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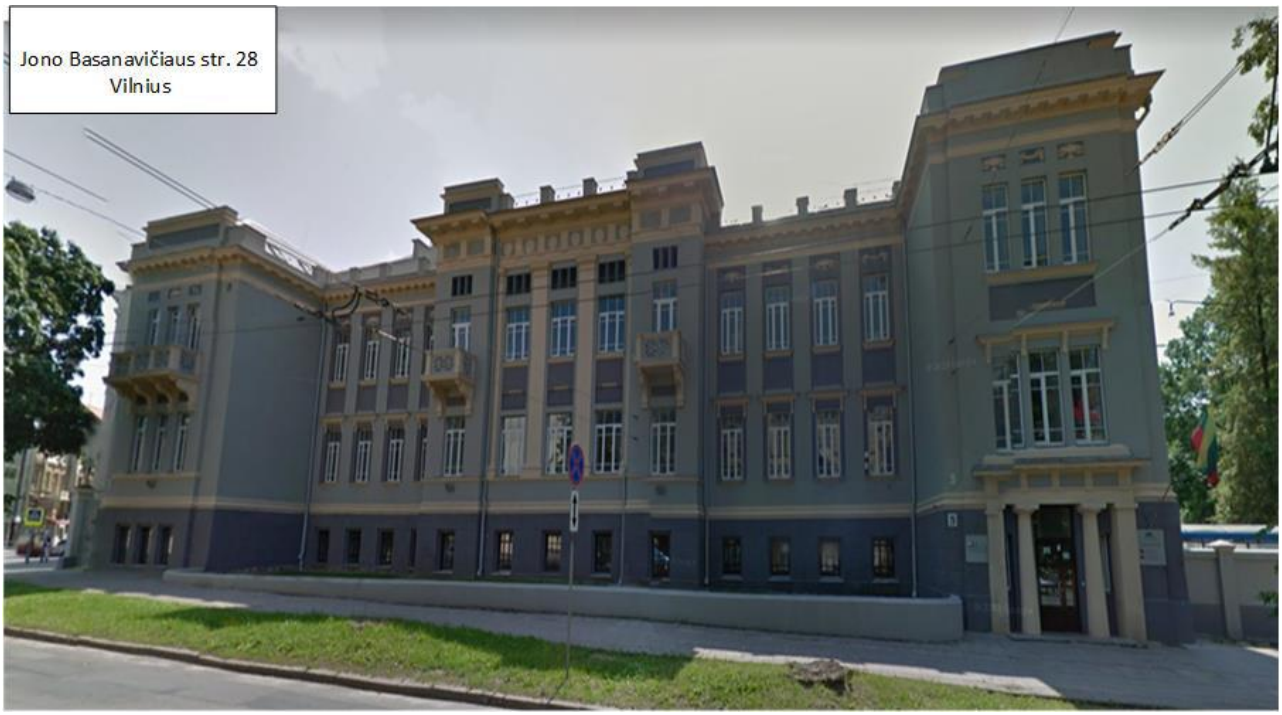

ABSTRACT BOOK

The 16th International Conference "Mechatronic Systems and Materials" (MSM 2021) is being organized by:

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MECHATRONIC SYSTEMS

5 – DOF planar – rotary motions piezoelectric robot

Andrius ČEPONIS[1,a *], Vytautas JURĖNAS[1,b] and Dalius MAŽEIKA[2,c]

[1]Robotics and Piezomechanics Laboratory, Institute of Mechatronics, Kaunas University of Technology, K. Donelaičio str. 73, Kaunas, Lithuania

[2]Department of Information Systems, Faculty of Fundamental Sciences, Vilnius Gediminas Technical University, Saulėtekio avn., 11, Vilnius, Lithuania

[a]andrius.ceponis@ktu.lt, [b]vytautas.jurenas@ktu.lt, [c]dalius.mazeika@vilniustech.lt

*the corresponding author

Keywords: 5 – DOF, unlimited planar displacement range, micro – scale resolution, rotary motion.

Abstract. The paper represents numerical and experimental investigation of 5 – DOF piezoelectric robot which is able to provide two types of motions during operation in different modes i.e. planar and rotary motion modes. Therefore, while the rotary motion mode is active the robot is able to generate rotation of spherical rotor in three directions. Otherwise, if the planar motion mode is active the robot is able to generate unlimited displacement range motion in plane while rotary motion of spherical rotor is not generated. The planar displacement range is limited only by desired operation surface. The design of the robot is simple and is based on piezoelectric ring and passive layer made from stainless steel. The planar or rotary motion can be excited by one or two harmonic excitation signals which should be applied to appropriate electrodes which are formed on top surface of the ring. The operation principle of the robot is based on two vibration modes i.e. radial and bending modes of piezoelectric ring. Numerical and experimental investigations showed that proposed design of the robot is suitable to generate two types of motion and showed that motion modes does not interacts with and does not have influence to accuracy of motions.

Funding: This research was funded by the European Social Fund according to the activity “Promotion of postdoctoral fellowships studies” of Measure No. 09.3.3-LMT-K-712

Small size 2-DOF piezoelectric platform for unlimited locomotion

Andrius ČEPONIS[1,a *], Dalius MAŽEIKA[2,b], Vytautas JURĖNAS[3,c], Piotr VASILJEV[4,d], Regimantas BAREIKIS[4,e], Sergejus BORODINAS[5,f] and Vytautas OSTAŠEVIČIUS[3,g]

[1]Department of Engineering Graphics, Faculty of Fundamental Sciences, Vilnius Gediminas Technical University, Saulėtekio avn. 11, Vilnius, Lithuania

[2]Department of Information Systems, Faculty of Fundamental Sciences, Vilnius Gediminas Technical University, Saulėtekio avn. 11, Vilnius, Lithuania

[3]Institute of Mechatronics, Kaunas University of Technology, K. Donelaičio str. 73, Kaunas, Lithuania

[4]Education Academy, Vytautas Magnus University, K. Donelaičio str. 58, Kaunas, Lithuania

[5]Department of Applied Mechanics, Faculty of Civil Engineering, Vilnius Gediminas Technical University, Saulėtekio avn. 11, Vilnius, Lithuania

[a]andrius.ceponis@vilniustech.lt, [b]dalius.mazeika@vilniustech.lt, [c]vytautas.jurenas@ktu.lt,

[d]piotr.vasiljev@vdu.lt, [e]regimantas.bareikis@vdu.lt, [f]sergejus.borodinas@vilniustech.lt,

[g]vytautas.ostasevicius@ktu.lt

*the corresponding author

Keywords: 2DOF positioning platform, a piezoelectric actuator, unlimited displacement range.

Abstract. The paper represents a numerical and experimental investigation of a 2DOF piezoelectric positioning platform that can provide unlimited displacement in the plane. The platform consists of three piezoelectric bimorph plates that are located around the triangle-shaped supporting structure by an angle of 120 degrees. Spherical alumina contacts are glued at the bottom surface of each bimorph plate. The platform is an active part of the system and can move on the hard surface in an unlimited displacement range. The platform's operation principle is based on the excitation of the first bending mode of piezoelectric bimorph plates. Two thin connecting beams are placed at nodal lines of the bimorph plate's vibration and are used for plate clamping to the supporting triangle structure. The direction of the platform motion is controlled by corresponding excitation regimes of the piezoelectric bimorph plates. Linear movement of the platform is achieved when the harmonic signal is applied to the single bimorph plate. The remaining two plates operate as passive supports in this case. Moreover, in order to obtain the nonlinear trajectory of the platform motion, the bimorph plates are excited using harmonic electric signals with different amplitudes. A numerical investigation of the 2-DOF platform was performed, and it was found out that the suitable vibration mode of the bimorph plates occurs at 23.54 kHz. Harmonic response analysis showed that the maximum displacement amplitude of the contact reached 561.12 µm in the Z direction while an excitation signal of 210 Vp-p was applied. Prototype 2-DOF piezoelectric platform was made, and an experimental study was performed. Impedance–frequency measurements showed that the operating frequency of the platform is at 23.15 kHz. The maximum linear velocity of 44.45 mm/s was obtained while load of 55.68g N and applied and electrical signal of 210 Vp-p was used.

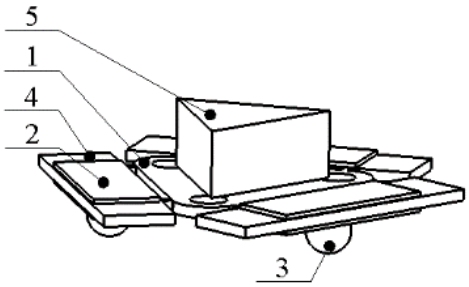

Fig.1. Design of 2-DOF platform; 1 – a support triangle; 2 – piezo ceramic plates; 3 – contact spheres; 4 – load of the platform; 5 – elastic plate.

Funding: This research has received funding from the European Regional Development Fund (project No 01.2.2-LMT-K-718-01-0010) under a grant agreement with the Research Council of Lithuania.

Precision of Simulation Models of Human Lower Limb Motion

Dmitri RÕBAK[1,a], Victor MUSALIMOV[2,b], Gennady ARYASSOV[3,c] and Igor PENKOV[4,d] *

[1] Department of Mechanical and Industrial Engineering, Tallinn University of Technology, Tallinn, Estonia

[2] Department of Mechatronics, National Research University of Information Technology, Mechanics and Optics, Saint-Petersburg, Russia

[3] Virumaa College, Tallinn University of Technology, Kohtla-Järve, Estonia

[4] Department of Mechanical and Industrial Engineering, Tallinn University of Technology, Tallinn, Estonia

[a]dmitrirybak@gmail.com, [b]musvm@ya.ru, [c]gennadi.arjassov@taltech.ee, [d]igor.penkov@taltech.ee

*the corresponding author

Keywords: Knee Joint, Modelling, Capture System, Bio-mechatronics, Inertia, Accelerometer.

Abstract. The paper discusses possibility for using marker and markerless capture systems for analyzing of human motion. Accuracy of human motion simulation will be compared on base of two optical systems – Vicon and Kinect. The first system uses markers for capture of human motion and the second one is markerless. Tests with Kinect system were made in laboratory of Tallinn University of Technology and Vicon system results were obtained in the research center of St. Petersburg State University of Film and Television [1]. Kinect is a device of small size, consisting of a projector emitting infrared radiation, an infrared receiver, a conventional optical camera and a chip, which allows recognizing the movements of objects and people in three-dimensional space. The device projects infrared rays and receives them back, analyzing the time spent on the path of the ray, and thus, building a depth manuscript of the images.

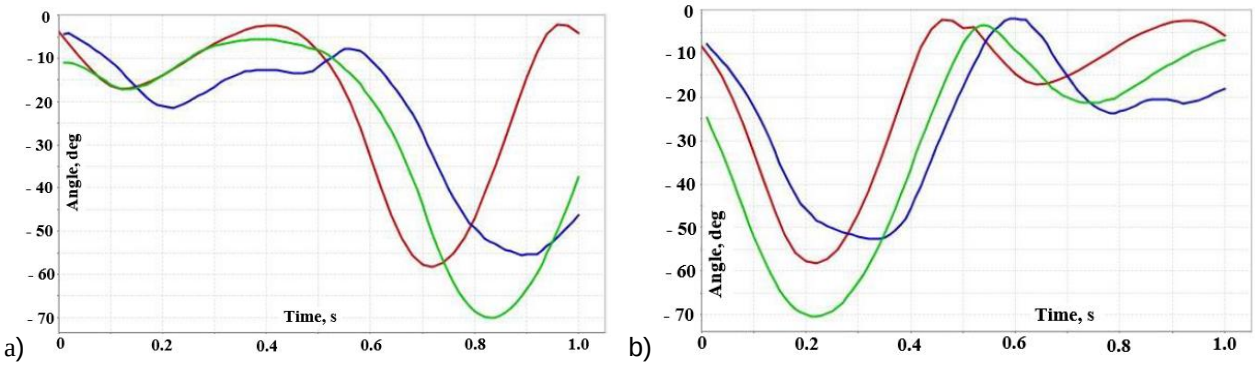

Fig. 1. Motion of human lower limb: a) right knee, b) left knee; green line – Vicon results, blue line – Kinect results, red line – OpenSim model results.

There were measured motion of human knee and ankle by Vicon and Kinect systems and obtained results were compared to standard model of OpenSim system. Results are presented in the Fig. 1. Generally, right and left knees motion obtained by marker and markerless systems are close to the standard model. Data obtained by Vicon system repeat the knees motions more precisely than the data obtained by Kinect system, but the angle change of the knee in the Kinect system is more precisely. This takes place due to the approximation of the lower limbs' movements in the process of the motion capture by the

systems Vicon and Kinect. The discrepancy between the data over time takes place due to the data lagging.

Since both marker and markerless systems give close results for motion simulation, let us analyze relative displacement of femur and cnemis by help of Matlab and based on the data obtained by Vicon and Kinect. Results are shown in the Figs. 3 and 4. It is possible to see that the magnitudes of angle between femur and cnemis for right leg vary in range from – 0.6° to – 70.0° in case of Vicon using. In case of Kinect this range is from – 4.2° to – 55.5°. For left leg these values will be from – 3.3° to – 70.4° and from – 1.8° to – 55.5° for Vicon and Kinect measuring accordingly.

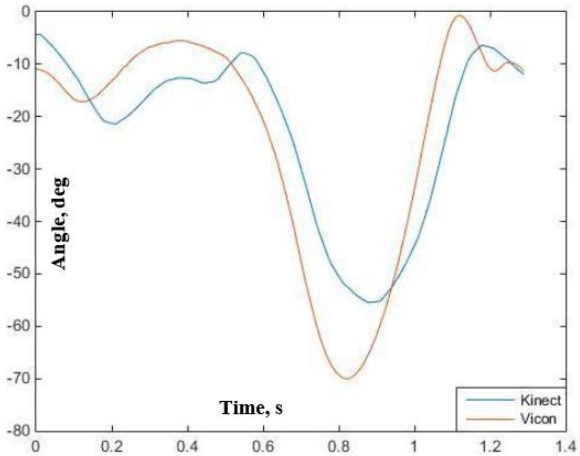

Fig. 2. Angle between femur and cnemis of the right leg

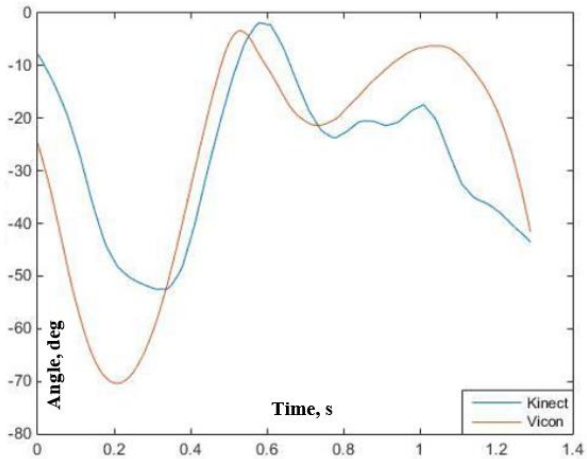

Fig. 3. Angle between femur and cnemis of the left leg

Analyzing of inertial systems is based on laboratory tests conducted in Tallinn University of Technology [2] and Saint-Petersburg National Research University of Information Technology, Mechanics and Optics [3]. Method is enough exact but needs lot of accelerometers and complicated analysis after obtaining of test data. Because of this, it will be considered only motion of human foot. Movements of right and left foot for one motion cycle are presented in Fig. 4.

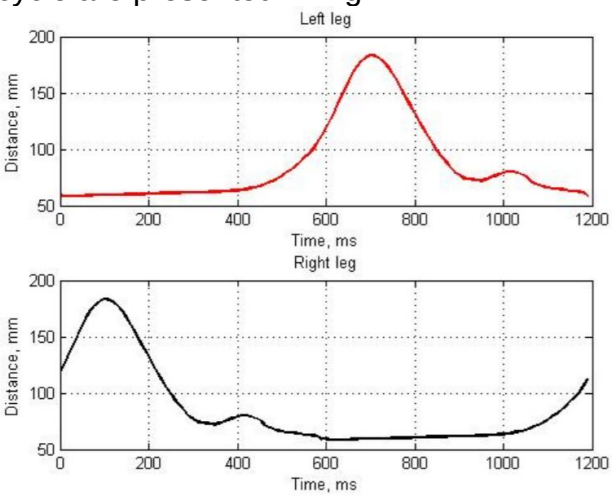

Fig. 4. Foot motion during walking of inertial

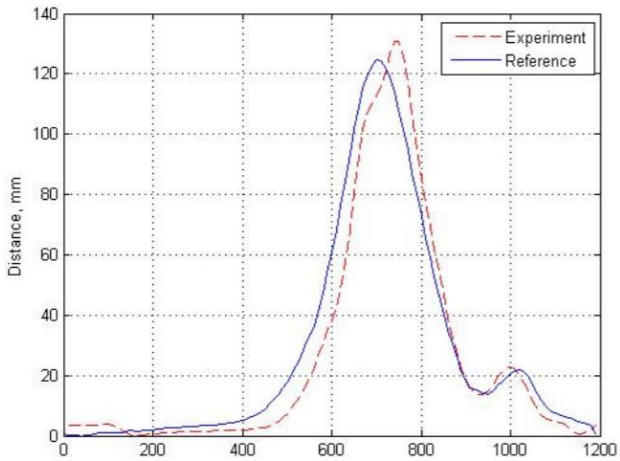

Fig. 5. Foot motion obtained by help measuring system

The experimental results obtained in our laboratory were compared to the results described above. The comparison is presented in Fig. 5. Experimental and referenced lines are very close but there is a little difference in time. The results deviation is about 5%.

