital twin of a type 1 diabetes patient, and fuzzification can significantly improve the efficiency of this model. A series of numerical experiments showed that enriching a simple deterministic patient model with a fuzzy approach gives much more accurate results than the simple deterministic model. The use of fuzzy sets opens up a number of possibilities and is a completely natural approach, resulting from, among others, the specificity of the simulated phenomenon - vital parameters of people with type 1 diabetes.

Keywords: fuzzy model, type I diabetes, patient's fuzzy digital twin.

Application of open source geo-informatics technologies for the analysis of stormwater drainage basin areas

Piotr Kościuk, Faculty of Environmental Engineering, Lublin University of Technology, piotr.kosciuk@pollub.edu.pl

Jacek Zaburko, Faculty of Mathematics and Information Technology, Lublin University of Technology, j.zaburko@pollub.pl

Magdalena Piłat-Rożek, Faculty of Mathematics and Information Technology, Lublin University of Technology m.pilat-rozek@pollub.pl

Grzegorz Łagód, Faculty of Environmental Engineering, Lublin University of Technology, g.lagod@pollub.pl

Abstract: The article identifies the key aspects of extending the core functionality of the open source geo-information software QGIS by means of "plug-ins" - i.e. add-ons to the software available to users within the program interface for the purpose of analyzing urbanized areas, especially in the context of stormwater management. The available IT solutions in this area, their use and impact on the functionality of QGIS software were presented. The research has shown that the discussed environment offers the possibility of creating multifaceted geo-information databases, useful for companies operating in the field of environmental engineering, administration, as well as science. The paper also identified the prospective areas with shortage of solutions, while common features are present with the areas where such solutions have already been developed.

Keywords: QGIS, stormwater.

Application of Entropy Based Analysis for Evaluation of Algal Community Structure Influenced by Stormwater Systems

Aleksandra Kozłowska, Faculty of Environmental Engineering, Lublin University of Technology, a.kozlowska@pollub.edu.pl

Magdalena Piłat-Rożek, Faculty of Mathematics and Information Technology, Lublin University of Technology, m.pilat-rozek@pollub.pl

Edyta Wojtaś, Faculty of Environmental Engineering, Lublin University of Technology, e.wojtas@pollub.pl

Grzegorz Łagód, Faculty of Environmental Engineering, Lublin University of Technology, g.lagod@pollub.pl

Abstract: This work presents a possible implementation of entropy based analysis for evaluation of algal community structure influenced by stormwater systems. This is an example of bioindication study for analysis of urban stormwater impact on the receiver - the river Bystrzyca, in the area of Muzyczna Street in Lublin, Poland. The present study analyzed the level of entropy based diversity evaluation and abundance of biofilm communities, which illustrate the state of the studied aquatic environment, enabling to determine its quality. The discharge at particular points was evaluated on the basis of the reaction of selected algal species representatives to the substances appearing in the watercourse. On the basis of chosen species, the Shannon Entropy index and their derivative, were calculated as quantitative description of indicator organisms communities structure. The final impact of urban stormwater discharge on surface water were evaluated on the basis of the entire study cycle in relation to the mean and median value of particular subsets of raw multidimensional data describing analyzing communities as well as mean and median values of entropy based indices.

Keywords: stormwater system, entopry, algal community.

Analysis of the impact of trailing-edge wing flaps on the aerodynamic characteristics and performance of the Tecnam P-2008JC aircraft

Izabela Kopeć, Aeronautics Faculty, Military University of Aviation, 35 Dywizjonu 303 St., 08-521 Dęblin, Poland, i.kopec@law.mil.pl

Mateusz Kawałko, Aeronautics Faculty, Military University of Aviation, 35 Dywizjonu 303 St., 08-521 Dęblin, Poland, m.kawalko5510@wsosp.edu.pl

Abstract: The aim of the article was to analyse the impact of three selected types of trailing-edge flaps on the aerodynamic characteristics and performance of the Tecnam P-2008JC aircraft. The SOLIDWORKS software, together with the FlowSimulation module, was used to design the 3D model of the aircraft and to simulate the air flow. The article contains descriptions of issues related to the aerodynamics and dynamics of aircraft motion, calculations describing the procedure for designing and building a model of the tested aircraft in the SOLIDWORKS software, performing simulations using the FlowSimulation module and determining the aerodynamic characteristics of the aircraft with the flaps applied, determining the basic performance of the aircraft with extended flaps, and then comparing the determined performance with the in a configuration without flaps.

Keywords: Tecnam P-2008JC, flow test, flaps, performance, characteristics, Aerodynamic characteristics.

Quantitative and qualitative analysis of surface runoff from the exemplary rest area (RA)

Paweł Suchorab, Faculty of Environmental Engineering, Lublin University of Technology, Lublin, Poland, p.suchorab@pollub.pl

Dariusz Kowalski, Faculty of Environmental Engineering, Lublin University of Technology, Lublin, Poland, d.kowalski@pollub.pl

Małgorzata Iwanek, Faculty of Environmental Engineering, Lublin University of Technology, Lublin, Poland, m.iwanek@pollub.pl

Beata Kowalska, Faculty of Environmental Engineering, Lublin University of Technology, Lublin, Poland, b.kowalska@pollub.pl

Ewa Hołota, Faculty of Environmental Engineering, Lublin University of Technology, Lublin, Poland, e.holota@pollub.pl

Abstract: Due to the changed nature of the atmospheric precipitation and increasing water deficit, the possibilities of water retention at the places of its occurrence are becoming more and more popular in recent decades. Yet, no comprehensive studies have been carried out in Poland showing the possibilities of economic use of water flowing out from roads, not only in terms of quantity, but also in terms of quality. The aim of this paper is to present the results of the quantitative and qualitative analysis of the surface runoff from an exemplary Motorway Rest Area (MRA). The analysis was performed using hydrodynamic method and was divided into two parts: runoff analysis and quality analysis related to amount of Total Suspended Solids (TSS) washoffed from the analysed MRA during precipitation events. The obtained results revealed that the case study MRA is effectively drained in terms of hydraulic conditions. The qualitative analysis showed that the concentration of the TSS exceeded the maximum acceptable level during all rainfall events. However, field studies with in-situ tests of the quantity and quality of rainwater from the MRA are highly recommended.

Keywords: surface runoff, runoff quality, Motorway Rest Area, hydrodynamic modeling.

Failure study of compressed thin-walled plate element with mechanical couplings

Katarzyna Falkowicz, Department of Machine Design and Mechatronics, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, k.falkowicz@pollub.pl

Abstract: This paper investigates the stability and failure analysis of thin-walled composite plate elements subjected to axial compression. The analyzed columns were made of composite material — carbon fiber reinforced polymer (CFRP) using the autoclave technique. The scope of the research included experimental tests on real samples and numerical simulations based on the finite element method (in ABAQUS® program). Both experimental tests and numerical analysis were performed over the full range of loading until structural failure. Experimental tests were performed using universal testing machine, Aramis system and acoustic emission method. Regarding the simultaneously conducted numerical simulations, the progressive failure analysis — PFA, allowing for a thorough analysis of the complex mechanism of the composite material failure phenomenon. The most important aspect of this paper is the potential to enable to understand the failure of the composite element with mechanical couplings during post buckling.

Keywords: mechanical couplings, asymmetrical configurations, progressive failure analysis, experimental tests, laminates.

Accelerations caused by underwater explosions on the naval gun foundation

Bogdan Szturomski, Mechanical and Electrical Engineering Faculty, Polish Naval Academy, ul. Inżyniera Jana Śmidowicza 69, 81-127 Gdynia, Poland, bsztur@gmail.com

Radosław Kiciński, Mechanical and Electrical Engineering Faculty, Polish Naval Academy, ul. Inżyniera Jana Śmidowicza 69, 81-127 Gdynia, Poland, r.kicinski@amw.gdynia.pl

Stanisław Milewski, Mechanical and Electrical Engineering Faculty, Polish Naval Academy, ul. Inżyniera Jana Śmidowicza 69, 81-127 Gdynia, Poland, s.milewski@amw.gdynia.pl

Abstract: The article presents a numerical model of the impact of a non-contact explosion from a TNT charge on the ship's hull in terms of the FEM finite element method as a compilation of many mathematical models (sub-models) describing significant physical phenomena. The non-linear equation of motion of the ship's hull is presented in terms of the finite element method, a mathematical discrete way of reflecting the geometry of the ship's hull, oriented to a significant reduction of the degrees of freedom. Material models described by the Johnson-Coke equations are discussed, taking into account plastic characteristics depending on the strain rate and failure criteria. The model of loading in the form of a pressure wave from the explosion of the TNT charge was presented, taking into account the reflection from the bottom and surface, the pulsation of the gas bubble, the angle of incidence on the wetted elements of the ship's hull. Empirical equations describing the detonation wave in water according to R.H. Cole, W. D. Reid, and T. L. Geers and K. S. Hunter. Exemplary results of numerical simulations are included.

Keywords: finite element method (FEM), impact resistance of the structure; pressure wave model, underwater explosion, model materiału Johnsona-Coke'a, equation R.H. Cole, W.D. Reid, and T. L. Geers and K.S. Hunter.

Numerical study of the energy absorption performance of 3D printed sandwich structures

Quirino Estrada, Instituto de Ingeniería y Tecnología, Universidad Autónoma de Ciudad Juárez (UACJ), Ciudad Juárez, Chihuahua, México, quirino.estrada@uacj.mx

Jarosław Zubrzycki, Mechanical Engineering Faculty, Lublin University of Technology, ul. Nadbystrzycka 38D, 20-618 Lublin, Poland, j.zubrzycki@pollub.pl

Elva Reynoso-Jardón, Instituto de Ingeniería y Tecnología, Universidad Autónoma de Ciudad Juárez (UACJ), Ciudad Juárez, Chihuahua, México, elva.reynoso@uacj.mx

Dariusz Szwedowicz, Centro Nacional de Investigación y Desarrollo Tecnológico/TecNM, Cuernavaca, Morelos, México, Mexico, dariusz.sd@cenidet.tecnm.mx

Alejandro Rodriguez-Mendez, Tecnológico Nacional de México campus Ciudad Guzmán, Ciudad Guzmán, Jalisco, Mexico, aleromende@gmail.com

Magdalena Marchewka, Mechanical Engineering Faculty, Lublin University of Technology, ul. Nadbystrzycka 38D, 20-618 Lublin, Poland, m.marchewka@pollub.pl

Julio Vergara-Vazquez, Unidad Profesional Interdisciplinaria de Ingeniería, Campus Palenque (UPIIP)/IPN, Palenque, Chiapas, Mexico, jvergarav@ipn.mx

Aztlán Bastarrachea, Departamento de Ciencias Básicas, Tecnológico Nacional de México campus Ciudad Juárez, Ciudad Juárez, Chihuahua, Mexico, aztlan.ba@itcj.edu.mx

Jesús Silva, Instituto de Ingeniería y Tecnología, Universidad Autónoma de Ciudad Juárez (UACJ), Ciudad Juárez, Chihuahua, México, jesilva@uacj.mx

Abstract: Nowadays the 3D printing techniques (FDM) is one of the most powerful tools to manufacturing complex components. This is due to customizable capacity, low cost, attainability, and fast prototyping time. From this, FDM is an alternative to manufacturing thin-walled structures, since novel designs can be obtained. In this way, the current article is focusing on the design and evaluation of 3D printed sandwich structures for energy absorption applications. For this purpose, five structures were designed and printed with acrylonitrile butadiene styrene (ABS) using Zortrax 3D printer. To guarantee the best performance of the structures, the 3D-printing parameters were optimized in accordance with the literature. The structures present geometries based on latticed cubes and truncated pyramids. During the study, the effect of the cross-section and density were analyzed. The evaluation of the structures was carried out by compression test using universal test machine. Several parameters were determined such as energy absorption, peak load, mean force, and crush force efficiency. Additionally, a numerical analysis was carried out using Abaqus finite element software. Finally, according to results, the energy absorption performance is mainly determined by the geometry followed of the density. The best performance was computed for truncated pyramid with a CFE of 0.75.

Keywords: sandwich structures, crashworthiness, 3D printed, energy absorption.

The possibility of using the Finite Element Method for determining thermal diffusivity on the example of nickel using the classic and the modified pulse method

Robert Szczepaniak, Polish Air Force University, r.szczepaniak@law.mil.pl

Janusz Terpiłowski, Military University of Technology, janusz.terpilowski@wat.edu.pl

Grzegorz Woroniak, Bialystok University of Technology, g.woroniak@pb.edu.pl

Abstract: The main purpose of the work is to present the possibility of using the finite element method implemented in the COMSOL 3.5a program in the heat transfer symmetry 2D module to determine thermal diffusivity by the classic and modified pulse methods. The method of determining the thermal diffusivity by means of measuring and recording the course of the temperature difference between the extreme surfaces of the tested sample and changes in the temperature increase on the back surface after a laser shot at its front surface, assuming that the sample is adiabatic for a representative experimental course at a given temperature, is discussed. This paper presents the basic metrological conditions for the implementation of the modified pulse method for testing the temperature characteristics of thermal diffusivity on the example of nickel. The heat pulse generated by the laser method at the extreme surface of the sample for a thermostatic temperature of 341.8°C was simulated. Using the inverse problem in both the classic and modified methods, the thermal diffusivity of the material in question was determined and these results were compared with the experimentally obtained values. The values of thermal diffusivity differ from those obtained experimentally by 3.3% for the classic method and approximately 2.5% for the modified method. A preliminary analysis of the influence of the number of nodal points on the numerical results obtained was also carried out and the results for the number of nodes between 64 and 17,000 change by only 1.1%. The paper presents a combination of experimental and numerical studies which is useful in science and simplifies the process of time-consuming experimental studies.

Keywords: FEM, thermal diffusivity, heat exchange, flash method.

Evaluation of density fields of numerical analysis output of solid carbon dioxide extrusion process

Jan Górecki, Poznan University of Technology, jan.gorecki@put.poznan.pl

Tymoteusz Lindner, Poznan University of Technology, tymoteusz.lindner@put.poznan.pl

Krzysztof Walesa, Poznan University of Technology, krzysztof.walesa@put.poznan.pl

Abstract: Efforts to reduce energy consumption and explore alternative energy sources are paramount in production process research. However, a research gap exists regarding the evaluation of density fields in numerical analysis output of solid carbon dioxide (CO_2) extrusion. This study aims to address this gap by examining the density fields in the numerical analysis output of the extrusion process for solid CO_2, commonly known as dry ice. Dry ice, a by-product of ammonia compounds production, requires efficient management due to its high sublimation rate. Ram pressing is a commonly used method for compressing dry ice, but the resulting product often exhibits non-uniform density fields, presenting challenges for process optimization. To bridge this research gap, an algorithm is verified for determining the percentage share of density fields in the numerical simulation results. By comparing simulations using single- and multiple-cavity dies, the algorithm provides valuable insights into the distribution of density within the extruded solid CO_2. In overcoming the limitations of subjective comparative evaluation, this study offers objective measures for assessing and comparing numerical analysis outputs. The findings contribute to a deeper understanding and optimization of the solid CO_2 extrusion process, facilitating the production of high-density dry ice products with reduced energy consumption. In conclusion, this research not only bridges the research gap in evaluating density fields but also advances the field of solid CO_2 extrusion and waste materials management.

Keywords: Densisty fields; stress fields; compaction; extrusion; dry ice.

Numerical study of the strength of the pylon designed for the unmanned helicopter

Marcin Brzozowski, USM sp. z o.o., Budowlana 26, 20-469 Lublin, Poland, kontakt@usm.net.pl

Jarosław Zubrzycki, Faculty of Mathematics and Information Technology, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, j.zubrzycki@pollub.pl

Dariusz Wołos, Faculty of Mechanical Engineering, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, d.wolos@pollub.pl

Abstract: The paper presents the results of numerical research on a pylon designed for an unmanned aerial vehicle. Calculations were performed using the finite element method based on a geometric model. The design was based on a few assumptions. The primary assumption was the maximum reduction of the structural weight while maintaining high strength. Additionally, requirements were defined for the material, which should exhibit high corrosion resistance without the need for frequent technical inspections and the application of corrosion-resistant coatings. The presented research analyzed total displacements, principal stresses, and the safety factor for two variants of the developed design: a pylon made of 40x40 steel profiles and a composite pylon made of 30x30 profiles.