References

[1] I. Rubinshtein. Modeling movement of the lower human limbs by using IT technology. MSc. thesis, Tallinn University of Technology, 2016.

[2] S. Zhigailov, V. Musalimov, G. Aryassov, I. Penkov. Modelling and Simulation of Human Lower-Limb Motion. International Review on Modelling and Simulations, Vol. 9, (No. 2): 114–123, 2016.

[3] A. Verchenko, Design of a control system of experimental plant for pelvis movement imitation, MSc. thesis, Tallinn University of Technology, 2015.

Mathematical modelling and theoretical research of micropositioning system

Jurga SUBAČIŪTĖ - ŽEMAITIENĖ[1,a *], Vaiva TREČIOKAITĖ[2,b], Nikolaj ŠEŠOK[3,c], Ernestas ŠUTINYS[4,d], Andrius DZEDZICKIS[5,e] and Vytautas BUČINSKAS[6,f]

[1,2,3,4,5,6] Vilnius Gediminas technical university, Department of Mechatronics, robotics and digital manufacturing, J. Basanaviciaus str. 28, LT-03224 Vilnius, Lithuania

[a]jurga.subaciute-zemaitiene@vilniustech.lt, [b]vaiva.treciokaite@stud.vgtu.lt,

[c]nikolaj.sesok@vilniustech.lt, [d]ernestas.sutinys@vilniustech.lt, [e]andrius.dzedzickis@vilniustech.lt,

[f]vytautas.bucinskas@vilniustech.lt

*the corresponding author

Keywords: micro positioning system; stepper motor; ball-screw drive; dynamic model.

Abstract. Robotic micropositioning systems - devices that operate with micrometre accuracy and are used in industry and scientific research [1], [2]. Due to the rapid development of technologies and the wide range of applications, the demand for micropositioning systems is growing every year [1], [3]. All micropositioning systems suffer from transient processes that affect the resolution, accuracy and smoothness of the motion [4], [3]. One of the methods to reduce the impact of transient processes is the mathematical modelling of such systems [5], [6]. Mathematically obtained results allow to determine system weaknesses and chose suitable control and positioning errors compensation methods [7], [8].

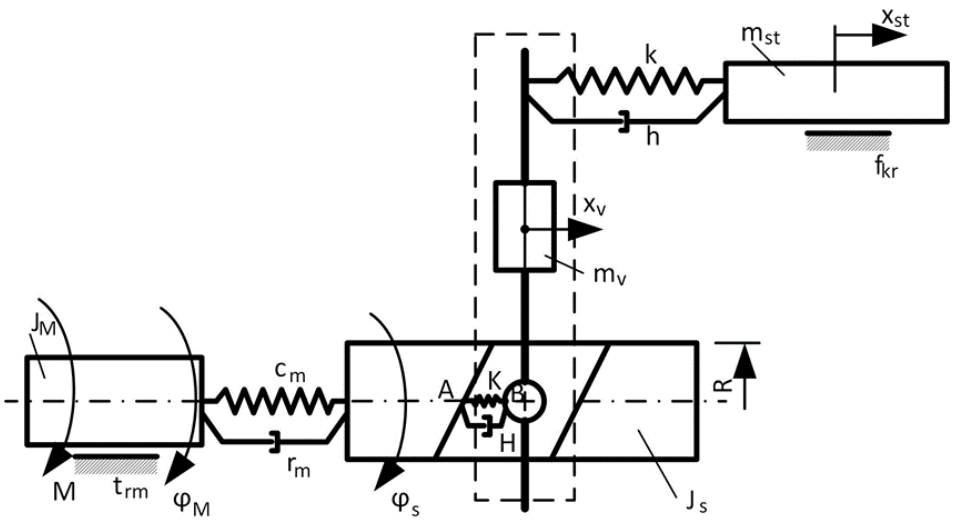

Fig.1. The dynamic model of one axis of the robotic micropositioning system

Our research is aimed to provide a mathematical model of one axis of a robotic micropositioning system. Modelled axis consists of a stepper motor, linear guides, ball-screw drive and bearing hub. Our developed dynamic model (Fig. 1) considers the main mechanical parameters of all mentioned components: motor rotor moment of inertia JM , the screw moment of inertia JS , the mass of the nut - mv, table mass mst, as well as stiffness and damping of all parts. The movement of the mechanical system is provided by the torque

M generated by the stepper motor. Stepper motor rotor, ball-screw, nut and table are considered as an absolutely rigid body.
Based on the dynamic model, we used the second-order Lagrange equation to construct the mathematical model. Obtained equations were solved using Matlab / Simulink software. The created model evaluates system resonant frequencies, accuracy and defines relations between motion smoothness and stepper motor operation mode under various load conditions.

Acknowledgements

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References

[1] J. Juuti, M. Leinonen, and H. Jantunen, “Micropositioning,” pp. 319–320, 2008.
[2] H. Xl *et al.*, “+ LJK SUHFLVLRQ : DIHU OHYHO & KLS ’ HWHFWLRQ,” pp. 381–387, 2016.
[3] S. Tayouri, I. Izadi, and J. Ghaisari, “Modeling and Parameter Identification of Piezoelectric Actuator in Micropositioning Systems,” *ICEE 2019 - 27th Iran. Conf. Electr. Eng.*, pp. 1193–1198, 2019, doi: 10.1109/IranianCEE.2019.8786431.
[4] K. Poletkin, “Static Pull-in Behavior of Hybrid Levitation Micro-Actuators: Simulation, Modelling and Experimental Study,” *IEEE/ASME Trans. Mechatronics*, vol. 4435, no. c, pp. 1–11, 2020, doi: 10.1109/TMECH.2020.2999516.
[5] X. H. Nguyen, T. H. Mau, I. Meyer, B. L. Dang, and H. P. Pham, “Improvements of piezo-actuated stick-slip micro-drives: Modeling and driving waveform,” *Coatings*, vol. 8, no. 2, pp. 1–16, 2018, doi: 10.3390/coatings8020062.
[6] F. Najar, S. Choura, S. El-Borgi, E. M. Abdel-Rahman, and A. H. Nayfeh, “Modeling and design of variable-geometry electrostatic microactuators,” *J. Micromechanics Microengineering*, vol. 15, no. 3, pp. 419–429, 2005, doi: 10.1088/0960-1317/15/3/001.
[7] H. N. Rahimi and M. Nazemizadeh, “Dynamic analysis and intelligent control techniques for flexible manipulators: A review,” *Adv. Robot.*, vol. 28, no. 2, pp. 63–76, 2014, doi: 10.1080/01691864.2013.839079.
[8] D. V. Sabarianand, P. Karthikeyan, and T. Muthuramalingam, “A review on control strategies for compensation of hysteresis and creep on piezoelectric actuators based micro systems,” *Mechanical Systems and Signal Processing*, vol. 140. Academic Press, p. 106634, Jun. 2020, doi: 10.1016/j.ymssp.2020.106634.

An optimisation problem for exoskeleton-aided functional rehabilitation of an upper extremity

Piotr FALKOWSKI[1,2,a *]

[1] Warsaw University of Technology, Warsaw, Poland

[2] ŁUKASIEWICZ Research Network – Industrial Research Institute for Automation and Measurements PIAP, Warsaw, Poland

[a]piotr.falkowski@piap.lukasiewicz.gov.pl

*the corresponding author

Keywords: exoskeleton, functional rehabilitation, optimisation, rehabilitation robotics, remote-home-rehabilitation.

Abstract. With pandemics, a problem of non-guaranteed constant access to rehabilitation aroused. As civilisation diseases attack a significant share of the population, providing motor treatment seems to be one of the biggest challenges towards the healthcare system of the future. While taking into account the severe level of disabilities and unexpected circumstances, the trainings may require being held in a house of a patient. Moreover, due to emergencies, a physiotherapist may not be able to participate in it personally. Thus, to mitigate the repercussions of such situations, advanced mechatronic systems for remote-home-rehabilitation have to be developed.

Moreover, surveyed physiotherapists, claim that function-oriented training, robot aid, remote treatment and home therapy are the leading trends for rehabilitation of the future. Combining these is relatively difficult, as automated robotic rehabilitation requires an advanced control system. As to partially support motion along the pre-programmed trails, an optimisation problem needs to be solved. Not only to follow the trail transitionally but also to control a tilt of a gripped object and to avoid immediate large changes of velocities and accelerations if not necessary.

This paper presents an approach towards an optimisation problem based on an exoskeleton of three driven and two free degrees of freedom. Simulated function-oriented training consists of diverse typical motions, such as drinking, eating, writing, steering a control wheel, lifting a bag from the ground, and lifting an object onto a shelf. Based on these, an optimisation problem is formulated.

Works presented in the paper are an integral part of a planned long-term research on a home-remote-rehabilitation with a use of an exoskeleton.

Quality Research of Edge Banding of Unit Furniture

Ugnė MIŠKINYTĖ[1,a *] and Romualdas JUKNELEVIČIUS[1]

[1]Vilnius Gediminas Technical University (VILNIUS TECH), Lithuania,

[a]ugne.miskinyte@stud.vgtu.lt

*the corresponding author

Keywords: furniture, edge banding, acrylonitrile butadiene styrene, oak veneer, quality, particleboard.

Abstract. Edge banding is used to cover cut sides of wood materials such as plywood or particleboard. The quality of two different furniture edge banding materials and their thickness were studied in this paper. The research was focused on most widely used in the Lithuanian furniture industry acrylonitrile butadiene styrene (ABS) and oak veneer. The experiments were performed to investigate the mechanical properties of materials and SolidWorks Simulation were made as well. The conclusions and recommendations can ensure the improvement and optimization of the processes of furniture industry. Structure of the paper: introduction, review of literature, methodology of experiment, results of research and their consideration, conclusions, references.

Cyber-physical Universal Safety and Crash Detection System for Autonomous Robot

Heiko PIKNER[1,a *], Raivo SELL[2,b] and Mohsen MALAYJERDI[3,c]

[1,2,3]Department of Mechanical and Industrial Engineering, Tallinn University of Technology, Tallinn, Estonia

[a]heiko.pikner@taltech.ee, [b]raivo.sell@taltech.ee, [c]momala@taltech.ee

*the corresponding author

Keywords: cyber-physical system, safety controller, crash detection.

Abstract. Multi-purpose mobile robots with modular layout have become a hot research topic in recent years. The safe performance of these robot's operations is relying on the low-level cyber-physical system (CPS). In this paper, the scientific goals underscore the analysis of the computational (cyber) units for low-level real-time fault monitoring. The purpose of these units is to monitor control signals issued by other (cyber) units or sensors and if there is a safety-critical problem, then predefined actions can be triggered. The safety controller was built and tested on the TalTech iseAuto platform. The results were analyzed, and a new multi-layer universal safety system was developed. In the first layer all signals and messages are checked to be in a suitable range or order. The second layer detects if an accident is happening using crash sensors. The third layer includes remote control switches support. If a failure or malfunction is happening, then the emergency action plan is executed to stop the vehicle safely.

References

[1] R. Sell, M. Leier, A. Rassõlkin, and J. Ernits, "Self-driving car ISEAUTO for research and education," in 2018 19th International Conference on Research and Education in Mechatronics (REM), Jun. 2018, pp. 111–116.

[2] A. Rassõlkin, R. Sell, and M. Leier, "Development case study of the first estonian self-driving car, iseauto," Electrical, Control and Communication Engineering, vol. 14, no. 1, pp. 81–88.

[3] H. Pikner, E. Malayjerdi, R. Sell, and T. Velsker, "Cyber-physical Control System for Autonomous Logistic Robot," in 2020 IEEE 19th International Power Electronics and Motion Control Conference (PEMC), Gliwice-Poland, 2020, unpublished.

[4] K. An, "Development of high-performance safety controller for excavator," IOP Conf. Ser.: Mater. Sci. Eng., vol. 922, no. 1, p. 012003, Sep. 2020.

[5] K. Kalaiyarasu, and C. Karthikeyan, "Design of an automotive safety system using Controller Area Network," 2015 International Conference on Robotics, Automation, Control and Embedded Systems (RACE), 2015, doi: 10.1109/race.2015.7097263.

[6] V. K. Singh, and K. Archana, "Implementation of 'CAN' protocol in automobiles using advance embedded system," International Journal of Engineering Trends and Technology (IJETT), Oct. 2013, vol 4(10), pp 4422-4427.

[7] K. G. Gurmanpreet, and L. Meenu, "Vehicle collision detection and reporting," International Journal of Innovative Research in Technology, vol. 5, no. 4, pp. 220–222.

[8] D. H. Kumar, S. Srivastava, S. Kumar, and S. Gupta, "Accident Detection and Reporting System Using GPS and GSM Module," International Journal of Emerging Technologies and Innovative Research, vol. 2, no. 6, pp. 1433–1436, 2015.

[9] D. García, R. Barber, and M. A. Salichs, "Design and development of a wireless emergency start and stop system for robots," in 2014 11th International Conference on

Informatics in Control, Automation and Robotics (ICINCO), Sep. 2014, vol. 02, pp. 223–230.
[10] A. Rassolkin, T. Vaimann, A. Kallaste, and R. Sell, “Propulsion Motor Drive Topology Selection for Further Development of ISEAUTO Self-Driving Car,” 2018 IEEE 59th International Scientific Conference on Power and Electrical Engineering of Riga Technical University (RTUCON). 2018, doi: 10.1109/rtucon.2018.8659887.
[11] A. Maier, A. Sharp, and Y. Vagapov, “Comparative analysis and practical implementation of the ESP32 microcontroller module for the internet of things,” 2017 Internet Technologies and Applications (ITA). 2017, doi: 10.1109/itecha.2017.8101926.
[12] V. Thirupathi, and K. Sagar, “Implementation of Home Automation System using MQTT Protocol and ESP32,” Int. J. Eng. Adv. Technol. (IJEAT) ISSN, vol. 8, pp. 2249–8958, 2018.
[13] A. Augustin, J. Yi, T. Clausen, and W. M. Townsley, “A Study of LoRa: Long Range & Low Power Networks for the Internet of Things,” Sensors, vol. 16, no. 9, Sep. 2016, doi: 10.3390/s16091466.
[14] S. A. Asadollah, R. Inam, H. Hansson, “A Survey on Testing for Cyber Physical System,” In: El-Fakih K., Barlas G., Yevtushenko N. (eds) Testing Software and Systems. ICTSS 2015. Lecture Notes in Computer Science, vol. 9447. Springer, Cham, doi: 10.1007/978-3-319-25945-1_12.
[15] InvenSense Inc, “MPU-6000 and MPU-6050 Product Specification,” 28.01.2021. [Online], Available: https://product.tdk.com/info/en/documents/catalog_datasheet/imu/MPU-6000-Datasheet1.pdf.

Intelligent filtering system for self-excited acoustic measurement system

Krzysztof LALIK[1,a *], Mateusz KOZEK[1,b], Patryk BAŁAZY[1,c], Paweł GUT[1,d] and Paweł KNAP[1,e]

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

[a]klalik@agh.edu.pl, [b]kozek@agh.edu.pl, [c]balazy@agh.edu.pl, [d]pgut@agh.edu.pl, [e]pknap@agh.edu.pl,

*the corresponding author

Keywords: FPGA, embedded systems, intelligent filtration, vibration, measurement systems.

Abstract. This paper presents the results of research performed using a control-measurement device for signal filtering and processing, in a positive feedback loop for a self-excited acoustic SAS system. The prototype of the control-measurement system was developed based on the FPGA structure and the processor working under the control of the real-time system. The application of such a solution allows to effectively manage the computational power and processing time of the input-output system. Signal acquisition and processing is performed by the FPGA platform, in particular intelligent filtering. The applied directly programmable gate array has dedicated blocks to facilitate digital signal processing, which allowed the implementation of a lossless signal filtration in time. The proposed control-measurement system was used during research on non-destructive evaluation of the load capacity of mining anchors. The results are presented in this article.