Keywords: finite element method, pylon, strength of a structure, unmanned aerial vehicle.

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MATERIAL PROPERTIES AND STRUCTURE RESEARCH METHODS

Cavitation erosion of NiCoCrAlFeTi high-entropy alloys containing different additions of titanium

Mirosław Szala, Faculty of Mechanical Engineering, Lublin University of Technology, Nadbystrzycka 36D, Lublin 20-618, Poland, m.szala@pollub.pl

Mariusz Walczak, Faculty of Mechanical Engineering, Lublin University of Technology, Nadbystrzycka 36D, Lublin 20-618, Poland, m.walczak@pollub.pl

Małgorzata Grądzka-Dahlke, Faculty of Mechanical Engineering, Bialystok University of Technology, Wiejska 45 C, 15-351 Białystok, Poland, m.dahlke@pb.edu.pl

Dariusz Perkowski, Faculty of Mechanical Engineering, Bialystok University of Technology, Wiejska 45 C, 15-351 Białystok, Poland, d.perkowski@pb.edu.pl

Marzena Tokarewicz, Faculty of Mechanical Engineering, Bialystok University of Technology, Wiejska 45 C, 15-351 Białystok, Poland, marzena.tokarewicz@sd.pb.edu.pl

Wojciech J. Nowak, Faculty of Mechanical Engineering and Aeronautics, Rzeszow University of Technology, Powstanców Warszawy 12, 35-959 Rzeszów, Poland, w.nowak@prz.edu.pl

Tadeusz Kubaszek, Faculty of Mechanical Engineering and Aeronautics, Rzeszow University of Technology, Powstanców Warszawy 12, 35-959 Rzeszów, Poland, tkubaszek@prz.edu.pl

Andrzej Gradzik, Faculty of Mechanical Engineering and Aeronautics, Rzeszow University of Technology, Powstanców Warszawy 12, 35-959 Rzeszów, Poland, andrzej_gradzik@prz.edu.pl

Abstract: High-entropy alloys (HEAs) present potential in broad applications due to their promising microstructure and properties. The study aimed to recognize the effect of titanium content on cavitation erosion resistance of NiCoCrAlFeTi alloys. The set of HEA samples were casted as NiCoCrAlFeTix alloys (x = 0, 0.05, 0.2 and 0.5) by using the induction melting method. Moreover, the microstructure's effect on HEA alloys' erosive behavior has been studied. The vibratory apparatus was used to study cavitation erosion resitance, and tests were conducted according to the ASTM G32 standard. Cavitation eroded surfaces were examined using an optical profilometer and scanning electron microscopy. The surface roughness of eroded surfaces was examined at different times of exposition to cavitation erosion. The SEM-EDS combined with XRD methods reveals the microstructure development due to the NiCoCrAlFe alloying with different portions of titanium. The addition of titanium increases the Vickers hardness and successfully facilitates the erosion residence of

the HEA alloys. HEAs' overall cavitation erosion residence is higher than the reference stainless steel grade AISI 304. The phase composition development due to cavitation loads was studied using the XRD method. The comparative erosive model, which included the differences in phase composition of HEA's+xTi has been elaborated. The research confirms that NiCoCrAlFeTi alloy has a high potential for preventing cavitation erosion damage of metallic components.

Keywords: cavitation erosion, high entropy alloys, microstructure, wear, casting, tribology.

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Experimental determination of material boundary conditions for computer simulation of sheet metal deep drawing processes

Tomasz Miłek, Faculty of Mechatronics and Mechanical Engineering, Kielce University of Technology, tmatm@tu.kielce.pl

Abstract: In solving technological problems related to sheet metal deep drawing with the use of computer tools, the key issue is still the correct determination and entering of boundary conditions to FEM-based software. The procedure for preparing input data for modelling such processes includes geometric data (drawing of tools and material), technological parameters along with the contact conditions between the workpiece and the tools (friction model and type of lubricant) and material properties, in which work-hardening curves are of particular importance. In typical material databases of FEM-based software and designed for computer modelling of deep drawing processes, the properties of only a small number of material grades are available, and commercial software producers charge additional fees for each additional quantity. Those properties that are already in the database are usually devoid of basic information, e.g. related to the state of the material (material after recrystallization, annealing, cold working has different properties). The paper describes the most common procedures for entering work-hardening curves into FEM-based software for the purpose of simulation of deep drawing processes. In addition, experimental tests were carried out to determine flow curves based on cold tensile curves for flat samples made of EN-AW 1050A aluminium, Cu-ETP copper, CuZn37 brass and S235JRG2 steel. The investigation used a universal testing machine with a 20kN pressing force, equipped with specialized software for measuring forces and displacements. It was calibrated and satisfies the metrological requirements for class 0.5. A comparative analysis of the curves determined by the analytical method was carried out. The results obtained in the research can be used in industrial practice for computer-aided design of cold-deep drawing processes for drawpieces of various shapes from the discussed materials.

Keywords: engineering processes, metal forming, deep drawing, computer modelling, FEA, flow curves.

The use of cluster analysis to assess the wear resistance of cermet coatings sprayed by HVOF on magnesium alloy substrates

Ewa Jonda, Department of Engineering Materials and Biomaterials, Silesian University of Technology, ewa.jonda@polsl.pl

Dariusz Fydrych, Institute of Manufacturing and Materials Technology, Faculty of Mechanical Engineering and Ship Technology, Gdańsk University of Technology, darfydry@pg.edu.pl

Leszek Łatka, Department of Metal Forming, Welding and Metrology, Faculty of Mechanical Engineering, Wroclaw University of Science and Technology, leszek.latka@pwr.edu.pl

Abstract: Cermet coatings are one of the best surface protection of machine elements against wear. On the other hand, the most universal and economically justified method of applying such coatings is high velocity oxy-fuel (HVOF) spraying. This method makes it possible to produce coatings characterized by compact structure, low porosity and very good adhesion to the substrate. All these fundamental properties contribute to the high wear resistance of these coatings. However, carrying out full wear tests (e.g. ball-on-disc) is time-consuming, especially when it is necessary to select the proper feedstock material and carefully selected process parameters. The aim of the following researches was to statistically investigate the possibility of replacing long-term wear resistance tests with determination of this performance on the basis of determining the fundamental mechanical properties of the coatings. Three types of coating materials were selected: WC-Co, WC-Co-Cr and WC-Cr-Ni, which were deposited on AZ31 magnesium alloy substrates from three different spray distances: 320, 360 and 400 mm. On the basis of the tests carried out and using cluster analysis techniques (the Ward and k-means methods), the relative similarity between the obtained coatings was determined. The applied methodology allowed to select from the analyzed cermet coatings such samples that were characterized by improved resistance to abrasive wear. The obtained results of the analyzes were also referred to the results of tests of resistance to abrasive wear.

Keywords: cluster analysis, HVOF spraying, cermet coating, AZ31 magnesium alloy, mechanical properties, wear resistance.

Tests of the adjustable support system in order to eliminate the causes of operational damage

Kazimierz Drozd, Faculty of Mechanical Engineering, Lublin University of Technology, k.drozd@pollub.pl

Iryna Boretska, Department of Information Technologies, Ukrainian, National Forestry University, 103, Gen. Chuprynky, Lviv, Ukraine, boretska@nltu.edu.ua

Abstract: Support structures are commonly used in machines, devices and vehicles. In the simplest case, a beam is used as a support, or a more complicated, but at the same time light truss. However, sometimes the bracket needs to be able to adjust the force (pressure) or position. In this case, it is a mechanism with an internal drive, often performed hydraulically. This type of bracket, the damage of which was the cause of the road accident, was analyzed in this article. The research began with an analysis of the structure. Due to the limited installation space and assembly errors, it was characterized by different strength of individual nodes. In addition, materials with extremely different strengths were used to manufacture the supporting elements that work together. Subsequently, simulations were carried out using the finite element method (FEM). The support structure model contained a different degree of simplification in comparison with the real object. As a result of the simulation, it was shown that some parts of the support practically do not participate in the transfer of the operating load. The lack of automatic pressure regulation in the hydraulic cylinder can cause damage to the support system at the very beginning, when securing the load. The occurrence of dynamic forces during cargo transport is associated with plastic deformation of less durable parts of the structure. Small changes in the assembly method and the use of additional components can significantly increase the service life of the tested bracket system.