References

[1] Lalik, K., & Kozek, M. (2020, July). Cubic SVM neural classification algorithm for Self-excited Acoustical System. In 2020 International Conference Mechatronic Systems and Materials (MSM) (pp. 1-5). IEEE.

[2] Skrzypkowski, K., Korzeniowski, W., Zagórski, K., Dominik, I., & Lalik, K. (2019). Fast, non-destructive measurement of roof-bolt loads. Studia Geotechnica et Mechanica, 41(2).

[3] Li, C. C. (2010). A new energy-absorbing bolt for rock support in high stress rock masses. International Journal of Rock Mechanics and Mining Sciences, 47(3), 396-404.

[4] Kwaśniewski, J., Dominik, I., Lalik, K., & Sakeb, A. A. (2014). Analysis of Dependence Between Stress Change and Resonance Frequency for Self-excited Acoustical System. In Solid State Phenomena (Vol. 208, pp. 194-199). Trans Tech Publications Ltd

Positioning algorithm for AGV autonomous driving platform based on artificial neural networks

Patryk BAŁAZY[1,a *], Paweł GUT[2,b] and Paweł KNAP[3,c]

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

[a]balazy@student.agh.edu.pl, [b]pgut@student.agh.edu.pl, [c]pknap@student.agh.edu.pl

*the corresponding author

Keywords: autonomous systems, smart sensors, neural networks, environmental understanding.

Abstract. This paper presents an artificial intelligence algorithm responsible for the autonomy of a platform. The proposed algorithm allows the platform to move from an initial position to a set one without human intervention and with understanding and response to the dynamic environment. The implementation of such a task is possible by using a combination of a camera identifying the environment with a laser LIDAR sensor and a vision system. The signals from the sensors are analysed through convolutional neural networks. Based on AI inference, the platform makes decisions, including determining the optimal path for itself. A transfer learning method will be used to teach the neural network. This article presents the results of learning the applied neural algorithm.

References

[1] Liu, X., & Zhang, Z. (2021). A Vision-Based Target Detection, Tracking, and Positioning Algorithm for Unmanned Aerial Vehicle. Wireless Communications and Mobile Computing, 2021.

[2] Kim, J., Shin, M., Kim, D., Park, S., Kang, Y., Kim, J., ... & Yoo, J. (2021, January). Performance Comparison of SRCNN, VDSR, and SRDenseNet Deep Learning Models in Embedded Autonomous Driving Platforms. In 2021 International Conference on Information Networking (ICOIN) (pp. 56-58). IEEE.

[3] Zhou, X., Jiang, Z., & Li, Q. (2020, December). A Location Algorithm for Autonomous Vehicles in Large-scale Scenarios Using a Multilayer LIDAR. In 2020 IEEE 9th Joint International Information Technology and Artificial Intelligence Conference (ITAIC) (Vol. 9, pp. 631-635). IEEE.

[4] Liu, X., Sun, X., & Xia, X. (2020). LiDAR point's elliptical error model and laser positioning for autonomous vehicles. Measurement Science and Technology, 32(3), 035107.

Convolutional mask-wearing recognition algorithm for an interactive smart biometric platform

Patryk BAŁAZY[1,a], Paweł GUT[2,b*] and Paweł KNAP[3,c]

[1,2,3]AGH University of Science and Technology, Faculty of Mechanical Engineering and Robotics, Al. Mickiewicza 30, 30-059 Krakow, Poland

[a]balazy@student.agh.edu.pl, [b]pgut@student.agh.edu.pl, [c]pknap@student.agh.edu.pl

*the corresponding author

Keywords: artificial intelligence, face recognizing, intelligent systems, humanoid, covid.

Abstract. This paper presents the results of a neural convolutional system for recognizing the wearing of a mask by people entering a building. The algorithm is provided with input data thanks to cameras placed in the humanoid robot COVIDguard. The data collected by the humanoid - the temperature of people entering the facility, the location of the person, the way the protective mask was applied - are stored in the cloud, which enables the application of advanced image recognition algorithms and, consequently, the tracking of people within the range of the robot's sensory systems by the administrator and the verification of the security level in the given premises. The paper presents the architecture of the intelligent COVIDguard platform, the structure of the sensory system and the results of the neural network learning.

References

[1] Le, D. N., Parvathy, V. S., Gupta, D., Khanna, A., Rodrigues, J. J., & Shankar, K. (2021). IoT enabled depthwise separable convolution neural network with deep support vector machine for COVID-19 diagnosis and classification. International Journal of Machine Learning and Cybernetics, 1-14.

[2] Zhang, X., & Zhao, H. (2021). Hyperspectral-cube-based mobile face recognition: A comprehensive review. Information Fusion.

[3] Esteva, A., Chou, K., Yeung, S., Naik, N., Madani, A., Mottaghi, A., ... & Socher, R. (2021). Deep learning-enabled medical computer vision. npj Digital Medicine, 4(1), 1-9.

[4] Manekiya, M., & Donelli, M. (2021). Monitoring the Covid-19 Diffusion by Combining Wearable Biosensors and Smartphones. Progress In Electromagnetics Research M, 100, 13-21.

[5] Colaco, J., & Lohani, R. B. (2021). IoT based Biomedical Intelligent System in Agriculture. Available at SSRN 3769106.

Neural classifying system for predictive maintenance of rotating devices

Patryk BAŁAZY[1,a], Paweł GUT[2,b] and Paweł KNAP[3,c] *

[1,2,3]AGH University of Science and Technology, Faculty of Mechanical Engineering and Robotics, Al. Mickiewicza 30, 30-059 Krakow, Poland

[a]balazy@student.agh.edu.pl, [b]pgut@student.agh.edu.pl, [c]pknap@student.agh.edu.pl

*the corresponding author

Keywords: convolutional neural networks, transfer learning, diagnostic systems, vibration.

Abstract. This paper presents the results of research on a neural classifier system for the recognition of electrical drive disturbances and its speed. The classification task is performed by a convolutional neural network implemented on an artificial intelligence accelerator. The operation of the drive is monitored using intelligent accelerometers. Based on the sensor data, it is possible to create spectrograms of the signal using Short Time Fourier Transformation. Since convolutional neural networks are excellent at recognizing images and detecting objects, the signal spectrograms were used as input data for learning the network. Transfer learning method has been used, to create a model of neural network.

References

[1] Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). Imagenet classification with deep convolutional neural networks. Advances in neural information processing systems, 25, 1097-1105.

[2] Torrey, L., & Shavlik, J. (2010). Transfer learning. In Handbook of research on machine learning applications and trends: algorithms, methods, and techniques (pp. 242-264). IGI global.

[3] Zarei, J., Tajeddini, M. A., & Karimi, H. R. (2014). Vibration analysis for bearing fault detection and classification using an intelligent filter. Mechatronics, 24(2), 151-157.

[4] Janssens, O., Slavkovikj, V., Vervisch, B., Stockman, K., Loccufier, M., Verstockt, S.,&Van Hoecke, S. (2016). Convolutional neural network based fault detection for rotating machinery. Journal of Sound and Vibration, 377, 331-345.

[5] P.G. Clem, M. Rodriguez, J.A. Voigt and C.S. Ashley, U.S. Patent 6,231,666. (2001)

The phenomena of rumbling during operation of aircrafts and their diagnostic significance

Andrzej GĘBURA[1,a *], Mariusz MASIEWICZ[1,b] , Jarosław FLORCZAK[1,c], Kacper HANDZEL[1,d] and Andrzej KOŁCOŃ[1,e]

[1]Aircraft Institute of Technology

[a]andrzej.gebura@itwl.pl, [b]mariusz.masiewicz@itwl.pl, [c]jaroslaw.florczak@itwl.pl, [d]kacper.handzel@itwl.pl, [e]andrzej.kolcon@itwl.pl

*the corresponding author

Keywords: rumble, diagnostics, frequency modulation of alternator output voltage, signal theory, Kotelnikov-Shannon condition, zero cross comparator, helicopter rear gear, wave interference, tail rotor, gear, wavy teeth.

Abstract. In this article, we present the phenomena of rumbling in aircraft and their diagnostic significance. The preferred method for monitoring these phenomena will be the FAM-C method developed at ITWL, where the aircraft's on-board alternator performs the role of the conveter. Each on-board alternator is a synchronous machine and synchronously transforms the angular velocity fluctuations of individual mechanical elements into frequency modulations of the output voltage [3]. Thanks to the appropriate algorithms, each element of the aircraft's mechanical power unit is transformed into a separate characteristic set. Each of such sets reflects the wear of another mechanical element - Fig. 1. Its position on the 0-x axis identifies this subassembly and the height of the set of point on the pattern (Fig. 1, Fig. 2) is a measure of wear. Thus, the identification of a damaged mechanical element reflected in the FAM-C imaging does not pose a problem here, which causes many problems in other methods, e.g. vibroacoustic methods [6]. According to the nomenclature from the signal theory, the above-mentioned coordinate value on the 0-x axis is (fig.1, f_p axis) the subcarrier frequency [1], [2], [8]. If a given mechanical element, e.g. the upper bearing, the main gear bearing (Fig. 1, detail A2), falls into resonance, then the given characteristic set decays into several subsets with increased Q value (Fig. 2, details: A21, A22, A23), A24). When the lifting frequencies of the various components in the structure of the helicopter power train align, a spatial resonance is created, causing asymmetrical wear of some rotating elements. If one of the elements of the drive unit, e.g. a shaft with a gear wheel, has increased circumferential clearances or was built from bearing mountings, then at times we deal with an additional resonator with a slightly different frequency than the main subcarrier frequency - the difference in these frequencies creates the so-called beats [4], [5] - Fig. 3. The FAM-C method is well suited for the monitoring of beats. The FAM-C method is well suited for the monitoring of beats.The beating signals have low frequencies in relation to the carrier frequency of the alternator-converter, which significantly increases the resolution of the method [3]. In this way, the incipient stage of asynchronism in mechanical drive units can be detected. The long-term process of such asynchronism may lead to stresses in the mechanical power transmission system, cause plastic deformation of mechanical elements, e.g. twisted shafts (Fig. 4), and even lead to a threat to flight safety.

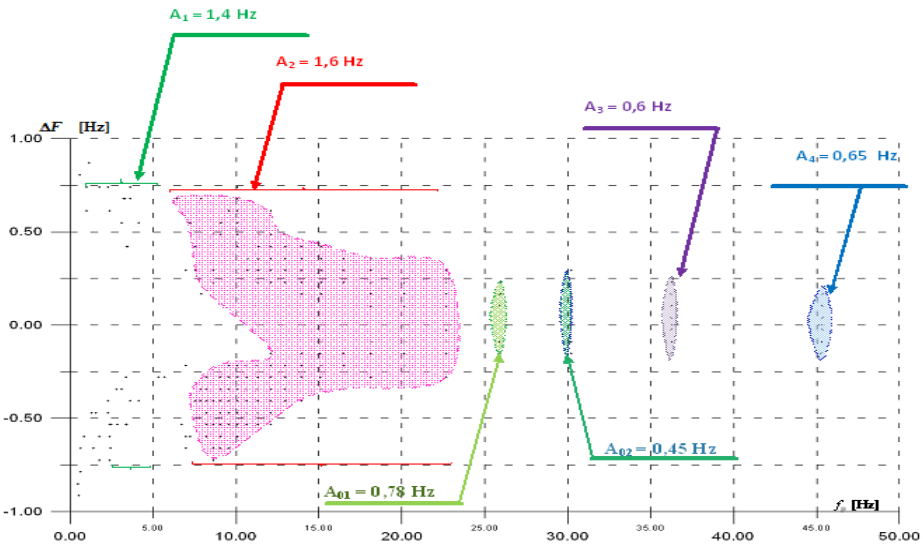

Fig. 1. Characteristic sets obtained for the drive unit of the positive pattern of the Mi-24 helicopter No. "b" with a correctly functioning upper bearing of the WR-24 transmission

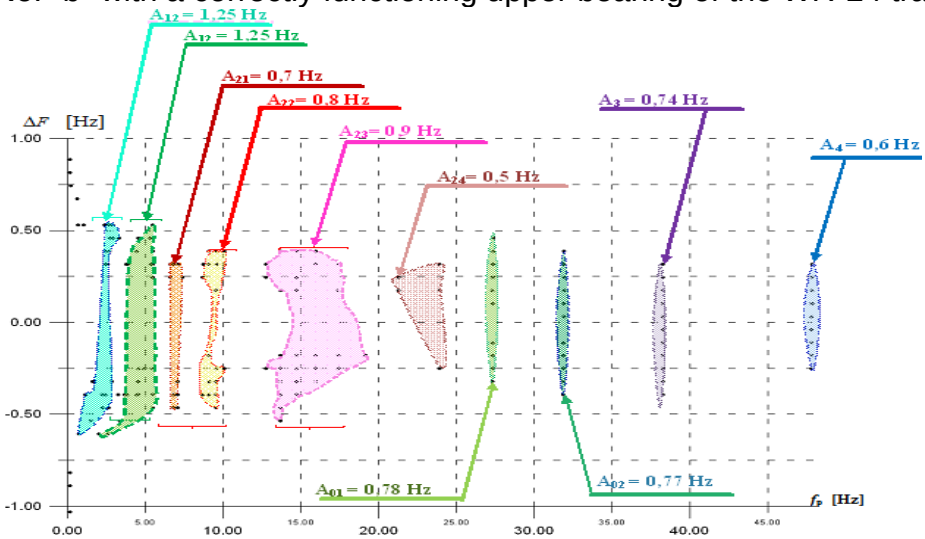

Fig. 2. Characteristic sets obtained for the drive unit of the negative pattern of the Mi-24 helicopter No. "a" with a damaged upper bearing (characteristic sets A21 ÷ A24) of the WR-24 transmission in the state of mechanical resonance

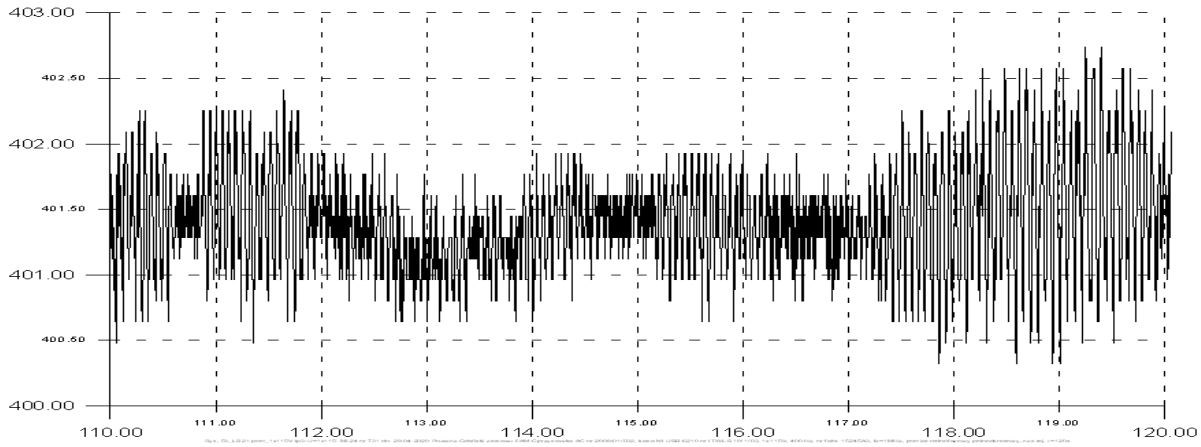

Fig. 3. The waveform of the instantaneous frequency obtained by the FAM-C method from the 1x115V, 400 Hz measuring channel - visible slow-varying component of the pulsation in the form of an envelope

Fig. 4. Twisted rear shaft: 1 - control line applied with paint on the shaft during the manufacturing (renovation) process - visible significant twist of the shaft (approx. 2 mm); 2 - control rule; β1 - angle between the shaft twists

References

[1] Gębura A., Markiewicz W.: Presentations in FAM-C and FDM-A methods and some problems of the signals theory (in Polish), 4-th International Conference Mechatronic Systems and Materials MSM'2008, Białystok 2008.

[2] Gębura A., Mroszkiewicz K.: The FDM-A and FAM-C methods with regard to effects associated with transmission of FM signals. Aviation Advances & Maintenance, 2010, 27.27: 151 ÷ 164. ISSN 1234-3544.

[3] Gębura A.: The method of frequency modulation of on-board alternators' voltage in diagnosing power units. (in Polish), Publishing house of the Air Force Institute of Technology, ISBN 978-83-61021-20–9, Monography, Warszawa, 2010.

[4] Houxin She, Chaofeng Li, Qianseng Tang, Bangchun Wen: Effect of blade's interconnection on the modal characteristics of a shaft-disk-blade system. Signal Processing,Volume 146, (2021) 106955, ISSN 0165-1684.