Keywords: bracket, plastic deformation, assembly method.

Analysis of the mechanical properties of quail femur under impact loading condition

Anna Skic, Department of Mechanical Engineering and Automation, University of Life Sciences in Lublin, Lublin, Poland

Paweł Kołodziej, Department of Mechanical Engineering and Automation, University of Life Sciences in Lublin, Lublin, Poland

Karolina Beer-Lech, Department of Mechanical Engineering and Automation, University of Life Sciences in Lublin, Lublin, Poland

Kamil Drabik, Institute of Biological Basis of Animal Production, University of Life Sciences in Lublin, Lublin, Poland

Kamil Skic, Institute of Agrophysics, Polish Academy of Sciences, Lublin, Poland

Ricardo Branco, Department of Mechanical Engineering, Centre for Mechanical Engineering, Materials and Processes (CEMMPRE), University of Coimbra, Coimbra, Portugal

Abstract: In natural conditions, bone fractures most often occur as a result of an impact or fall, i.e. under dynamic loads, when a large force acts on the bone in a short time. This work presents the results of a dynamic two-point bending test of the quail femur. Bones from females and males of two quail breeds were analyzed: the meat breed Pharaoh (F) and the laying type of Japanese quail (S). The values of the force to fracture in a bending test under impact loading conditions were determined. Additionally, the mechanical strength of eggshell under quasi-static and impact loading conditions was also examined.
The obtained results showed that the bones of male quails of both analyzed types of quails were characterized by statistically significantly higher mechanical strength compared to the bones of females. Moreover, the mechanical strength of the eggshell measured under impact load conditions was characterized by higher values compared to the result obtained under quasi-static load conditions. The observed differences between quail species were not statistically significant.

Keywords: impact loading, quasi-static conditions.

Strength analysis aspects of psyllium husks/thermoplastic starch films under impact loading conditions

Karolina Beer-Lech, Department of Mechanical Engineering and Automatic Control, University of Life Sciences in Lublin, 28 Głęboka St., 20-612 Lublin, Poland, email: karolina.beer-lech@up.lublin.pl, ORCID 0000-0003-1679-8785

Paweł Kołodziej, Department of Mechanical Engineering and Automatic Control, University of Life Sciences in Lublin, 28 Głęboka St., 20-612 Lublin, Poland, email: pawel.kolodziej@up.lublin.pl, ORCID 0000-0003-0479-1770

Anna Skic, Department of Mechanical Engineering and Automatic Control, University of Life Sciences in Lublin, 28 Głęboka St. 20-612 Lublin, Poland, email: anna.skic@up.lublin.pl, ORCID 0000-0002-7042-8294

Ricardo Branco, Department of Mechanical Engineering, ISEC, Polytechnic Institute of Coimbra, R. Misericórdia Lagar dos Cortiços - S. Martinho do Bispo, 3045-093 Coimbra, Portugal, email: ricardo.branco@dem.uc.pt, ORCID 0000-0003-2471-1125

Abstract: Tensile testing under quasi-static loads conditions is usually used to determine the mechanical strength of thermoplastic starch films. This does not fully illustrate the load conditions for packaging films, which, under the conditions of use, are succumb to dynamic loads. The aim of the study was to present the possibilities of using a patented soft tissues measurement testing station to analyze the mechanical strength of thermoplastic starch films under impact loading conditions. Two groups of film samples containing the addition of psyllium husks and psyllium husks flour were used for the measurements. The casting method was applied and glycerol was used as a plasticizer. Microstructure of the surface of the samples were analyzed by a stereoscopic microscope.
Samples with the addition of psyllium husk flour had a more uniform microstructure. These films were characterized also by a much greater impact force than samples containing unground psyllium seed husks. Research confirms usefulness of patented soft tissues measurement testing station to analyze the mechanical strength of thermoplastic starch films.

Keywords: impact loading, pendulum, mechanical properties, biocomposites, thermoplastic starch film, psyllium husks.

Effects of thickness of the corn seed coat on the strength of processed biological materials

Łukasz Gierz, Poznan University of Technology, pl. M. Skłodowskiej-Curie 5, 60-965 Poznan, lukasz.gierz@put.poznan.pl

Weronika Kruszelnicka, Bydgoszcz Univeristy of Science and Technology, Al. Prof. S. Kaliskiego 7, 85-796 Bydgoszcz, werkru001@pbs.edu.pl

Wiktor Łykowski, Poznan University of Technology, pl. M. Skłodowskiej-Curie 5, 60-965 Poznan, wiktor_lykowski@o2.pl

Mikołaj Steike, Poznan University of Technology, pl. M. Skłodowskiej-Curie 5, 60-965 Poznan, mikolaj.steike@student.put.poznan.pl

Abstract: The strength and energy of processed biological materials depend, among others, on the properties of the processed material. The visible biodiversity of plant materials, even within one species, makes it difficult to model machines and processing devices in terms of efficiency and energy consumption. The determination of the mechanical properties of grain biomaterials, including corn, requires the use of specialized research equipment with high measurement accuracy, which is primarily related to the internal structure of grain materials of plant origin. Maize is one of the most cultivated crops in the world and plays a significant role in the agro-food industry. for food, feed, and energy purposes. The aim of the work is to indicate the correlation between the thickness of the maize seed coat and the strength of the biological flow. To achieve the assumed goal, selected physical properties (length, width, and thickness) of corn grains were distinguished, and a static compression test was carried out on the MTS Insight 50 kN testing machine with a test system for experimental verification of the compression forces of biological materials. In addition, after the compression test, the thickness of the seed coat was measured using a laboratory microscope. It was found that there is a correlation between the thickness of the seed coat of maize grain and the strength of the biological flow. These data were used to develop a strength model considering the variable strength of seed coat and endosperm. Further research should focus on determining the forces and energy of processing under dynamic conditions, which better reflect the real nature of mechanical processing.

Keywords: mechanical properties, maize, seed coat thickness, biological flow strength, strength model.

Tribology characteristics of heatproof alloys at a dynamic pin ladening in the variable temperature field

Michał Bembenek, Department of Manufacturing Systems, Faculty of Mechanical Engineering and Robotics, AGH University of Krakow, al. Mickiewicza 30, 30-059 Kraków, Poland, bembenek@agh.edu.pl

Volodymyr Tsyganov, Department of Machine-tool Sand Instrument, National University Zaporizhzhia Polytechnic, 64 Zhukovskogo Str., UA-69063 Zaporizhzhia, Ukraine, tsyganov705@gmail.com

Nataliia Sakhniuk, Department of Aircraft Engine Technology, National University Zaporizhzhia Polytechnic, 64 Zhukovskogo Str., UA-69063 Zaporizhzhia, Ukraine, nat76sah@ukr.net

Olha Lazarieva, Department of Aircraft Engine Technology, National University Zaporizhzhia Polytechnic, 64 Zhukovskogo Str., UA-69063 Zaporizhzhia, Ukraine, lazarevaolha@gmail.com

Ryszard Machnik, Department of Manufacturing Systems, Faculty of Mechanical Engineering and Robotics, AGH University of Krakow, al. Mickiewicza 30, 30-059 Kraków, Poland, machnik@agh.edu.pl

Liubomyr Ropyak, Department of Computerized Mechanical Engineering, Ivano-Frankivsk National Technical University of Oil and Gas, 15 Karpatska Str., UA-76019 Ivano-Frankivsk, Ukraine, l_ropjak@ukr.net

Abstract: An analysis of the operating conditions of gas turbine engines, their components, and the destruction causes was carried out. The designer problems of tribo-joints operating under difficult conditions of force and temperature loads are singled out. The study aimed at obtaining the comparable quantitative dependences of blade material wear, taking into account the role of both cyclical changes in the temperature of the gas flow under the conditions close to real ones, and their frictional characteristics. Deformable heat-resistant nickel alloys and foundry heat-resistant nickel alloys from which T-shaped samples were made, were chosen for the research. The tests were carried out on the developed gas dynamic stand, which simulates the working conditions of the bandage joints of the bladed turbomachines of gas turbine installations. The intensity of wear was determined as the ratio of the worn material volume to the number of load cycles under different temperature conditions. The wear resistance of three-way connections operating under the conditions of non-stationary thermal loads and fluctuations in the contact was considered. It was shown that thermal cycling leads to a decrease in the wear resistance of heat-resistant nickel alloys by 2–3 times and depends on the average temperature of the cycle. It was found that resistance to the wear, and also the character of change of coefficient of friction is mainly determined by the terms of education and destruction of the protective superficial layer. Basic factors managing tribology processes in the zone of contact were determined.

Keywords: heatproof alloys, thermocycling, tribocoupling, superficial layer, wear, wearproofness, coating.

Investigation of carbon nanotube particles addition effect on the dispersed composite structure thermal diffusivity

Łukasz Omen, Faculty of Mechatronics, Armament and Aerospace, Military University of Technology, Gen. S. Kaliskiego Street No 2, 00-908 Warsaw, Poland, lukasz.omen@wat.edu.pl

Robert Szczepaniak, Faculty of Aviation, Polish Air Force University, Dywizjonu 303 Street No 35, 08-521 Deblin, Poland, r.szczepaniak@law.mil.pl

Andrzej J. Panas, Air Force Institute of Technology, Księcia Bolesława Street No 6, 01-494 Warszawa, Poland, andrzej.panas@wat.edu.pl

Abstract: The article addresses the issue of the possibility of improving the thermal transport parameters of an epoxy resin, such as thermal diffusivity (TD) and thermal conductivity (TC), by the addition of carbon nanotubes (CNT) as a high thermal conductivity filler. In the case presented here, the effect of the addition of high TC carbon nanotubes to commercial epoxy resin LH145 cured with H147 hardener was investigated experimentally. The main parameter studied was thermal diffusivity. Measurements were carried out for samples of epoxy resin and epoxy resin matrix composites with dispersed CNTs with a volume fraction of carbon nanotubes ranging from 1% to 6%. A modified Ångström temperature oscillation method was used to obtain TD. Basic measurements were performed in the temperature range from −20 ºC to 80 ºC while maintaining high temperature resolution that allows to observe the TD changes with the temperature change. During extended temperature range additional differential scanning calorimetry studies, the effects after curing of the epoxy resin were also characterized. As a result, the temperature dependence of thermal conductivity was determined and data for determining thermal conductivity was obtained. However, the analysis of the obtained results did not show a significant dependence of the studied parameters on the amount of CNT additive for the studied compositions.

Keywords: thermal conductivity, thermal diffusivity, Ångström method, epoxy resin matrix composites, carbon nanotubes filler, disperdes composite structures.

Impact damage tolerance of multilayer epoxy-glass composites with XPS core and polyurethane prepolymer modified matrix

Joanna Masiewicz, Faculty of Aviation, Polish Air Force University, j.masiewicz@law.mil.pl

Paweł Przybyłek, Faculty of Aviation, Polish Air Force University, p.przybylek@law.mil.pl

Martyna Roszowska – Jarosz, Łukasiewicz Research Network – Institute for Sustainable Technologies, martyna.roszowska-jarosz@itee.lukasiewicz.gov.pl

Marcin Kostrzewa, Faculty of Chemical Engineering and Commodity Science, Kazimierz Pulaski University of Technology and Humanities in Radom, m.kostrzewa@uthrad.pl

Wojciech Kucharczyk, Faculty of Mechanical Engineering, Kazimierz Pulaski University of Technology and Humanities in Radom, wojciech.kucharczyk@uthrad.pl

Mateusz Czyż, Faculty of Information and Communication Technology, Wrocław University of Science and Technology, 242424@student.pwr.edu.pl

Abstract: A significant need within the design of materials for vehicles or other engineering structures is to determine their potential to mitigate impact loads. The material acting as a shield during an impact absorbs energy, dissipating the excess in a process of irreversible deformation. In order to prevent this, or to limit the areas of damage as much as possible, have begun to be used materials that absorb impact energy without drastically compromising their strength. Energy Absorbing Composite Structures (EACS) have the ability to convert impact energy into some form of energy absorbed through deformation. Compared to homogeneous materials, a number of factors also point to the increasing advantage of using composite sandwich structures, which, in addition to their high strength ratings, have a lower weight and a much more effective ability to absorb shock or impact load energy. This paper presents the results of damage tolerance testing of epoxy-glass sandwich composites with chemical modified matrix. The damage tolerance of the composites was determined using an Instron CEAST 9340 testing machine with an impact energy ranging from 5-35J and indicated the value at which visible damage to the composite occurs while it retains some of its strength properties. It was the most important test to determine the damage tolerance, but additional tests to characterise the strength of the composite more comprehensively were also performed. Experimental studies were used to present a methodology for the preliminary characterisation of the material strength and to analyse the relation between structure and mechanical response of the composite.

Keywords: composites, mechanical engineering, modification of composites, mechanical properties.

Numerical study of the natural oscillations of perforated vibrating surfaces with holes of complex geometry

Serhii Kharchenko, Department of Applied Mechanics, Lublin University of Technology, Poland, s.kharchenko@pollub.pl,

Sylwester Samborski, Department of Fundamentals of Production Engineering, Lublin University of Technology, Poland, s.samborski@pollub.pl

Farida Kharchenko, Department of Agricultural Engineering, Sumy National Agrarian University, Ukraine, faridakharchenko@gmail.com

Jakub Paśnik, Department of Machine Design and Mechatronics, Lublin University of Technology, Poland, jakub.pasnik@pollub.edu.pl

Izabela Korzec, Department of Applied Mechanics, Lublin University of Technology, Poland, i.korzec@pollub.pl

Andrzej Mitura, Department of Applied Mechanics, Lublin University of Technology, Poland, a.mitura@pollub.pl

Łukasz Kłoda, Department of Applied Mechanics, Lublin University of Technology, Poland, l.kloda@pollub.pl

Abstract: The widespread use of perforated vibrating surfaces in various industries requires maximum productivity and construction reliability. The research task is to determine the significant factors and their degree of influence on the natural oscillations of vibrating surfaces with multiple holes of complex geometry. For this purpose, studies were carried out for three samples of plates: non-perforated, with basic round holes and holes of complex geometry in the form of a five-petal epicycloid. Studies of the natural oscillations of perforated vibrating surfaces have been conducted using the finite element method in Abaqus, which has proved sufficient accuracy of calculations. The dependencies of the natural oscillation frequency of perforated surface samples on their thickness, partition width between the holes, material type, and fixing method have been obtained. In addition, the analysis involved the study of eight modes of oscillation common in practice. The dependencies of the natural oscillation frequency of perforated surface on the relative parameters of ligament efficiency and stiffness coefficient have also been obtained. These parameters take into account the ratios of the partition width between the holes to the plate thickness and the dimensions of the holes. The research results allow to obtain levels of influence of the perforated vibrating surface parameters on their natural oscillations frequency. The obtained research results make it possible to further determine the absence of damage between the holes and predict the durability of perforated vibration surfaces in the presence of holes of complex geometry.

Keywords: finite element method, natural frequencies, vibration forms, visualization, perforated surface, holes of complex geometry, damage.