[5] Information on https://pl.wikipedia.org/w/index.php?title=Dudnienie&oldid=62516769.

[6] Iosif Mporas, Todor Ganchev, Otilia Kocsis, Nikos Fakotakis: Context-adaptive pre-processing scheme for robust speech recognition in fast-varying noise environment. Signal Processing,Volume 91, Issue 8, 2011, Pages 2101-2111, ISSN 0165-1684, https://doi.org/10.1016/j.sigpro.2011.03.020.

[7] Rodrigo T. RochaaFeras Alfosail abWen ZhaoaMohammad I. YounisaSami F. Masric: Nonparametric identification of a micro-electromechanical resonator. Signal Processing,Volume 161 (2021) 107932, ISSN 0165-1684.

[8] Szabatin J.: Fundamentals of the signal theory (in Polish), Publishing House of Communication (in Polish WKŁ), Warszawa 1982.

Mi-24 helicopter tail rotor failure - causes, effects, monitoring options using the FAM-C method

Henryk KOWALCZYK[1,a *], Andrzej GĘBURA[1,b], Tomasz TOKARSKI[1,c] and Tadeusz KWIATKOWSKI[1,d]

[1]Air Force Institute of Technology

[a]henryk.kowalczyk@itwl.pl, [b]andrzej.gebura@itwl.pl, [c]tomasz.tokarski@itwl.pl, [d]tadeusz.kwiatkowski@itwl.pl

*the corresponding author

Keywords: tail rotor failure, torsion of the transmission shaft, diagnostics, frequency modulation of the alternator output voltage, aggregate drive box, straight toothed gear wheel, mechanical spatial resonance of two components.

Abstract. In this article, we present the phenomenon of tail rotor failure. The primary reason was the spatial resonance coupling [1], [2], [5], [6], [7], [8] of the worn upper bearing of the WR-24 main transmission with the idler shaft with a significant level of wear of bearing supports in the aggregate drive box (SNA) [4]. In this way, synchronous periodic accelerations and delays of the angular movement of the above-mentioned shaft were created. It was reflected in the FAM-C method in the course of changes of the instantaneous frequency - Fig. 1. This resulted in spatial angular movements of the idler shaft with the Z30 gear wheel mounted on it. In this way, the Z30 wheel was moved away once (fig. 2, detail "possibility of chilling) and once pressed against the Z70 gear mating with it (fig. 3, detail" possibility of undercutting the tooth base "), fatigue breakage of teeth in the Z30 gear wheel mounted on the SNA idler shaft and cessation of the tail rotor operation [3]. As a consequence, the helicopter crashed – Fig. 3. Currently, the authors monitor the level of wear of the above components using the FAM-C method. The aircraft's on-board alternator performs the role of the converter. Each on-board alternator is a synchronous machine and synchronously transforms the angular velocity fluctuations of individual mechanical elements into frequency modulation of the output voltage. Thanks to the appropriate algorithms, each element of the aircraft's mechanical power unit is transformed into a separate characteristic set [4]. Each of these sets reflects the wear of a different mechanical element. Its position on the 0-x axis identifies this subassembly and the height of the set is a measure of wear. With its help, it is possible to metrically describe the technical condition of each rolling bearing in an accurate way and detect their resonances – in the FAM-C method, the decay of this set into subsets is then observed.

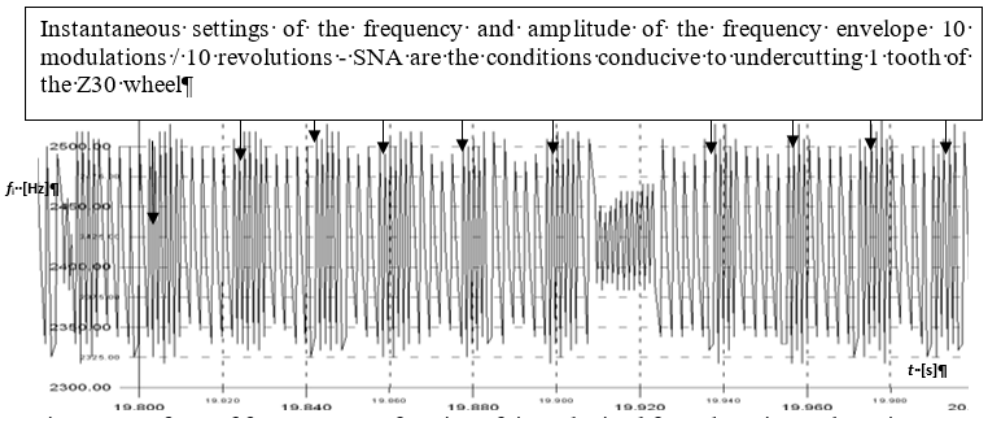

Fig. 1. Waveform of frequency as a function of time obtained from the Mi-24 sub-exciter No. 456 test No. 31, measurement No. 2 - visible temporary increase in the frequency and

amplitude of the frequency envelope with the repetition rate fp ≈ 100 Hz - observation time: 0.2 s

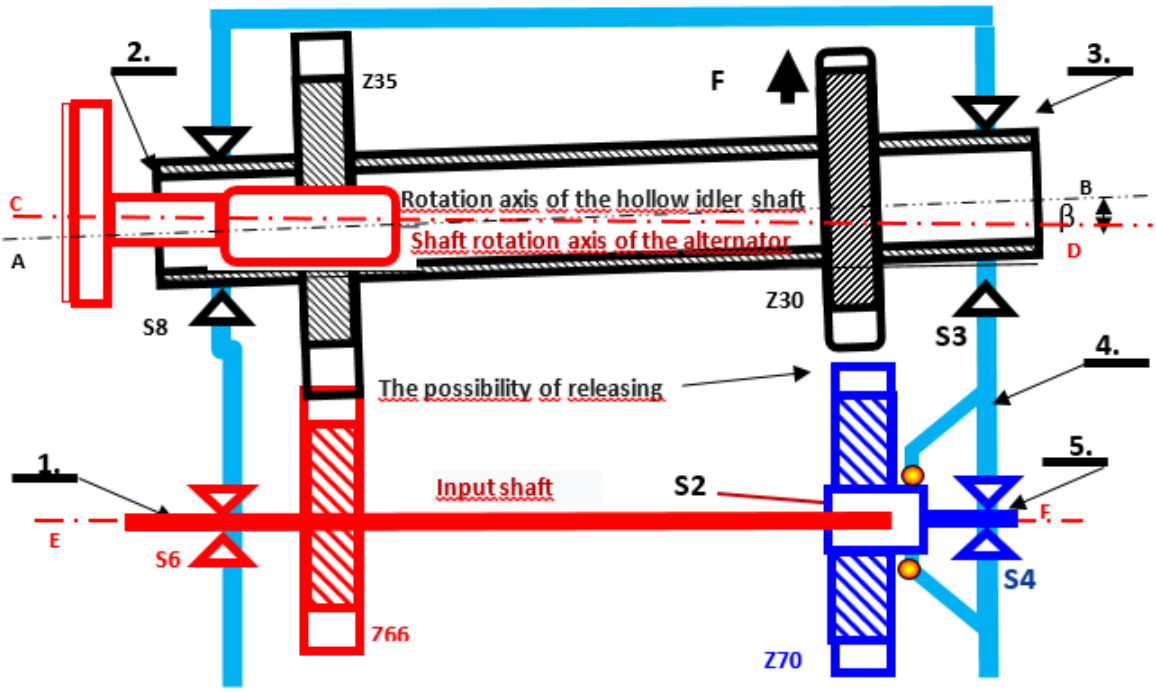

Fig. 2. Conical movements of the intermediate shaft in a worn gearbox of aggregates subjected to synchronous accelerations of angular velocity - temporary increase in angular velocity: 1. - input shaft, 2. - drive shaft of GT-4PCz6 alternator No. “e” - intermediate shaft (hollow), 4. - SNA body, 5. - output shaft, S1 ÷ S8 - bearing supports (rolling bearings), Z66, Z35, Z30, Z70 - gears transmitting mechanical power from the SNA input shaft to the shaft output SNA, F - resultant force acting on the intermediate shaft

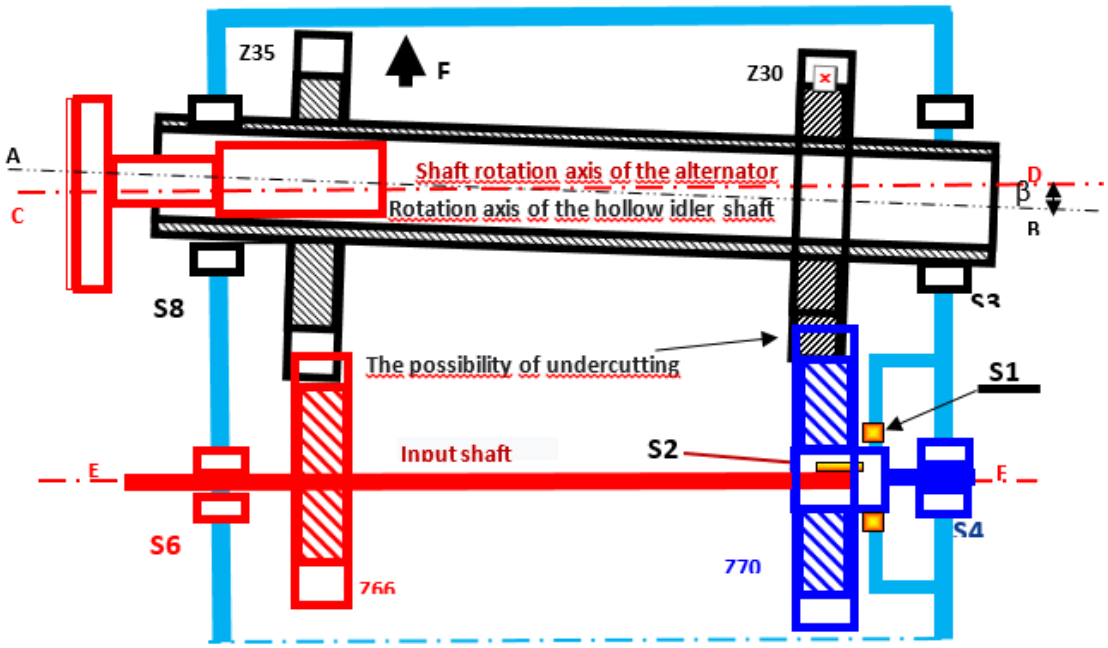

Fig. 3. Conical movements of the intermediate shaft in a worn gearbox of aggregates subjected to synchronous accelerations of angular velocity - temporary increase in angular velocity: S1 ÷ S8 - bearing supports (rolling bearings), Z66, Z35, Z30, Z70 - gears transmitting mechanical power from the SNA input shaft to the shaft output SNA, F - resultant force acting on the intermediate shaft

Fig. 4. The Mi-24 helicopter with a broken transmission system towards the tail rotor - due to internal damage in the generator drive box (Afghanistan 2011): a) helicopter during flight - disruption of the tail rotor drive causes it to tilt to the port side and turn left; b) the helicopter touching the aerodrome plane; c) the aggregate drive box (SNA) after breaking out of the tail beam plating; d) - broken teeth in the SNA, causing the power transmission to the rotor of the tail rotor to be interrupted

References

[1] Billah K., Scanlan R.: *Resonance, Tacoma Narrows Bridge Failure, and Undergraduate Physics Textbooks*, American Journal of Physics, 59(2), 118–124 . (1991)

[2] Braun, Martin (1993). *Differential Equations and Their Applications: An Introduction to Applied Mathematics*(4 ed.). New York: Springer-Verlag. p. 175. ISBN 0-387-97894-1. Retrieved 30 May 2009.

[3] Gębura A. Kłysz S., Tokarski T.:: *Monitoring wear of gear wheel of helicopter transmission using the FAM-C and FDM-A methods*, Procedia Structural Integrity 16:184-19, DOI: 10.1016/j.prostr.2019.07.039

[4] Gębura A.: *The method of frequency modulation of on-board alternators' voltage in diagnosing power units.* (in Polish), Publishing house of the Air Force Institute of Technology, ISBN 978-83-61021-20–9, Monography, Warszawa, 2010.

[5] Information on https://en.wikipedia.org/w/index.php?title=Resonance&oldid=1018575806.

[6] Information on https://en.wikipedia.org/w/index.php?title=Resonance&oldid=1017425448.
[7] Jiang, WA., Chen, LQ. & Ding, H. *Internal resonance in axially loaded beam energy harvesters with an oscillator to enhance the bandwidth*. Nonlinear Dynamic 85, 2507–2520 (2016).
[8] Lewitowicz J., Szelmanowski A., Gębura A., Pazur A., Franczuk E.: *Investigation of local and complex resonances in aircraft power units* (in Polish). Przegląd Elektrotechniczny, Zeszyt nr 11/2019, ISSN 0033-2097, pp. 59-62.
[9] Tooley, Michael H. (2006). *Electronic Circuits: Fundamentals and Applications*. Oxford: Taylor & Francis. ISBN 978-0-7506-6923-8.
[10] Ułanowicz L., Jastrzębski G., Szczepaniak P., Sabak R., Rykaczewski D.: *Malfunctions of aviation hydraulic pumps.* Journal of KONBIN, Volume 50, Issue 3, ISSN 1895-8281, ESSN 2083-4608, pp 257-266.

Automatic diagnostic systems for generators or their power unit

Piotr MICHAŁOWSKI[1,a]*, Andrzej GĘBURA[1,b], Tomasz TOKARSKI[1,c], Andrzej CIEŚLIK[1,d] and Tadeusz KWIATKOWSKI[1,e]

[1]Air Force Institute of Technology

[a]piotr.michalowski@itwl.pl, [b]andrzej.gebura@itwl.pl, [c]tomasz.tokarski@itwl.pl, [d]andrzej.cieslik@itwl.pl, [e]tadeusz.kwiatkowski@itwl.pl

*the corresponding author

Keywords: frequency modulation, diagnostic tester, powertrain, diagnosis, military aircraft, one-way clutch, roller bearing, tooth breakage, gear, flight safety, on-board generator, frequency modulation, amplitude modulation, harmonic amplitude value, electricity quality, voltage surge pulse, voltage decay pulse.

Abstract. This article presents the automatic diagnosis systems developed and made by ITWL:
1) technical condition of on-board generators. The systems for diagnosing the direct current LUK-1 and the alternating current LUK-2 (Fig. 1) were discussed. The centerpiece of these systems is an electronic block that analyses the quality of electricity. The method of diagnosing dynamic changes in the generator load, e.g. increasing the load from 10% to 170% is particularly noteworthy. The electronic system analyses (integrates) the voltage waveform over time, calculates parameters and compares them to the normative parameters. In case of exceeding the limits, it displays the appropriate alarm information "Transient frequency" or "Transient voltage".
2) mechanical power unit of aircraft: MiG-29 - diagnosing one-way clutches (Fig. 2), TS-11 "Iskra" – diagnosing engine bearing supports; Mi-24 - diagnosis of mechanical power transmission nodes between the engine and the propeller.
Ad 1 - the system enables the loading of a generator with a rated power of 40 kVA (Fig. 1a, item "Load: 10%, 100%, 160%). When the load is switched over, the analysis system starts automatically and the appropriate alarms are displayed on the display after 0-30 s.
Ad. 2 - discusses the design and principle of operation of three diagnostic testers designed by the authors of this study and intended for three different aircraft power units. These devices have one common method of processing the primary diagnostic signal - they use the FAM-C method. This method is based on the natural processing of rotational speed fluctuations of individual kinematic links of the drive unit by an on-board generator into frequency modulations. Due to its special properties, the method is extremely advantageous for digital automatic diagnostic processing. The tester can be connected in any convenient place for servicing the power grid, away from the dangerous zones of the aircraft.

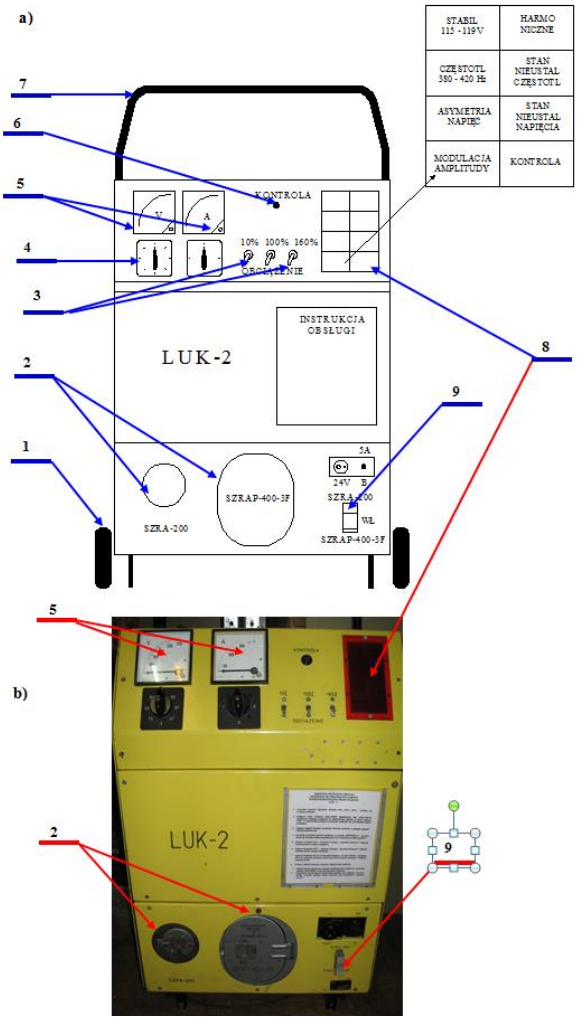

Fig. 1. LUK-2 AC power generator quality control device at the airport: 1 - road wheel, 2 - electrical source terminal connection, 3 - load level switches, 3 - measurement switches for individual phases, 5 - analogy indicators, 6 - indicator light indicating the connection of the tested source, 7 - handle, 8 - alarm display plate, 9 - socket switch

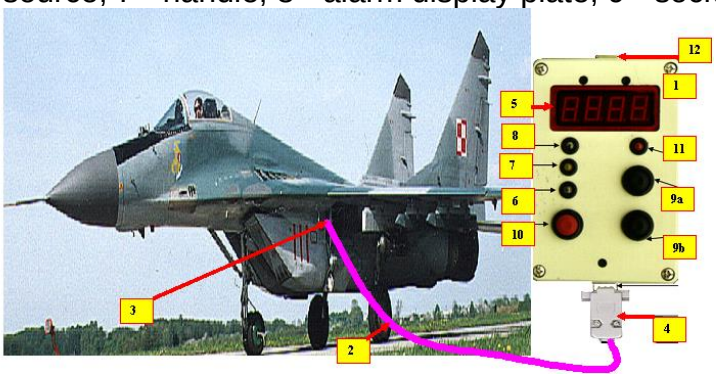

Fig. 2. Diagnostic tester DIA-KSA-CM against the MiG-29 aircraft: 1 - housing of the diagnostic tester DIA-KSA-CM; 2 - cable connecting the tester with the on-board AC power network 1x115 V, 400 Hz; 3 - electrical connector in the recess of the left landing gear; 4 - CANON DB9 connector of the tester input circuit; 5 - display; 6 - green LED diode indicating safe operation status; 7 - yellow LED indicating partial wear; 8 - red LED to indicate failure or failure status; 9 - manipulation buttons ("+" and "-") for entering the airplane number, engine designation and searching diagnostic data for a given test; 9a - manipulation button "+" (when pressed before the test, the entered tactical number of SP changes ascendingly; when pressed after the test, a symbol of a mechanical element of the power unit with a higher wear level is displayed); 9b - manipulation button "-" (when pressed before the test, the entered tactical number of SP changes decreasingly; when

pressed after the test, the symbol of the mechanical element of the power unit with a lower level of wear is displayed); 10 - START test activation button; 11 - orange LED indicating the test is in progress; 11 - computer connection (for reading the data contained in the tester's memory)

References

[1] Gębura A. Kłysz S., Tokarski T. Monitoring wear of gear wheel of helicopter transmission using the FAM-C and FDM-A methods, Procedia Structural Integrity 16:184-19, DOI: 10.1016/j.prostr.2019.07.039

[2] Gębura A., Pietnoczko B., Tokarski T.: Diagnostic testers operating on the basis of the FAM-C method, Diagnostyka Vol. 17, No 3, pp. 87-95, ISSN: 1641-6414, e-ISSN: 2449-5220, http://diagnostyka.net.pl/archive/viem-articles/diagnostyka-vol-17-no-3-2016, Olsztyn 2016

[3] Gębura A.: The method of frequency modulation of on-board generators' voltage in diagnosing power units. (in Polish), Publishing house of the Air Force Institute of Technology, ISBN 978-83-61021-20–9, Monography, Warszawa, 2010.

[4] Lewitowicz J., Szelmanowski A., Gębura A., Pazur A., Franczuk E.: Investigation of local and complex resonances in aircraft power units (in Polish). Przegląd Elektrotechniczny, Zeszyt nr 11/2019, ISSN 0033-2097, pp. 59-62..

[5] Tokarski T. H.: Evaluation of direct current electric power systems of the aircraft based on characteristics of a transient state. Diagnostyka. 2019;20(1):81-91. doi:10.29354/diag/100439.

[6] Borowczyk H., Spychała J.: On designing an expert diagnostic system of the aircraft turbine engine functional units. Journal of KONBiN 2020, Volume 50, Issue 1, DOI 10.2478/jok-2020-0011

On the development and application of a mobile 2d robot for data acquisition from open aquariums

Uldis ŽAIMIS[1,a *], Roberts JŪRMALIETIS[2,b], Dzintars TOMSONS[3,c] and Andrejs KUKUŠKINS[4,d]

[1,2,3,4]Liepaja University, Latvia

[a]uldis.zaimis@liepu.lv, [b]roberts.jurmalietis@liepu.lv, [c]dzintars.tomsons@liepu.lv, [d]andrejs.kukuskins@liepu.lv

*the corresponding author

Keywords: mobile robot, aquariums, environmental parameters.

Abstract. Aquariums monitoring requires mobile remote-controlled robots capable of collecting environmental data. For routing of a mobile 2D device created at the Liepaja University GPS, coordinates for autonomous control are used. In environmental research, they are the depth of the water area, the temperature at different depths, and the transparency of water in the optical range, salinity, pH level, the content of dissolved oxygen. The above data is read, structured, and linked to the GPS coordinates and stored in the on-board memory device. This data structure allows to visualize data and obtain 3D mappings. Data analysis can be used to control management works, can serve as a basis for forecasts of environmental parameters, climate change, detection of local pollution and other environmental measures.

A Villari reversal in the model of magnetic permeability tensor dependence on mechanical stress tensor

Roman SZEWCZYK

Warsaw University of Technology, Faculty of Mechatronics, sw. Boboli 8, 02-525 Warsaw, Poland

roman.szewczyk@pw.edu.pl

Keywords: permeability tensor, magnetoelastic effect, Villari reversal

Abstract. Microwave magnetoelastic effect is connected with the changes of magnetic state of material subjected to mechanical stresses. This effect can be observed as changes of magnetic permeability tensor μ of the material under stresses from external forces. Magnetoelastic effect seems to be one of the most mysterious phenomenon in the area of solid state magnetism. From fundamental point of view it can be explained only on the base of quantum physics. However, such explanation, valid for different types of crystalline, polycrystalline and amorphous magnetic material, was still not presented in the literature.
However, from macroscopic point of view, material can be subjected to mechanical axial and shear stresses. In such a case, accordingly to Mohr's circle theory, stresses in the material can be represented by axial principal stresses σPx, σPy, σPz in the coordinate system rotated by rotation matrix ***R***.
In addition stresses $\sigma_{\perp}$ acting perpendicularly to magnetizing field direction generates efficient stresses σ given as [1]:

$$\sigma = -\nu \cdot \sigma_{\perp}$$

where v is the Poisson ratio. Finally, the magnetic permeability tensor $\boldsymbol{\mu}$ dependence on mechanical stress tensor $\boldsymbol{\sigma}$ can be calculated from the following equation [2]:

$$\mu(\sigma) = R * \begin{bmatrix} \mu_r(\sigma_{Px} - \nu\sigma_{Py} - \nu\sigma_{Px}) & 0 & 0 \\ 0 & \mu_r(\sigma_{Py} - \nu\sigma_{Px} - \nu\sigma_{Pz}) & 0 \\ 0 & 0 & \mu_r(\sigma_{Pz} - \nu\sigma_{Px} - \nu\sigma_{Py}) \end{bmatrix} * R^{-1}$$

Above equation can be efficiently used for linear approximation of stress dependence of magnetic permeability. However, in the real magnetic material subjected to stresses, magnetic permeability first increases and next decreases for increasing value of axial stresses. Presented paper is closing the gap in the state of the art explaining this effect (known as Villari reversal [3]) from the point of view of magnetic permeability tensor – mechanical stress tensor interaction.

References

[1] M. Sablik et al., A model for hysteretic magnetic properties under the application of noncoaxial stress and field, Journal of Applied Physics 74, 1993, 480–488.

[2] R. Szewczyk, Generalization of the model of magnetoelastic effect: 3D mechanical stress dependence of magnetic permeability tensor in soft magnetic materials, Materials 13 (2020) 4070

[3] A. Bieńkowski, The possibility of utilizing the magnetomechanical Villari effect in ferrite as stress transducer, Journal of Magnetism and Magnetic Materials, 83 (1990) 411–412.

The influence of mesh granularity on the accuracy of the FEM modeling the resonant state in a microwave magnetic chamber

Anna OSTASZEWSKA-LIŻEWSKA[1,a *], Dominika KOPALA[1,b],

Jakub SZAŁATKIEWICZ[2,c], Roman SZEWCZYK[1,d] and Peter RÅBACK[3,e]

[1]Warsaw University of Technology, Faculty of Mechatronics, sw. Boboli 8, 02-525 Warsaw, Poland

[2]Phoenix Surowce Sp z o.o., ul. Kasztanowa 18, 05-816 Michałowice Wieś, Poland

[3]CSC–IT Center for Science, P.O. Box 405, FI-02101 Espoo, Finland

[a]anna.lizewska@pw.edu.pl, [b]dominika.kopala.stud@pw.edu.pl, [c]jakub.szalatkiewicz@gmail.com, [d]roman.szewczyk@pw.edu.pl, [e]peter.raback@csc.fi

*the corresponding author

Keywords: microwave chamber, resonance conditions, finite element model.

Abstract. Microwave technology is widely used in different areas of advanced industry, when energy has to be provided to the water containing material. For this reason microwave heaters are very efficient in food and biochemical industry, where heat has to be uniformly distributed in the whole mass of heated material. The example of such application is the microwave moisture analyzer, introduced to the market by RADWAG Company [1].

The main barrier in the development of microwave devices is the possibility of efficient modeling of microwave systems in resonant state. For the real systems, Finite Element Method (FEM) has to be used. However, commercially available tools for such modelling are expensive. Moreover, due to the license, there is no possibility to validate the source code of commercial software.

To overcome these problems, the open-source microwave solver was implemented to freely available ELMER FEM software [2]. This solver enables efficient modeling the microwave chambers in the wide range of frequencies and independently on its shape. The efficiency of the model was confirmed during the development of microwave devices for industrial applications [3].

On the other hand, the convergence process in microwave finite element solver is sophisticated. The convergence process and its influence on the accuracy of modeling of microwave chambers in the resonant state was not investigated previously. Presented paper is filling this gap.

The resonance conditions of microwave chamber were tested from the point of view of both spatial resolution of FEM mesh as well as from the point of view of convergence criteria. Whole experiment was carried out with the use of open-source microwave modelling toolchain covering NETGEN mesh generator, ELMER FEM microwave FEM solver and PARAVIEW software for visualization of results.

Presented results experimentally determine the limits of accuracy of microwave FEM-based models. The determined values of microwave resonant chamber dimension tolerances should be considered for both open-source and commercial software for microwave modeling.

References

[1] R. Szewczyk, A. Ostaszewska-Liżewska, D. Kopala, J. Szałatkiewicz, Elmer FEM Webinar - Microwave Modeling in Elmer, 2021, https://www.youtube.com/watch?v=aGf4sC5q0QE.

[2] P. Råback, P.-L. Forsström, M. Lyly and M. Gröhn, Elmer - finite element package for the solution of partial differential equations, EGEE User Forum, 2007, Manchester, UK
[3] J. Szałatkiewicz, R. Szewczyk, M. Kalinowski, J. Kataja, P. Råback, J. Ruokolainen, M. Kachniarz, Open source ELMER software based FEM modeling of waveguides and resonant cavities for microwave heating and drying devices, Archives of Electrical Engineering 66 (2017) 745.

MATERIALS

Properties of rubbers modified in oligomer medium

Andrei V. KASPEROVICH[1,a], Elena P. USS[1,b] and Zhanna S. SHASHOK[1,c]

[1]Belarussian State University of Technology, Sverdlova str. 13a, 220006, Minsk, Republic of Belarus
[a]uss@belstu.by, [b]andkasp@belstu.by, [c]shashok@belstu.by

*the corresponding author

Keywords: polyisoprene rubber, polybutadiene rubber, elastomer, modification, oligomer, polyethylene oxide.

Abstract. The aim of this work was to study deformation and strength characteristics of elastomer compositions modified in oligomer medium.
As objects for our study, we used filled elastomer compositions based on combination of synthetic polyisoprene and polybutadiene rubbers. These compositions are used in the production of items for industrial and engineering applications.
Elastomeric compositions based on synthetic polyisoprene and polybutadiene rubbers were molded and cured in a hydraulic press to a certain degree of cure, in which the samples have the necessary frame, monolithic and freely removed from the mold without breaking their geometric dimensions. Further, the rubber samples were kept in a relaxed state at temperature 140±2°C in oligomer modifier during 30-90 min.
The used modifier was a mixture of polyethylene oxides (PEO) with different molecular weight 400 and 4000. It is water-soluble, relatively inert, viscous liquids (PEO 400) and low-melting solids (PEO 4000). Due to their multifunctional properties, PEOs are widely used in in detergents industry, lubricants, coatings, paints, also in the formulation of cosmetics and medical products etc. Besides, polyethylene oxides are nonionic surfactants, consisting of a hydrophilic head group and a hydrophobic tail [1]. For comparison purposes, we used unmodified press-cured elastomer products and the same elastomer products modified in mixture of low-molecular polyethylene oxides 400 and 4000.
As a result of the modification, polyethylene oxide molecules are adsorbed and diffused into the surface layers of elastomeric material, further modifier migrates may be into the bulk of polymer and can induce the formation of micelles.
To study the stress-strain behavior of modified rubber materials, a tensile testing machine Tensometer T 220 DC was used. The Shore a hardness values of samples were measured at DIGI-TEST Automatic device.

It was found that rubber samples based on combination of synthetic polyisoprene and polybutadiene rubbers modified in mixture of low molecular weight polyethylene oxides had more higher deformation-strength characteristics in comparison with the unmodified sample. In this case, tensile strength of modified rubber increased up to 11% and elongation at break – up to 16%. However, with increase of modification time to 90 min, mechanical parameters of the modified samples were reduced. It may be due to the excess of the oligomer component in the surface layer of the samples, which caused plasticization of the system. Shore A hardness of modified rubbers was within the experimental error. The change in deformation and elastic characteristics of modified rubbers may be due to the action of low molecular weight polyethylene oxide, which affects the curing process of rubbers.

References

[1] D.R. Karsa, Surfactants in Polymers, Coatings, Inks and Adhesives, Blackwell Publ., Oxford, 2003.

Investigation of Micro Hardness Properties of Jute/Epoxy Bio-Composite as Alternative Material for Automotive Applications

Hasan SERIN[1,a *], Tolga ARUSOĞLU[1,b] and Şafak YILDIZHAN[1,c]

[1] Department of Automotive Engineering, Cukurova University, Adana, Turkey

[a]hserin@cu.edu.tr, [b]tolgaarusoglu@gmail.com, [c]yildizhans@cu.edu.tr

*the corresponding author

Keywords: Bio-composite, Jute, Epoxy, Micro-hardness, Automotive.

Abstract. The investigations on renewable and eco-friendly composite materials have a great importance especially in automotive industry [1]. Automotive industry considers manufacturing renewable lighter and safer materials to reduce carbon emissions and energy consumption, also improve material properties. Mostly carbon fiber reinforced composites and glass fiber reinforced composites are used for manufacturing purposes which are synthetic materials [2], [3]. The hybridization of natural fiber with glass or carbon fiber provides to enhance the mechanical properties of composite material. Jute fibers are one of the alternative bio-materials which can be used instead of synthetic glass fibers [4]. In this study, jute fibers were used as reinforcement agents and by using hand lay-up method jute/epoxy composite materials (30% by weight) were fabricated. After the composite fabrication, micro hardness properties of the specimens were determined experimentally. The hardness measurements were evaluated by using a THV-1MD Micro-Vickers Hardness Instrument with 20 seconds dwell time and 1kgf load (9,81 N). The experiments showed that jute/epoxy bio-composite has 93.41±13.65 HV1 hardness value. Jute fibers can be used as reinforcing agent instead of synthetic fibers considering experimental results, the relatively lower cost and being renewable characteristic of jute fibers.