The influence of pressure in the infusion method upon mechanical properties of polymer composites

Jacek Janiszewski, Polish Air Force University, Dęblin, Poland, j.janiszewski@law.mil.pl

Andrzej Komorek, Polish Air Force University, Dęblin, Poland, a.komorek@law.mil.pl

Mieczysław Bakuła, Polish Air Force University, Dęblin, Poland, b.pekala5167@wsosp.edu.pl

Rafał Bieńczak, Polish Air Force University, Dęblin, Poland, r.bienczak@law.mil.pl

Bartosz Pękala, Polish Air Force University, Dęblin, Poland, b.pekala5167@wsosp.edu.pl

Abstract: In the modern aerospace industry, a steady increase in the share of composite materials is recorded every single year. Polymer layer composites seem to be the ones that are used most commonly in aviation. There are multiple methods of producing this type of materials, of which the most commonly used methods are as follows: the infusion method, the negative pressure bag method and the hydraulic press method. The infusion process makes it possible to obtain composites with the best mechanical properties. In the infusion process, the mould is pre-prepared (together with the reinforcement made of the material from which the composite is made, e.g. carbon fibre), which is tightly closed in a negative pressure bag, and the equipment supplying the previously mixed resin with hardener is connected to the injection points. The negative pressure generated by the negative pressure pump in the mould prepared in this way (negative pressure bag) makes the previously prepared resin seep through the reinforcement material. Various negative pressure levels can be used. This work describes the effect of the applied negative pressure level on the obtained mechanical properties of a composite reinforced with carbon fibres. It appears that the best visual properties of the composite material are obtained with the use of indirect (optimal) negative pressure but the best strength properties with the use of maximal negative pressure.

Keywords: sandwich composites, composite manufacturing processes, infusion method.

The influence of conditioning on dynamic behaviour of polymer composites

Marek Borowiec, Department of Applied Mechanics, Lublin University of Technology, ul. Nadbystrzycka 36, 20-618 Lublin, Poland, m.borowiec@pollub.pl

Robert Szczepaniak, Faculty of Aviation, Polish Air Force University, ul. Dywizjonu 303 no. 35, 08-521 Dęblin, Poland, r.szczepaniak@law.mil.pl

José Machado, MEtRICs Research Center, University of Minho, Campus of Azurém, 4800-058 Guimarães, Portugal

Abstract: The aim of this study is to determine the effect of environmental factors in the form of UV radiation and temperature on the amplitude-frequency behaviour of polymer composites (prepregs) based on a framework of thermosetting epoxy resin reinforced with high-strength R-glass fibres. Two series of composites with different fibre arrangements were prepared. The series had fibres arranged at angles of 30°, 45°, and 60°, at symmetric and asymmetric orientations in relation to the central layer. The composites were subjected to conditioning which simulated a six-month period of use in the spring and summer in the temperate warm transitional climate of Central and Eastern Europe. An UV QUV/SPRAY/RP accelerated aging chamber manufactured by Q - Lab Corporation was used for this purpose, and UV-A 340 lamps were used to simulate daylight. In addition, varying loads caused by sudden temperature changes were simulated using the Thermal Shock Chamber T/60/V2 Weisstechnik. Conditioned samples were tested using a TIRAvib 50101 electromagnetic exciter in combination with an LMS Scadias III controller and Test.Lab software. The results of the tests, in the form of amplitude-frequency diagrams in resonance regions, indicated that certain changes occurred as a result of the conditioning, which is a new development in the area of material tests. The results shed light on the effects of environmental conditions on the stiffness characteristics of composites, causing dynamic nonlinearities when operating at resonant frequencies

Keywords: vibrations, conditioning, composites.

Corrosion resistance of heat treated 17-4PH steel fabricated using DMLS technology

Aleksander Świetlicki, Department of Materials Engineering, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, aleksander.swietlicki@pollub.edu.pl

Mariusz Walczak, Department of Materials Engineering, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, m.walczak@pollub.pl

Mirosław Szala, Department of Materials Engineering, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, m.szala@pollub.pl

Abstract: Additive technologies have gained in popularity in recent years, direct metal laser sintering (DMLS) technology belonging to powder bed fusion method allows to fabricate of object of complex shapes with high accuracy easily. DMLS is advanced material fabrication method where laser scans the powder bed filled with metallic material. Application of 17-4PH steel ranges from aerospace, maritime, and automotive to medical instruments and nuclear power plant applications. This grade of steel is often applied where high mechanical performance is required. 17-4PH, AISI 630, X5CrNiCuNb16-4 steel is intended for participation hardening heat treatment process that enables the combination of high mechanical strength and hardness trough precipitation of highly dispersed Cu particles in martensitic matrix. However, those high mechanical properties might be achieved only after precipitation hardening. Such a process is often applied to conventional 17-4PH steel. On the other hand, is material fabricated via DMLS method with similar mechanical but different microstructural properties. Due to the fact that heat treatment may influence corrosion resistance and the results obtained for DMLS steel are different this investigation was needed. Mechanical properties were investigated using a Vickers microhardness tester together with contact profilometry. Corrosion resistance was measured through electrochemical accelerated test in 3,5% NaCl solution on the electrochemical Atlas 0531 test kit. Optical microscopy was applied to investigate the corrosion pits. Tafel curves were established and corrosion from that corrosion potential together with corrosion current density were determined.

Keywords: Additive manufacturing, heat treatment, corrosion resistance, DMLS.

Influence of deposition parameters on properties of coatings made by plasma-powder PTA method

Weronika Henzler, Students Research Group of Materials Technology, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, weronika.henzler@pollub.edu.pl

Natalia Fedec, Students Research Group of Materials Technology, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland

Julia Wójtowicz, Students Research Group of Materials Technology, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, s98360@pollub.edu.pl

Nikola Woźniak, Students Research Group of Materials Technology, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, s98358@pollub.edu.pl

Klaudia Tarach, Students Research Group of Materials Technology, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, s98352@pollub.edu.pl

Mirosław Szala, Department of Materials Engineering, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, m.szala@pollub.pl

Abstract: The plasma transferred arc (PTA) deposition method is applied to prolong the durability of the metal tools and components in metal forming automotive and energy industries. This study aimed to evaluate the effect of PTA plasma-powder deposition parameters on the hardness, internal structure and geometry of the surfacings. The surfacing layers were made using two types of powders: Stellite 6 and 316L on S235JR steel substrate. The surfacing process was carried out on a robotized powder-plasma PTA surfacing station. The set of overlay welds was welded using different deposition parameters. The changeable parameters were the value of the welding current and the welding speed, and the effects of these parameters on the geometry of the weld beads, microstructure, mixing ratio and hardness were studied.

The research proved that, among other things, the surfacing speed affects the width of the surfacing, and the height of the surfacing affects the value of the mixing coefficient. The made surfacings were characterized by a dendritic structure, in addition, at the edges of the surfacings made of Stellite 6, the occurrence of smaller dendrites was observed, which may be associated with higher hardness values in these areas compared to the central part of the surfacing face. The hardfacings made from 316L steel, which were characterized by a greater height and width, obtained a lower value of the material mixing ratio. The average hardness of the surfacings made from Stellite 6 is higher than those made from corrosion-resistant 316L steel. The highest microhardness values in the surfacing of Stellite 6 are found at the top and side edges, while in the surfacing of 316L steel they are found in the surfacing

center. The preliminary results introduce the optimization of PTA technological parameters to obtain the low dilution and wear resistant layers.

Keywords: plasma deposition, coatings, surface engineering, welding.

Modification of 42CrMo4 steel hardness via heat treatment

Julia Wójtowicz, Students Research Group of Materials Technology, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, s98360@pollub.edu.pl

Nikola Woźniak, Students Research Group of Materials Technology, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, s98358@pollub.edu.pl

Weronika Henzler, Students Research Group of Materials Technology, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, weronika.henzler@pollub.edu.pl

Klaudia Tarach, Students Research Group of Materials Technology, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, s98352@pollub.edu.pl

Mirosław Szala, Department of Materials Engineering, Mechanical Engineering Faculty, Lublin University of Technology, Nadbystrzycka 36, 20-618 Lublin, Poland, m.szala@pollub.pl

Abstract: 42CrMo4 steel is an interesting material applied in different types of industries such as automotive, mechanica and mining. The subject of the research paper is the analysis of the effect of heat treatment parameters on 42CrMo4 steel. In the research part of the work, the characterization of 42CrMo4 steel was performed, and the heat treatemnt equipment used to carry out selected heat treatment processes such as annealing, case hardening and tempering were presented. Another part of this part of the work was the execution of the machining procedures. This was followed by a metallographic study, which showed the microstructure of the steel after the processes performed. Vickers hardness tests alows to estimate the effect of heat treatemtn. Analysis of the results shows that the highest hardness of 805 HV was achieved by sample number II, subjected to the hardening process. On the other hand, the lowest hardness of 166 HV was obtained by sample number VI, subjected to softening annealing. The purpose of the study was realized and showed how heat treatment parameters and their selection influenced the hardness of 42CrMo4 steel in selected processes in such an important and constantly developing industrial area as heat treatment.