References

[1] J. Holbery, D. Houston, Natural-fiber-reinforced polymer composites applications in automotive. Jom, 58 (2006). 80-86.

[2] M.A. Fuqua, S.S. Huo, C.A. Ulven, Natural Fiber Reinforced Composites. Polymer Reviews, 52 (2012) 259-320.

[3] S. Yildizhan, A. Calik, M. Ozcanli, H. Serin, Bio-composite materials: a short review of recent trends, mechanical and chemical properties, and applications, European Mechanical Science, 2 (2018) 83-91.

[4] M.Zakriya, G. Ramakrishnan, N. Gobi, NK Palaniswamy, J. Srinivasan, Jute-reinforced non-woven composites as a thermal insulator and sound absorber - A review. J. of Reinforced Plastics and Composites, 36 (2017) 206-213.

Influence of Iron Oxide Nanomaterial Addition into Biodiesel/Hydrogen Powered Diesel Engine Performance and Emissions

Mustafa ÖZCANLI[1,a*], Erdi TOSUN[1,b] and Mustafa Atakan AKAR[1,c]

[1]Department of Automotive Engineering, Çukurova University, Adana, Turkey

[a]ozcanli@cu.edu.tr, [b]etosun@cu.edu.tr, [c]aakar@cu.edu.tr

*the corresponding author

Keywords: Nanomaterial, nanoparticle, hydrogen, combustion.

Abstract. Not only diminishment on petroleum based conventional energy sources but also questing efforts on more environmentally friendly fuels have been attractive subjects among scientists recently. Although biodiesel is one of the satisfactory alternatives, it has certain deficiencies to be tackled such as impairment on performance level due to lower calorific value and increase on carbon dioxide emission release which contributes to global warming phenomenon [1], [2]. In biodiesel operated engines nanomaterial employment has been suggested by various studies in literature to improve performance characteristics. Nanomaterial use in cylinder may help to obtain improved performance and emission values [3], [4]. These enhancements with nanomaterial lay hid in superior properties of them such as oxygen buffer behavior and catalyst effects etc. On the other hand, hydrogen is most abundant element in universe and it has been predicted as the fuel of future. Carbon-free nature of it causes to obtain clean combustion characteristics. Besides that, high heating value and higher speed of flame during combustion make it charming to be utilized in internal combustion engines [5]. This paper intended to reveal the outcomes of investigations on hydrogen enriched diesel engine with diesel, biodiesel and nanoparticle blends. Combined effects of Fe3O4 nanomaterial and hydrogen caused to obtain improvements on engine performance and emission levels which were impaired by sunflower biodiesel operation.

References

[1] T. Kaya, O.A. Kutlar, O.O Taskiran, valuation of the Effects of Biodiesel on Emissions and Performance by Comparing the Results of the New European Drive Cycle and Worldwide Harmonized Light Vehicles Test Cycle, Energies. 11 (2018) 2814.

[2] M. Özcanlı, A Keskin, K. Aydin. Biodiesel Production from Terebinth (Pistacia Terebinthus) Oil and its Usage in Diesel Engine, International Journal of Green Energy. 8 (2011) 518-528.

[3] A.I. El-Seesy, H. Hassan, S. Ookawara, A.M.A. Attina, A.R. Abd-Elbar. The Effect of Nanoparticles Addition with BiodieselDiesel Fuel Blend on a Diesel Engine Performance, 5th International Conference on Renewable Energy: Generation and Applications (ICREGA), Al Ain, United Arab Emirates. (2018) 98-101.

[4] S.N.A. Yusof, N.A.C. Sidik, Y. Asako, W. Mohd, A.A Japar, S.B. Mohamed, N.M. Muhammad. A comprehensive review of the influences of nanoparticles as a fuel additive in an internal combustion engine (ICE), Nanotechnology Reviews. 9 (2020) 1326-1349.

[5] M. Ozcanli, M.A. Akar, A. Calik, H. Serin. Using HHO (Hydroxy) and Hydrogen Enriched Castor Oil Biodiesel in Compression Ignition Engine, International Journal of Hydrogen Energy, 42 (2017) 23366-23372.

Effects of nanoparticle-alcohol-diesel ternary blends on performance and emission of a diesel engine

Tayfun ÖZGÜR[1,a *] and Ali Cem YAKARYILMAZ[1,b]

[1]Department of Automotive Engineering, Çukurova University, Adana, TURKEY

[a]tozgur@cu.edu.tr, [b]acyakaryilmaz@cu.edu.tr

*the corresponding author

Keywords: Diesel engine, Alcohols, Nanoparticle, NO_x, soot.

Abstract. Due to the increase in the world population and industrialization in recent years, the need for petroleum-based fuels has also increased with the rapid increase in energy demand [1]. The increasing consumption of petroleum-derived fuels threatens the world in terms of global warming and environmental pollution [2]. In particular, NOx emissions and soot formation are the main pollutants that are mostly caused by diesel engines are used in plenty of areas. For this reason, new alternative fuels or technologies are needed to handle this crucial threat. Alcohols are one of the new alternative fuels used in diesel engines for energy thanks to their various properties such as calorific value, environmental benefits, and availability [3]. In addition to alcohols, nanoparticles are also used as additives to reduce emissions [4], [5]. In this study, the performance and emission characteristics of a diesel engine fueled with nanoparticle-alcohol-diesel ternary blends were investigated. The results showed that the prepared ternary blends reduce soot and NOx emissions related to catalyst effects of nanoparticle additions that encourage heat transfer in the combustion chamber by virtue of their metallic base structure [6].

References

[1] V.W. Khond, V.M. Kriplani, Effect of nanofluid additives on performances and emissions of emulsified diesel and biodiesel fueled stationary CI engine: A comprehensive review, Renew. Sustain. Energy Rev. 59 (2016) 1338–1348.

[2] V. Saxena, N. Kumar, V.K. Saxena, A comprehensive review on combustion and stability aspects of metal nanoparticles and its additive effect on diesel and biodiesel fuelled C.I. engine, Renew. Sustain. Energy Rev. 70 (2017) 563–588.

[3] K. Nanthagopal, R.S. Kishna, A.E. Atabani, A.H. Al-Muhtaseb, G. Kumar, B. Ashok, A compressive review on the effects of alcohols and nanoparticles as an oxygenated enhancer in compression ignition engine, Energy Convers. Manag. 203 (2020) 112244.

[4] J.B. Ooi, H.M. Ismail, V. Swamy, X. Wang, A.K. Swain, J.R. Rajanren, Graphite Oxide Nanoparticle as a Diesel Fuel Additive for Cleaner Emissions and Lower Fuel Consumption, Energy and Fuels. 30 (2016) 1341–1353.

[5] J.B. Ooi, H.M. Ismail, B.T. Tan, X. Wang, Effects of graphite oxide and single-walled carbon nanotubes as diesel additives on the performance, combustion, and emission characteristics of a light-duty diesel engine, Energy. 161 (2018) 70–80.

[6] T. Ozgur, G. Tuccar, E. Uludamar, A.C. Yilmaz, C. Güngör, M. Ozcanli, H. Serin, K. Aydin, Effect of nanoparticle additives on NOx emissions of diesel fuelled compression ignition engine, Int. J. Glob. Warm. 7 (2015) 487–498.

Empirical analysis of piezoelectric stacks composed of plates with different parameters and excited with different frequencies

Jacek HARAZIN[1,a *] and Andrzej WRÓBEL[2,b]

[1,2] Silesian University of Technology, Konarskiego 18A, 44-100 Gliwice, Poland

[a]jacek.harazin@polsl.pl, [b]andrzej.wrobel@polsl.pl

*the corresponding author

Keywords: piezoelectric materials, piezoelectric stack, piezoelectric plates.

Abstract. Piezoelectric materials offer an ability to exchange energy between electrical and mechanical systems with fair ease, by using the simple and inverse piezoelectric effect. Piezoelectric transceivers, sensors, microphones, actuators, or active acoustic noise cancellation devices are some of many applications for piezoelectric materials. Due to the natural ability of the material to convert electricity and mechanical strain, solutions based on piezoelectric materials are often compact and allow applications on micro scales. One of the forms of piezoelectric actuation involves the use of piezoelectric stacks. The stack is composed of multiple piezoelectric plates layered by thin dielectric sheets, with electrodes attached along the sides. The main aim of piezoelectric stacks is the increase in maximum displacement by multiplying the number of piezoelectric plates that make up the stack. Stacks are composed of plates with the same material properties and the same dimensions. This study aims to investigate the idea of composing piezoelectric stacks of plates that have separate control circuits inducing different carrier frequencies or plates with differing properties and dimensions, in search for new applications for piezoelectric stacks. The main point of interest is the investigation of the ability to use piezoelectric stacks to generate complex vibration spectrums composed of multiple frequencies, resulting from the use of different piezoelectric plates in the stack or different carrier frequencies that stimulate each plate. To achieve this, a stack composed of two piezoelectric plates, each controlled by its own circuit, will be measured by a laser vibrometer, to check the complexity of the output vibration pattern.

References

[1] Y. Jiashi, „An Introduction to the Theory of Piezoelectricity”, Advances in Mechanics and Mathematics, (2018), ISBN 978-3-030-03137-4

[2] D. Berlincourt, "Piezoelectric ceramics: Characteristics and applications", The Journal of the Acoustical Society of America, vol. 70, (1981), pp. 1586-1595, doi: https://doi.org/10.1121/1.387224

[3] T.R. Shrout, S.J. Zhang, “Lead-free piezoelectric ceramics: Alternatives for PZT?”,J Electroceram, vol. 19, (2007), pp. 113–126, https://doi.org/10.1007/s10832-007-9047-0

[4] K. Maity, D. Mandal, “Chapter Seven - Piezoelectric polymers and composites for multifunctional materials” in “Advanced Lightweight Multifunctional Materials” by P. Costa, C. M Costa, S. Lanceros-Mendez, Woodhead Publishing in Materials, (2021), pp. 239-282, doi: https://doi.org/10.1016/B978-0-12-818501-8.00001-9

[5] M. Goldfarb, N. Celanovic, "Modeling piezoelectric stack actuators for control of micromanipulation," in IEEE Control Systems Magazine, vol. 17, no. 3, (1997), pp. 69-79,doi: 10.1109/37.588158.

Gold nanoparticle-based biofuel cell catalytic efficiency reliance on medium pH

Antanas ZINOVICIUS[1,a *], Juste ROZENE[1,b], Vakare Guoba SATAITE[1,c], Timas MERKELIS[2,d] and Inga MORKVENAITE-VILKONCIENE[1,e]

[1] Department of Mechatronics, Robotics and Digital Manufacturing, Faculty of Mechanics, Vilnius Gediminas Technical University, 03224 Vilnius, Lithuania;

[2] Department of Physical Chemistry, Faculty of Chemistry and Geosciences, Vilnius University, 03225 Vilnius, Lithuania;

[a]antanas.zinovicius@vilniustech.lt, [b] juste.rozene@vilniustech.lt, [c] vakare-guoba.sataite@stud.vgtu.lt, [d] timas.merkelis@chgf.stud.vu.lt, [e] inga.morkvenaite-vilkonciene@vilniustech.lt

*the corresponding author

Keywords: gold nanoparticles, nanozymes, catalytic activity, AuNP, biofuel cell, fast scan cyclic voltammetry.

Abstract. Over the past several decades, biology, chemistry, and medicine took advantage of gold nanoparticles (AuNPs) for their fascinating characteristics. Today these nanomaterials can be synthesized in various methods from biosynthesis, when particles are made by microbial culture, to physical [1], [2]. Using the fast scan cyclic voltammetry, AuNPs can be electrodeposited from chloroauric acid (HAuCl4) directly onto the surface of a graphite electrode [3]. This method provides high reproducibility and allows to control the size of the nanoparticles (from 4 to 75 nm) and electrode coverage by changing HAuCl4 concentration, scan speed, and a number of applied cycles. Gold nanoparticles are known to express comparable catalytic activity to natural enzymes such as glucose oxidase or horseradish peroxidase [4]. Despite the advantages over natural enzymes, inorganic enzyme mimicking catalysts exhibit limited catalytical efficiency and selectivity. To increase efficiency, we used low size AuNPs which [1 increase reactivity; the lack of selectivity in a biofuel cell is advantageous since AuNPs can reduce/oxidize several substrates in the medium. Biofuel cell based on AuNP's has a superior life span, as the main active part of the system is inorganic, and thus it is not affected by oxygen stress, where typical microbial biofuel cells are struggling. The observed catalytic activity had a minimal dependency on temperature change [5]. pH was changed from 4 to 10 with the smallest synthesized AuNPs. However, pH has an impact on the reaction speed. Results showed that biofuel cell is suitable for raw wastewater as it usually deviates from pH 7, and usable current can be generated.

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References

[1] S. Ahmed, Annu, S. Ikram, and S. Yudha, 'Biosynthesis of gold nanoparticles: A green approach', J. Photochem. Photobiol. B Biol., vol. 161, pp. 141–153, 2016, doi: 10.1016/j.jphotobiol.2016.04.034.

[2] C. Daruich De Souza, B. Ribeiro Nogueira, and M. E. C. M. Rostelato, ‘Review of the methodologies used in the synthesis gold nanoparticles by chemical reduction’, J. Alloys Compd., vol. 798, pp. 714–740, 2019, doi: 10.1016/j.jallcom.2019.05.153.
[3] M. Etesami, F. S. Karoonian, and N. Mohamed, ‘Electrochemical deposition of gold nanoparticles on pencil graphite by fast scan cyclic voltammetry’, J. Chinese Chem. Soc., vol. 58, no. 5, pp. 688–693, 2011, doi: 10.1002/jccs.201190107.
[4] J. Lou Franco, B. Das, C. Elliott, and C. Cao, Gold Nanozymes : From Concept to Biomedical Applications, no. 0123456789. Springer Singapore, 2021.
[5] E. L. S. Wong, K. Q. Vuong, and E. Chow, ‘Nanozymes for Environmental Pollutant Monitoring and Remediation’, Sensors, vol. 21, no. 2, p. 408, Jan. 2021, doi: 10.3390/s21020408.

ZnO nanotetrapods functional properties and applications

Mindaugas ILICKAS[1], Paulius LAURIKĖNAS[1] and Simas RAČKAUSKAS[1,2] *

[1]Institute of Materials Science, Kaunas University of Technology, Lithuania
[2]Department of Physics, Kaunas University of Technology, Lithuania

simas.rackauskas@ktu.lt

*the corresponding author

Keywords: ZnO, tetrapods, synthesis, UV sensing, superhydrophobic, electrochemistry.

Abstract. Zinc oxide nanostructures are interesting due to their distinguished performance in electronics, optics, gas sensing and material science. Zinc oxide nanotetrapod is a structure consisting of 4 nanowires, which is especially interesting for its simple synthesis and extensive application [1].

In this work we propose a simple non-catalytic one-step process method for an efficient and rapid synthesis of ZnO tetrapods by Zn vapor oxidation under air environment and application for multifunctional coatings and fast UV sensors [2]. At the same time, the coating is supehydrophobic, with a contact angle of as high as 170° Moreover, ZnO tetrapod layer can be simply deposited on any surfaces, demonstrating the further application prospects. In this way, several ZnO nanotetrapod layers with novel function can be used to make a multifunctional coatings for the objects having potential commercial applications. In order to further improve the ZnO tetrapod based multifunctional coatings for solar harvesting, specific functionalization with other materials can be performed. ZnO nanotetrapods also show better performance for application in electrochemistry due to their morphology [3].

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References

[1] Y. Mishra, et al. ZnO tetrapod materials for functional applications. Materials Today 21(6), 631–651, 2018.

[2] S. Rackauskas, et al. A Novel Method for Continuous Synthesis of ZnO Tetrapods. The Journal of Physical Chemistry C, 119(28), 16366–16373, 2015.

[3] A. Sulciute, et al. ZnO Nanostructures Application in Electrochemistry: Influence of Morphology. J. Phys. Chem. C 2021, 125, 2, 1472–1482.

Evaluation of oxygen consumption at biologically active surfaces using scanning electrochemical microscopy

Antanas ZINOVICIUS[1,a] *, Juste ROZENE[1,b], Gediminas DIRMA[1,c], Laisvidas STRISKA[1,d], Simonas STANKAITIS[1,e] and Inga MORKVENAITE-VILKONCIENE[1,f]

[1]Department of Mechatronics, Robotics and Digital manufacturing, Vilnius Gediminas technical university, Basanaviciaus g. 28, Vilnius, Lithuania

[a]antanas.zinovicius@vilniustech.lt, [b]juste.rozene@vilniustech.lt, [c]gediminas.dirma@stud.vgtu.lt, [d]laisvidas.striska@gmail.com, [e]simonas.stankaitis@stud.vgtu.lt, [f]inga.morkvenaite-vilkonciene@vilniustech.lt

*the corresponding author

Keywords: scanning electrochemical microscopy, oxygen, living cells, mathematical model.

Abstract. Scanning electrochemical microscopy (SECM) is local electrochemical analysis technique, which performs scanning of the sample by ultra-micro-electrode (UME) [1]. The result of measurement usually is the current, which depends on the electrochemical properties of the surface of interest. The errors can be observed if UME geometry is not ideal [2], [3]. This happens after UME polishing or breaking after contact with the surface of interest. In this work, we evaluated the oxygen consumption at the surface of interest with UME of different geometry. Model result were compared with experimental data. Computational experiment was performed with SECM model using diffusion equations in Comsol program.

Acknowledgements

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References

[1] I. Morkvenaite-Vilkonciene, A. Ramanaviciene, A. Kisieliute, V. Bucinskas, A. Ramanavicius, Biosens. Bioelectron. 141 (2019) 111411. DOI: 10.1016/j.bios.2019.111411.

[2] R. Astrauskas, F. Ivanauskas, I. Morkvenaite-Vilkonciene, A. Ramanavicius, I. Morkvenaite-Vilkonciene, A. Ramanavicius, Electroanalysis 31 (2019) 2214–2223. DOI: 10.1002/elan.201900313.

[3] F. Ivanauskas, I. Morkvenaite-Vilkonciene, R. Astrauskas, A. Ramanavicius, Electrochim. Acta. 222 (2016) 347–354. DOI: 10.1016/j.electacta.2016.10.179.

Surface laser modification of maraging steel parts made by selective laser melting technology: effect on pass geometry and hardness

Kęstutis BUČELIS[1,a *], Jelena ŠKAMAT[2,b] and Olegas ČERNAŠĖJUS[1,c]

[1]Department of Mechanics and Materials Engineering of Vilnius Gediminas Technical University, J. Basanavičius str. 28, LT-03224, Vilnius, Lithuania

[2]Laboratory of Composite Materials of Vilnius Gediminas Technical University Linkmenų Str. 28, LT-08217, Vilnius, Lithuania

[a]kestutis.bucelis@vilniustech.lt, [b]jelena.skamat@vilniustech.lt, [c]olegas.cernasejus@vilniustech.lt

*the corresponding author

Keywords: laser processing, laser alloying, additive manufacturing, selective laser melting, maraging steel, hardness.

Abstract. Due to the possibility to produce the parts with complex internal and external geometries, selective laser melting (SLM) process attracts growing interest in various fields of engineering segments such as aircraft, aerospace, biomedical, automotive, marine industries and tooling. Maraging steels, having excellent weldability and high resistance to thermal fatigue due to the lack of carbon, has showed good suitability for SLM [1]. However, owing to the limited hardness and wear resistance, maraging steels has limited application at the harsh wear conditions [2]. In this study, the possibility to improve the surface characteristics of DIN 1.2709 steel SLM parts by application of laser alloying technology is evaluated. The surface of SLM part was laser processed at various laser spot diameters and varying laser scanning speeds from 500 to 1500 mm·min^{-1}, with and without preposition of alloying element. The power density was provided in the range from ~0.8·103 W·cm^{-2} to ~51·103 W·cm^{-2} and heat input – from 4 to 12 J·mm^{-1}. The effect of laser processing parameters and presence of alloying element on the geometry of obtained processed passes and hardness of surface was evaluated. It was determined, that the application of CO2 continuous laser at the parameters of 1 kW laser power, 0.5 mm laser beam spot diameter and laser scanning speed in the range between 500 mm·min^{-1} and 1250 mm·min^{-1} allows obtaining laser pool of acceptable geometry and sizes directly on as-manufactured SLM part surface without any pre-processing. The increasing scanning speed to 1500 mm·min^{-1} or spot size to 2.0 and 3.0 mm results in too small pool depth and unstable pool geometry. Surface processing at 4.0 mm spot diameter provides only heating of the surface. The laser processing with preposition of alloying element layer provided surface alloying effect of the maraging steel SLM part. The hardness of processed surface areas ranged between ~600 HV0.2 at the lowest scanning speed and ~1770 HV0.2 at the highest speed, what is from 18% to ~3.5 times higher, as compared with maximum hardness of 1.2709 maraging steel after aging (~58 HRC or ~510 HV). The geometry of laser pool did not differ significantly from that of laser-processed without alloying element.

References

[1] D. Herzog et al. Additive manufacturing of metals. Acta Materialia 117, 15 (2016) 371-392. https://doi.org/10.1016/j.actamat.2016.07.019

[2] F. Cajner et al. Surface modifications of maraging steels used in the manufacture of moulds and dies. Materiali in Tehnologije 2010 44(2):85-91. http://mit.imt.si/izvoid/mit102/cajner.pdf

ENGINEERING TECHNOLOGIES

Finite Element Model Updating Approach for Structural Health Monitoring of Lightweight Structures Using Surface Response Optimization

Darius EIDUKYNAS[1,a] *, Adi ADUMITROAIE[2,b], Paulius GRISKEVICIUS[2,c], Valdas GRIGALIŪNAS[1,d] and Tomas VAITKŪNAS[2,e]

[1]Kaunas University of Technology, Institute of Mechatronics, Kaunas, Lithuania

[2]Kaunas University of Technology, Faculty of Mechanical Engineering and Design, Kaunas, Lithuania

[a]darius.eidukynas@ktu.lt, [b]adi.adumitroaie@ktu.lt, [c]paulius.griskevicius@ktu.lt, [d]valdas.grigaliunas@ktu.lt, [e] tomas.vaitkunas@ktu.lt

*the corresponding author

Keywords: structural health monitoring, structural dynamic response, finite element model updating, damage identification, surface response optimization, virtual experiments.

Abstract. Structural health monitoring (SHM) is tracking static or dynamic characteristics of a structure in order to identify and localize damage, monitor its evolution, and decides inspection and repair intervals in order to avoid the structural collapse. Mechanical defects in the structure changes it's vibration response. There is a wide variety of methods that examine changes in measured vibration response to detect, locate, and characterize damage in structural and mechanical systems. The basic idea behind this technology is that modal parameters (notably frequencies, mode shapes, and modal damping) are functions of the physical properties of the structure (mass, damping, and stiffness). Therefore, changes in the physical properties will cause detectable changes in the modal properties. One method to evaluate the structural changes and to analyze their causes is the Finite Element Model Updating (FEMU).

The objective of this research is to investigate the FEMU procedure for mechanical damage identification and to propose an experimental-computational SHM method for lightweight structures. The structural dynamic response to impact excitation of a structure with and without defects are collected from transient and modal analysis using Ansys FE software. In order to convert structure's response from time domain to frequency domain Fast Fourier Transformation (FFT) using Matlab code is done. Afterwards, FEMU algorithm using Ansys Surface Response Optimization is investigated for its applicability to damage identification. Obtained results revealed the possibility to use this algorithm with having minimum discrepancy between parameters obtained from experiments and finite element modelling.

References

[1] Sehgal, S., & Kumar, H. (2016). Structural dynamic model updating techniques: A state of the art review. Archives of Computational Methods in Engineering, 23(3), 515-533.

[2] Schommer, S., Nguyen, V. H., Maas, S., & Zürbes, A. (2017). Model updating for structural health monitoring using static and dynamic measurements. Procedia engineering, 199, 2146-2153.

Reference to a chapter in an edited book:

[3] He, W. Y., & Zhu, S. (2013). Progressive damage detection based on multi-scale wavelet finite element model: numerical study. Computers & Structures, 125, 177-186.

[4] Weng, J. H., Loh, C. H., & Yang, J. N. (2009). Experimental study of damage detection by data-driven subspace identification and finite-element model updating. Journal of structural engineering, 135(12), 1533-1544.
[5] Fritzen, C. P. (2014). Vibration-based methods for SHM. Germany: NATO.

Assessment of the condition of anilox rollers

Arnas SAVICKAS[1,a], Rimantas STONKUS[1,b *], Eugenijus JURKONIS[1,c] and Igor ILJIN[1,d]

[1]Vilnius Gediminas Technical University, Lithuania

[a]arnas.savi@gmail.com, [b]rimantas.stonkus@vilniustech.lt, [c]eug.jurkonis@gmail.com, [d]igor.iljin@vilniustech.lt

*the corresponding author

Keywords: anilox roller, flexography, clogging, wear, cells engraving, ink transfer.

Abstract. The anilox roller is an essential component of inking system in flexography and its purpose is to deliver a precise and consistent amount of ink to the printing plate and from there onto the printed material. Despite advanced anilox manufacturing technologies, problems with the unpredictable reduction in the amount of ink during the operation of anilox rollers still remains. This is due to improper maintenance of the anilox rollers, as well as different practice of inspecting ink transfer. In this work, the condition of anilox rollers in printing houses in the Baltic States was investigated. The study evaluated the wear and cell clogging of anilox rollers. The dependences of clogging on cell size, ink type and washing method, as well as the dependences of wear on cell size (change in cell volume) and quantity of doctor blades were investigated. In addition, the uniformity of cell clogging and wear on the surface of the anilox roller was evaluated. Studies have shown that more than half of the anilox rollers in printing houses do not wash properly; higher line-count anilox rollers tend to become more clogging, and it is important to take measurements at more than three locations to assess the reliable condition of more worn rollers.

References

[1] J. Johnson, Aspects of Flexographic Print Quality and Relationship to some Printing Parameters. PhD thesis. Karlstad University, 2008.

[2] Flexography: Principles and Practices. 6th ed. New York, Foundation of Flexographic Technical Association. p. 612. (2014)

[3] D.C. Bould, S.M. Hamblyn, D.T. Gethin and T.C. Claypole, Effect of impression pressure and anilox specification on solid and halftone density. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture. 225 (5), 699–709. (2011)

[4] T. Claypole, K. Cox, Measuring Anilox Volume: FQC's Gauge R&R Study. New York, FTA. Available from: https://www.flexography.org/industry-news/measuring-anilox-volume-fqc-gauge-rr-study (2010)

[5] Harper, Specifying the Right Anilox Roll. Charlotte, Harper Anilox & Coating Division. Available from: http://www.harperimage.com/AniloxRolls/Anilox-Guides/Specifying-the-Right-Anilox (2020)

[6] O.I. Khmiliarchuk & Y.S. Shubko, Modeling of Anilox Cells Pollution Process. Kiev, ELAKPI. Available from: https://ela.kpi.ua/handle/123456789/16538 (2016)

[7] M. Poppen, The Secret to Print Consistency: Maintaining Anilox Roll Volume. New York, FTA. Available from: https://www.flexography.org/industry-news/print-consistency-maintain-anilox-roll-volume (2020)

Influence of Prepress Processes on Quality of Flexographic Printed Labels

Vaida ROČYTĖ[1,a], Rimantas STONKUS[1,b *] and Igor ILJIN[1,c]

[1]Vilnius Gediminas Technical University, Lithuania

[a]vaidarocyte@gmail.com, [b]rimantas.stonkus@vilniustech.lt, [c]igor.iljin@vilniustech.lt

*the corresponding author

Keywords: Flexographic printing, halftone, print quality, compensation curves, pre-press, dot gain, screen ruling.

Abstract. The flexographic printing becomes almost irreplaceable method in the rapidly developing packaging and labels industry due to the ability to print on different thickness and texture substrates. The spread of technology has also been driven by improved digital platemaking technologies. However, the weakness of flexography is an inaccurate reproduction of light gray and smooth gradients. The probability of defects that occur during printing can be reduced by choosing proper parameters in prepress stage. In cases when design is quite complicated, for examples there are continuous coverage areas and halftone areas in one picture, it's difficult to say what prepress parameters will give the best quality result on the print. This paper evaluates the influence of specific prepress parameters such as screen ruling (133 lpi, 150 lpi, 174 lpi, 198 lpi) and type of screening (DFM, HD) on the reproduction of printed image on the three types of printing substrates: coated matte paper, coated gloss paper and polypropylene, usually used for label printing. The changes of prints quality according to changes in density, tone values and raster dots gain were evaluated. According to the research results, the selection criteria for screening method and the line ruling are provided depending on image structure.

References

[1] Flexography: Principles and Practices. 6th ed. New York, Foundation of Flexographic Technical Association. p. 612. (2014)

[2] J. Johnson, Aspects of Flexographic Print Quality and Relationship to some Printing Parameters. PhD thesis. Karlstad University, 2008.

[3] J. Johnson, The Influence of Moisture, Temperature, Pressure Pulse and Substrate on Print Quality in Flexographic Printing. Karlstad University Studies, 2003.

[4] D. Valdec, I. Zjakić, M. Milković, The influence of variable parameters of flexographic printing on dot geometry of pre-printed printing substrate, Technical Gazette 20(4): 659–667. 2013.

[5] Flexographic Technical Association (FTA). Flexographic Image Reproduction Specifications and Tolerances (FIRST) Book (5.1rd ed.). (2015).

[6] Anderson, J.; Schlotthauer, E. Kodak's Flat Top Dots: The effect of flexo dot shape on plate stress and wear. Eastman Kodak Company. Rochester, New York, 2010.

[7] A. Lorenz, A. Senne, J.Rohde, S. Kroh, M. Wittenberg, K. Krüger, F. Clement, D. Biro. Evaluation of Flexographic Printing Technology for Multi-Busbar Solar Cells. Energy Procedia 67 (2015) 126 – 137.

[8] D. C. Bould, SMHamblyn, D. T. Gethin, and T. C. Claypole. Effect of impression pressure and anilox specification on solid and halftone density. Proc. IMechE Vol. 225 Part B: J. Engineering Manufacture. 2010. DOI: 10.1177/2041297510394072.

System Parameters on Automatic Dynamic Balance Equipment with many Balls

Marijonas BOGDEVICIUS[1,a *], Jolanta JANUTIENIENE[2,b],

Vigaile SEMASKAITE[1,c] and Oleg BYSTROV[1,d]

[1] Vilnius Gediminas Technical University, Plytines 27, LT-10105, Vilnius, Lithuania

[2] Klaipeda University, Bijūnų 17 - 108, LT-91225 Klaipėda, Lithuania

[a]marius@ti.vilniustech.lt , [b]jolanta.januteniene@ku.lt ,

[c]s.vigaile@gmail.com, [d]oleg.bystrov@vgtu.lt

*the corresponding author

Keywords: nonlinear rotor dynamics, disbalance, self-balancing.

Abstract. Dynamic stability and behavior of an automatic dynamic balance (ADB) are analyzed by a theoretical approach.

Automatic dynamic balance equipment consists of electrical engine, transmission, rotor, pipe and balls. The general assumptions on the mathematical model are following: all elements of investigated system are absolutely stiff except support; ring is fixed on the geometrical center of rotor; the balls have contact with each other and slide on the surface of the ring. Differential equations of an analyzed system have been created using Lagrange's equation. Numerical analysis of the dynamic equations is performed. Influence of system parameters on the self-balancing process is estimated.

Combine harvester performance development using Telemetry data

Eglė JOTAUTIENĖ[1,2,a *] and Antanas JUOSTAS[1,b]

[1]Vytautas Magnus University, Agriculture Academy, Institute of Agricultural Engineering and Safety, Studentų 15, Akademija, LT-53362, Kaunas reg., Lithuania

[2]Department of Mechatronics, Robotics, and Digital Manufacturing, Vilnius Gediminas Technical University; J. Basanavicius str. 28, 03224 Vilnius, Lithuania

[a]egle.jotautiene@vdu.lt, [b]antanas.juostas@vdu.lt

*the corresponding author

Keywords: agriculture, combine harvester, monitoring, telemetry, crop data.

Abstract. Innovative technologies rapidly introduced in agriculture and its machinery. There is an increasing shift towards nature-friendly and soil-saving technologies. Machine constructions, technical-economic parameters changing, the work process is controlled and regulated by computer systems. The telemetry or remote monitoring system offers especially many possibilities [1], [2].

It is the farmer's task to select the machines that can be expected to maximize profits when used rationally. Rational use of machines not only reduces the cost of production but also increases the competitiveness of production [3]. Today's advanced farming technologies help to plan work and make rational decisions for the future [4].

Claas combine harvesters equipped with a remote monitoring system called telemetry were used for research and data analysis. Telemetry data allows full use of the machine potential by taking advantage of an improvement. Research has shown that less than 50% of the technically installed capacity of a combine-harvester is used. Reducing downtime by using remote diagnosis and maintenance monitoring would increase the machine's performance [5]. It was found that the combine harvester performance between drives varies by up to 40% in identical field conditions. The analysis of the data collected in the telemetry server allowing evaluates a combine harvester efficiency and takes the decision for planning future applications.