Keywords: Microstructure, hardness, heat treatment, steel.

Surface characteristics and corrosion resistance of 316L stainless steel after different shot peening parameters

Mariusz Walczak, Department of Materials Engineering, Faculty of Mechanical Engineering, Lublin University of Technology, m.walczak@pollub.pl

Abstract: According to data available in the literature the shot peening of stainless steel leads to nanocrystallization in surface layer which has a favorable influence on corrosion resistance and hardness except of strength increase. Dislocation density and treatment parameters can affect the properties of a surface layer of the products being modified. In accordance with our own research and information available in literature as a result of shot peening process, the shot grains can penetrate the surface layer (permanently depositing) and modify mechanical performance and corrosion resistance in the products being modified in this way. The objective of this study is to determine the effect of shot peening on the surface properties, hardness characteristics and corrosion resistance of AISI 316L stainless steel. Samples of this steel grade were shot peened with CrNi steel shot, External surfaces of the sample face were subjected to shot peening with the Peenmatic micro 750S (IEPCO, Switzerland), using CrNi steel shot. Two different peening pressures and were applied: 0.3 and 0.4 MPa. The peening time were treated separately 60 s and 120 s. After that, the samples were subjected to profilometry analysis and SEM examination to evaluate their surface's microhardness and corrosion resistance. Shot peening increases surface hardness and improves its resistance to corrosion.

Keywords: AISI 316L, stainless steel, shot peening, corrosion resistance.

Infrared sintering of various nanosilver inks in aerosol jet printing

Wojciech Łapa, Faculty of Mechanical Engineering, Wrocław University of Science and Technology, Łukasiewicza 5 St., 50-371, wojciech.lapa@pwr.edu.pl

Marcin Winnicki, Faculty of Mechanical Engineering, Wrocław University of Science and Technology, Łukasiewicza 5 St., 50-371, marcin.winnicki@pwr.edu.pl

Leszek Łatka, Faculty of Mechanical Engineering, Wrocław University of Science and Technology, Łukasiewicza 5 St., 50-371, leszek.latka@pwr.edu.pl

Abstract: The market for flexible electronics experiences annual growth, with electronics printing playing a significant role. Printed electronics finds application across various domains, encompassing sensors, RFID, displays, and energy harvesting. The inherent high elasticity of these devices has led to an increased focus on Direct Write processes, enabling the rapid manufacturing of diverse and innovative products. One such innovative technique is Aerosol Jet Printing (AJP), which leverages an aerosol stream of Ag nanosilver ink focused by an aerodynamic lens. AJP offers several advantages over the well-established Ink Jet printing method, including the capability to print on three-dimensional structures and the utilization of a broader spectrum of inks. Despite the existence of commercially available printers, challenges persist in ensuring process stability and obtaining consistent outcomes. The properties of the ink are of paramount significance, as is the drying and sintering process, in determining the final quality of the conductive pathways. Insufficient silver nanoparticle content or inadequate heating can result in structural damage to the printed traces. Consequently, this leads to a reduction in conductivity or even a complete interruption of electric charge transfer. The incorporation of a heated table and the application of an infrared lamp during the process enable precise control of the drying and sintering of the sprayed pathways.
In this study, data were gathered employing an optical microscope, a scanning electron microscope, and an atomic force microscope. Additionally, adhesion to the surface was assessed utilizing the tape-test method in accordance with ISO 2409 standard. Parameters related to the sintering process, such as the traverse speed of the infrared lamp and voltage, exhibit a significant correlation with the quantity of ink deposited on the substrate. The degree of material sintering plays a pivotal role in influencing both its adhesion to the substrate and its electrical conductivity. Methodologies for evaluating the adequacy of the sintering process have been introduced.

Keywords: Nanosilver ink, Aerosol Jet Printing, IR-sintering, printed electronics.

PRODUCTION ENGINEERING, MANAGEMENT AND QUALITY CONTROL

Analysis of the possibility of using neural networks to monitor the technical efficiency of diesel engines during operation

Olga A. Orynycz, Department of Production Management, Bialystok University of Technology, Wiejska Street 45A, 15-351 Bialystok, Poland, o.orynycz@pb.edu.pl

Karol Tucki, Department of Production Engineering, Institute of Mechanical Engineering, Warsaw University of Life Sciences, Nowoursynowska Street 164, 02-787 Warsaw, Poland, karol_tucki@sggw.edu.pl

Antoni Świć, Faculty of Mechanical Engineering, Lublin University of Technology, Nadbystrzycka 36 St., 20-618 Lublin, Poland, a.swic@pollub.pl

Andrzej Wasiak, Department of Production Management, Bialystok University of Technology, Wiejska Street 45A, 15-351 Bialystok, Poland, a.wasiak@pb.edu.pl

Remigiusz Mruk, Department of Production Engineering, Institute of Mechanical Engineering, Warsaw University of Life Sciences, Nowoursynowska Street 164, 02-787 Warsaw, Poland, remigiusz_mruk@sggw.edu.pl

Akadiusz Gola, Faculty of Mechanical Engineering, Lublin University of Technology, Nadbystrzycka 36 St., 20-618 Lublin, Poland, a.gola@pollub.pl

Abstract: The aim of the research was to analyze the possibility of detecting anomalies in the operation of common rail injectors using configured and trained artificial intelligence (AI) tools. On the selected diesel engine fuel system, instantaneous common rail pressure values were measured taking into account changes in: average common rail pressure, injector opening times for pilot fuel dose and for operating doses, engine speed and composition of fuel mixture with bioadditives. Subsequently, the research material was used to build a dynamic model for detecting common rail anomalies in dedicated tools. The machine learning process of the developed model of neural networks was carried out on the basis of the acquired data of the learners. Using software development tools for embedded systems, a dynamic common rail anomaly detection model has been prepared so that the embedded system can be programmed. Tests were carried out on the behaviour of an embedded system containing a dynamic anomaly detection model on a running engine. During engine operation, changes were made to the operating parameters of the common rail system to introduce anomalies. The behavior of the developed system towards correctness of detection of anomalies was analyzed.

Keywords: biofuel, engine, fuel, vehicle, DPF.

TECHNOLOGY MANAGEMENT IN ENERGY ACQUISITION PROCESSES

Characterizing sawdust fractional composition from oak parquet woodworking for briquette and pellet production

Łukasz Warguła, Poznan University of Technology, lukasz.wargula@put.poznan.pl

Dominik Wilczyński, Poznan University of Technology, dominik.wilczynski@put.poznan.pl

Bartosz Wieczorek, Poznan University of Technology, bartosz.wieczorek@put.poznan.pl

Maciej Sydor, Poznań University of Life Sciences, maciej.sydor@up.poznan.pl

Carla Nati, National Research Council in Florence, carla.nati@ibe.cnr.it

Teijo Palander, University of Eastern Finland, teijo.s.palander@uef.fi

Łukasz Gierz, Poznan University of Technology, lukasz.gierz@put.poznan.pl

Abstract: The particle size distribution of woodworking residues influences the quality of the biofuels made of these materials. Hence, it is essential to investigate the fractional composition of raw materials for pellet production. Tested materials originated from ten parquet manufacturing facilities located in western Poland. The research material consisted of uncontaminated oak (Quercus spp.) wood particles. The tested material had a moisture content ranging from 8.8% to 11.4% and a density of 210.7 ± 1.79 kg/m3. A sieve analysis method segregated the tested material into four distinct size fractions (<1.0 mm, 1.0-2.5 mm, 2.5-5.0 mm, and >5 mm). The average mass shares in these fractions were 53.72 ±0.51%, 35.14 ±0.27%, 9.59 ±0.36%, and 1.55% ±0.11%, respectively. The particle size distributions of wood particles generated in all the facilities demonstrate remarkable similarity. No substantial differences were observed in terms of tilt angle and calorific value. Factors such as variations in raw material species, geographical origins, density, humidity, and technological processes appear to have minimal influence on the sieve-size distributions of the generated sawdust. All these solid wood processing residues can undergo processing into high-quality solid biofuel production.

Keywords: carpentry waste, wood particles, production waste, wood particle size, fraction analysis.

Stress relaxation in sugar beet root under various mechanical load conditionsn

Paweł Kołodziej, Department of Mechanical Engineering and Automatic Control, University of Life Sciences in Lublin, 28 Głęboka St., 20-612 Lublin, Poland, email: pawel.kolodziej@up.lublin.pl, ORCID 0000-0003-0479-1770

Zbigniew Stropek, Department of Mechanical Engineering and Automatic Control, University of Life Sciences in Lublin, 28 Głęboka St., 20-612 Lublin, Poland, zbigniew.stropek.@up.lublin.pl

Krzysztof Gołacki, Department of Mechanical Engineering and Automatic Control, University of Life Sciences in Lublin, 28 Głęboka St., 20-612 Lublin, Poland, krzysztof.golacki@up.lublin.pl

Abstract: Identification and evaluation of the mechanical properties of biological materials, especially fruits, vegetables and industrial plants, can be carried out through commonly used stress relaxation tests. The tests are of particular significance because their results make it possible to propose a mechanical model of studied material. The aim of the study was to determine the effects of initial deformation and deformation velocity on the parameters of generalised Maxwell model during stress relaxation in sugar beet root. Tests were performed with texture analyser (model TA.HD plus, Stable Micro Systems, Goldaming, UK) at three deformations: 2 mm, 3.5 mm and 5 mm and four deformation velocities: 1 mm/s, 2 mm/s, 10 mm/s and 20 mm/s. The cut sugar beet samples used for the experiment were cylindrical in shape, with 9.5 mm in diameter and 20 mm in height. The samples were initially compressed along the vertical axis in a state of uniaxial stress and constant deformation was maintained while recording the force response for 35 seconds. Two-branched generalised Maxwell model with an additional elastic element was used to describe the experimental force response curves. Dimensions of the sample as well as initial deformation velocity were taken into consideration in the model formula. Two relaxation times of the model decreased with the increase of deformation velocity and increased with the increase of deformation value. The relaxation times were related to the process of gas and liquid flows in the intercellular spaces. Changes of model parameters in the function of deformation velocity could testify the appearance of internal micro damages in the material during deformation. The increase in the peak force response along with the increase of deformation velocity shows typical viscoelastic behaviour of sugar beet root flesh.

Keywords: mechanical properties, sugar beet root, stress relaxation.

Enhancing the efficiency of the Levenshtein distance based heuristic method of arranging 2D apictorial elements for industrial applications

Stanisław Skulimowski, Lublin University of Technology, s.skulimowski@pollub.pl

Jerzy Montusiewicz, Lublin University of Technology, j.montusiewicz@pollub.pl

Marcin Badurowicz, Lublin University of Technology, m.badurowicz@pollub.pl

Abstract: The article addresses the challenge of reconstructing 2D broken pictorial objects by automating the search for matching elements, which is particularly relevant in fields like archaeology and forensic science. The authors propose a method to match such elements and streamline the search process by detecting and filtering out low quality matches.
The study delves into optimizing the search process in terms of duration and assembly quality. It examines factors like comparison window length, Levenshtein measure margin, and number of variants to check, using theoretical calculations and experiments on synthetic elements. The experimental results demonstrate enhanced method effectiveness, yielding more useful solutions and significantly reducing the complexity of element comparisons by up to 100 times in extreme cases.

Keywords: Levenshtein measure, apictorial, assembly, cut-off, fuzzy-logic.

Research of electrical parameters of start-up process of single-cylinder diesel engine

Jacek Caban, Lublin University of Technology, j.caban@pollub.pl

Abstract: The start-up is a transient state of operation of an internal combustion engine during which many negative phenomena occur that affect the technical condition of the engine, its electrical equipment and the natural environment. The start-up process of an internal combustion engine is influenced by many factors, such as: technical condition of the starting system, technical condition of the engine, battery charge level, lubricant properties, engine standstill time, engine temperature, etc. Mechanical energy is required to start the engine, supplied by an electric starter by drives the engine's crankshaft. Knowledge about the operating parameters of the electric starter during the start-up process is important not only for the user of the engine (vehicle driver), but above all for designers of modern combustion engine starting systems and service personnel. The paper presents the results of experimental tests of electrical parameters of the single-cylinder diesel engine start-up process at variable fuel injection parameters under ambient temperature conditions.

Keywords: electrical current consumption; electric starter; technical condition; combustion engine.

Effect of bond end shape on CFRP to steel joint strength under the fatigue load

Maciej Kowal, Department of Roads and Bridges, Faculty of Civil Engineering and Architecture, Lublin University of Technology, ul. Nadbystrzycka 40, 20-618 Lublin, Poland, m.kowal@pollub.pl

Abstract: The main issue in reinforcing steel structures with the use of CFRP composites is the proper and permanent connection of the elements. When it comes to reinforcing steel structures with adhesive bonded CFRP composite tapes, the adhesive is the weakest link. That is why proper shaping the adhesive joint when reinforcing steel elements with composites is so important. Reinforcement of the structure is considered in the event of damage, cracks or the need to increase the load capacity of the structure. And if it is economically and technically justified. The selection of the cross section of CFRP required for reinforcement or repair depends on the amount of damage or cross section necessary to carry the loads. The article describes the experimental studies of the influence of the shape of the CFRP-adhesive-steel joint ends on the joint's load capacity under fatigue load. Highly modular CFRP tapes with a cross-section of 20 x 1.4 mm were used in the tests. Mild steel samples with a round notch with an artificial crack were adopted for reinforcement. The shape of the samples was to imitate damaged riveted elements. Four shapes of CFRP plate ends were tested. The research is an extension of the authors' previous research and an introduction to the fatigue strengthening of steel elements with a notch. The results showed that small cross-sections of CFRP may good alternative of reinforcing with passive methods. The proper shape of the bond end has impact on the bond strength between CFRP and steel under fatigue load.

Keywords: steel structures, CFRP plates, bond end shaping, fatigue load.

Implementation of PID autotuning procedure based on doublet-pulse method in PLC controller

Michał Awtoniuk, Institute of Mechanical Engineering, Warsaw University of Life Sciences, Nowoursynowska 166, 02-787 Warsaw, Poland, michal_awtoniuk@sggw.edu.pl

Robert Sałat, Faculty of Electrical and Computer Engineering, Cracow University of Technology, Warszawska 24, 31-155 Krakow, Poland, robert.salat@pk.edu.pl

Miłosz Worwa, Faculty of Electrical and Computer Engineering, Cracow University of Technology, Warszawska 24, 31-155 Krakow, Poland, milosz.worwa13@gmail.com

Bartosz Klimek, Faculty of Production Engineering, Warsaw University of Life Sciences, Nowoursynowska 166, 02-787 Warsaw, Poland, bartosz.klimek9@gmail.com

Volodymyr Reshetiuk, Institute of Mechanical Engineering, Warsaw University of Life Sciences, Nowoursynowska 166, 02-787 Warsaw, Poland, volodymyr_reshetiuk@sggw.edu.pl

Abstract: The paper describes the implementation of a PID controller autotuning procedure based on the doublet-pulse method. The doublet-pulse method is used as a tool to identify the control object. Its main advantage is its simplicity, requiring only two parameters to be declared, i.e. the amplitude and duration of the two step signals. We combined the doublet-pulse method with the AMIGO tuning rules and implemented this combination as a stand-alone autotuning procedure in Siemens S7-1200 PLC controller. The procedure was tested for three types of simulated plant models and for a pilot-scale dryer model. The simulated models were diverse in terms of dynamics, as we used lag-dominated, balanced, and delay-dominated models. We compared the doublet-pulse method with the classical identification method in the form of step response. We conducted tests for two scenarios, i.e. a step change in the set point and load disturbances. To assess control quality, we used several integral indexes, i.e. IAE, ISE, CE, TVu. The described method is universal and can also be implemented in controllers from other manufacturers.

Keywords: doublet-pulse, system identification, PID, PLC.