References

[1] Bochtis, D. D.; Oksanen, T. Combined coverage path planning for field operations. In: Proc. Joint International Agricultural Conference, JIAC (2009) 521-527.

[2] Risius, N. W. Analysis of a combine grain yield monitoring system. Graduate Theses and Dissertations. Iowa State University, 2014.

[3] Prístavka, M., Bujna, M., & Korenko, M. (2013). Reliability monitoring of grain harvester in operating conditions. J. of Central European Agriculture, 14(4), (2013) 0-0.

[4] Garkuha S., Skazhennik M., Chizhikov V, Kiselev E, Petrushin A. Analysis of the use of a combine harvester equipped with a precision farming system in rice growing conditions. ERSME 2020, IOP Conference Series: Materials Science and Engineering, 2020 1-8.

[5] Prístavka M, Krištof K, Findura P 2017 Reliability monitoring of grain harvester. Agronomy Research. 15.3 (2017) 817–829.

CFD Simulation of Heat Transfer and Airflows in an Open Refrigerated Display Cabinet

Tadas VENGALIS[1,a *] and Vadim MOKŠIN[1,b]

[1]Department of Mechanical and Materials Engineering, Vilnius Gediminas Technical University,

J. Basanavičiaus str. 28, 03224, Vilnius, Lithuania

[a]tadas.vengalis@vilniustech.lt, [b]vadim.moksin@vilniustech.lt

*the corresponding author

Keywords: Open refrigerated display cabinet, CFD, heat transfer, airflow, refrigeration, temperature, air velocity.

Abstract. The open-type vertical refrigerated display cabinet used to store food at temperatures between -1°C and +7°C is schematically presented in Fig. 1. The cabinet has 5 shelves for food products. The air enters into the cabinet from the air grill at the front of the bottom panel. Fans blow air through the evaporator. The cooled air travels through a tunnel to the top of the refrigerator. The perforated distributor at the top distributes the cooled air. Part of the air is blown through the perforated back panel and the other part passes through the air-off honeycomb at the front top of the cabinet, thus forming air curtain between the inside of the refrigerator and the ambient warm air to protect the chilled food products. The cooled air entering through the back perforated panel into the display area helps to maintain the required food temperature. The overall dimensions of the cabinet (W×D×H) are following: 2500×970×1460 mm. Spacing between base and first shelf is 280 mm, between other shelves – 250 mm. The honeycomb dimensions (W×H) are 120×20 mm. "COMSOL Multi physics" software was used to simulate airflows and heat transfer in the refrigerated cabinet. The total number of 2D finite elements is about 12000. A higher number of finite elements does not influence the results. In the COMSOL Multiphysics model, the fan is simulated with normal outflow velocity, which value was set as 1.2 m/s. The outflow air temperature was considered as constant -1°C value. This value was obtained experimentally above the evaporator.

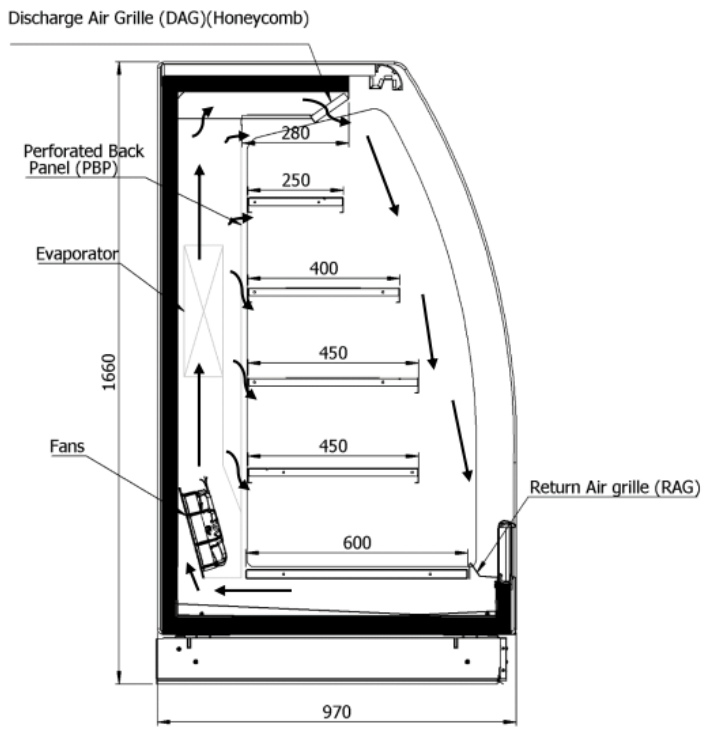
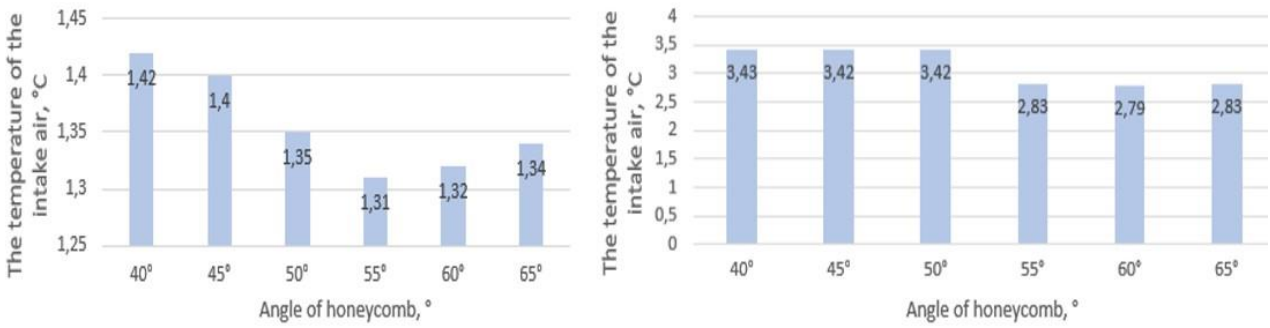


Fig. 1. Scheme of the refrigerated cabinet (side view)

The open-type refrigerated cabinet has strong natural convection between chilled air curtain and warm ambient air. To simulate this natural convection, the gravity was activated in the model and the density of the air was calculated based on the ideal gas formula. In this study, the thin layer structure was used for honeycomb modelling to provide more accurate flow direction. Hooked shelves, bottom

shelf, back perforated panel and other parts of the cabinet are made from a sheet of steel through which heat transfer occurs. Hooked shelves and bottom shelf were modelled as steel walls with a thickness of 1.4 mm. Other inner parts were modelled as steel walls with a thickness of 0.7 mm. For simulation open boundary conditions was applied to the model that means that air can freely move in and out of the testing environment.

It can be seen from Fig. 2, a that the honeycomb inclination angle influences the temperature of the intake air. In case of 55° angle the temperature is lowest that means that this airflow angle is optimal. Fig. 2, b shows the same graph obtained for cabinet full of food products. The temperature simulation results are different from results obtained for empty refrigerated cabinet. The heat exchange between the airflow curtain and the environment takes longer because the airflow rate has remained the same, but the path it travels has increased, so the elongated airflow curtain does not completely separate the interior of the refrigerator from the warm ambient air.



a) b)

Fig. 2. The airflow temperature in the intake grill obtained for empty cabinet (a) and cabinet full of food products (b)

Numerical simulation showed that the airflow curtain fully formed after 60 s. in case of empty cabinet. The increased angle made a straighter airflow curtain with a bigger radius. In 55-65° angle range, the airflow lines almost do not cross the refrigerated cabinet contour. The velocity of the airflow out of the honeycomb is 0.6 m/s and 0.4 m/s near the intake grill at the bottom of the cabinet. The reason for reduced airflow curtain velocity is cold and warm air mixing in all curtain length. In case of full cabinet, the airflow curtain fully created after 120 s. The airflow curtain changed its shape and its lines cross the refrigerated cabinet contour. In 55-65° angle interval, the airflow curtain formed near cabinet outside contour and environmental factors do not influence its shape sufficiently. Air velocity values are the same as obtained for case of empty cabinet.

In this study, a simplified steady state heat transfer model was developed for an open-type refrigerated cabinet. In summary, the following conclusions can be drawn:

Numerical simulation results show that honeycomb inclination angle influences the intake temperature in empty and full loaded refrigerated cabinet.

The results of the study show that the increase of honeycomb inclination angle to 55° allow to reach the highest efficiency of the air flow curtain. Further increase in angle does not lead to significant increase of the efficiency.

Heat transfer model developed in this study can be used in further research to simulate the effect of length of hanging shelves on food temperature.

Research of the Quality of Surfaces Machined by Combined Machining Techniques

Tomas SERAPINAS

J. Basanavičiaus str. 28, Vilnius, Lithuania

tomas.serapinas@stud.vgtu.lt

Keywords: milling, turning, turn mill, combined machining techniques, surface quality.

Abstract. Different machining techniques require a solid level of prediction of the outcome results to be known. Selection of the right machining method or technique includes evaluation of total costs of production, time consumption and labor. It is possible to achieve same results of outcome of a machining method, in this case, the quality of a machined surface choosing different or combined methods.

In this paper a study of surface quality dependence of machining parameters when turn milling a part, a combined machining method when a turned part is milled at the same time is compared to a dependence of parameters of similar influence to the outcome surface quality in turning method.

Influence of electroplating parameters on properties of Ni-nanodiamonds coatings

Vadzim CHAYEUSKI[1,a *], Valery ZHYLINSKI[2,b], Nikolaj VIŠNIAKOV[3,c] and Olegas ČERNAŠĖJUS[4,d]

[1]State Technological University, Information Technology Faculty, the Department of Physics, Sverdlov str. 13a, 220006 Minsk, Belarus

[2]Belarusian State Technological University, Faculty of Chemical Engineering and Technology, the Department of Chemistry, Electrochemical Production Technology and Materials for Electronic Equipment, Sverdlov str. 13a, 220006 Minsk, Belarus

[3]Vilnius Gediminas Technical University, Faculty of Mechanics, Laboratory of Materials research, J. Basanaviciaus str. 28, LT-03224 Vilnius, Lithuania

[4]Vilnius Gediminas Technical University, Faculty of Mechanics, Department of Mechanics and Materials Engineering, J. Basanaviciaus str. 28, LT-03224 Vilnius, Lithuania

[a]chayeuski@belstu.by, [b]zhilinski@yandex.by, [c]nikolaj.visniakov@vilniustech.lt, [d]olegas.cernasejus@vilniustech.lt

*the corresponding author

Keywords: nanodiamonds coating, surface defect.

Abstract. The paper presents the parameters of deposition of composite electrochemical coatings of Ni- detonation nanodiamonds (DNDs) on a steel (R6M5) base for the purpose of uniform distribution of nanodiamonds on the surface of coatings and the presence of a small number of defects, which improves the mixing of nanodiamonds with aqueous solutions and allows targeted delivery of medicines using nanodiamonds. Electrochemical coatings of Ni-DNDs with a small number of surface defects that have high microhardness values have been synthesized, which contributes to a significant improvement in the durability of medical instruments and implants.

References

[1] X. Yuan [et al.] Structure and mechanical properties of Ni–P electrodeposited coatings, Applied Surface Science. Vol. 255, no. 6 (2009), pp. 3613–3617.

[2] M. K. Chang, C. H. Chen, B. H. Chen. Fabrication of magnetic nickel-tungsten-phosphorus particles by electroless deposition, J. Magn. Mater. Vol. 305, Iss. 2 (2006), pp. 342–347.

[3] P. B. Kubrak, V. B. Drozdovich, I. M. Zharski, V. V. Chaevskiy. Electrodeposition of Composite Coatings Containing Carbon-based Nanomaterials and Properties of Coatings Obtained, Electroplating and Surf. Treat. XX (2) (2012), pp. 43-49 (in Russian).

[4] V. Yu. Dolmatov. Detonation synthesis ultradispersed diamonds: properties and applications, Rus. Chem. Rev. 70 (7) (2001), pp. 607–626.

[5] P. A. Vityaz, V. I. Zhornik, A. F. Ilyushchenko, V. T. Senyut, A. I. Komarov, A. P. Korzhenevskiy, A. V. Ivakhnik. Nanodiamonds of detonation synthesis: preparation and application, Belaruskaya navuka, Minsk, (2013) (in Russian).

[6] I. Vlasov , S. Turner , G. Van Tendeloo, A. Shiryaev. Recent Results on Characterization of Detonation Nanodiamonds, Kidlington: William Andrew Pub., (2006), pp. 291–326.

[7] V.Yu. Dolmatov. Detonation Nanodiamonds. Preparation, Properties, and Applications, SPO "Professional", St. Petersburg, (2011) (in Russian).
[8] L. C. L. Huang, H.-C. Chang. Adsorption and immobilization of cytochrome c on nanodiamonds, Langmuir, Vol. 20, Iss. 14 (2004), pp. 5879–5884.
[9] S. Osswald, G. Yushin, V. Mochalin, S. O Kucheyev, Yu. Gogotsi. Control of SP2 /SP3 carbon ratio and surface chemistry of nanodiamond powders by selective oxidation in air, Journal of the American Chemical Society. Vol. 128, Iss. 35 (2006), pp. 11635–11642.
[10] R. A. Shimkunas, E. Robinson, R. Lam, S. Lu, X. Xu, X.-Q. Zhang, H. Huang, E. Osawa, D. Ho. Nanodiamond-insulin complexes as pH-dependent protein delivery vehicles, Biomaterials, 30 (2009), pp. 5720–5728.
[11] R. Yu. Yakovlev [et al.]. Nanodiamonds in pharmacy and medicine. Ryazan: RSMU, (2016) (in Russian).
[12] A. G. Kononov, Ya. S. Sachivko, A. P. Korzhenevskiy, R. G. Shtemplyuk, Thermal stability of chromium coatings modified with nano-sized oxygen-containing additives, Mechanics of Machines, Mechanisms and Materials, Vol. 4 (2015), pp. 353–357.
[13] L. E. Tyryshkina, G. A. Chiganova, A. K. Abkaryan, Influence of Nanodiamonds on Microstructure of Nickel Coatings, Univer. Proc. Powder Metal. and Funct. Coat. 2 (2014), pp. 54-58.

Investigation of the Sustainability, Durability and Abrasion of Printed Elements Applied to Sports Equipment from Composite Materials

Artiom SIDOROV[1,a] and Igor ILJIN[1,b *]

[1]Vilnius Gediminas Technical University, Lithuania

[a]artiom.sidorov95@gmail.com, [b]igor.iljin@vilniustech.lt

*the corresponding author

Keywords: sustainability, durability, abrasion, printed elements, printing ink, composite materials.

Abstract. The work investigated the durability of the labeling of sports equipment made of composite materials. Professional hockey sticks were taken for research. To study the abrasion of elements using the UGRA method, an original stand was created. With the help of this stand, studies of the abrasion of printed elements were carried out. Research has been done on hockey stick wear for different players: center and winger and defender. In addition, a study was made of hockey sticks for left-handers and right-handers. In the study of the wear of printed elements, sports equipment of various lengths was used. Contact research was carried out during training and competition. The study of the number of contacts was carried out on the basis of video recordings of trainings and games of the teams “Energija” - Elektrėnai (Lithuania) and the national team of the Belarusian Republic. The study carried out showed that the hockey stick wear of the center striker and the winger during the competition and training is similar. During the competition, the clubs of the center strikers are most often in contact. It was found that the difference between contacts during training and playing depends on the intensity of the game, penalty time and strategy. When conducting a study of the wear of the printed elements applied to the hockey stick, depending on the position of the player, it was found that the wear of the sticks of the winger and the defender is the same, but that of the center striker is different. When conducting a study of hockey stick wear depending on its length, the following conclusion was made: the taller the player, the longer his club and the maximum contact area. Research has shown that hockey stick wear is not affected by how the player holds the hockey stick, i.e. whether he is left-handed or right-handed. Based on the study, it was concluded that the abrasion of printed elements most often occurs at the moment of contact of the objects of research, both with each other and with objects on the playing field. As a result, the printed elements split, peel off and become less noticeable, in addition, the name of the manufacturer's company is worn out and the club loses the player's personal identification data printed on the stick. Recommendations are given on the peculiarities of printing and the location of printed elements on sports equipment.

References

[1] H. P. Le, Progress and Trends in Ink-jet Printing Technology, Journal of Imaging Science and Technology 1(42): 1998, 49–62.

[2] C. Timothy, E. Jewell, N. Wells, P. Casey: Influence of paper and printing process on the visual perception and colorimetric characteristics of newsprint. Welsh Centre for Printing and CoatingSchool of Engineering, Grenoble IARIGAI, 2007, 205–212.

[3] J. Heilmann, U. Lindqvist: Effect of drops interactions on ink-jet print quality. Journal of Imaging Science and Technology 44(6), 2000, 491-494.

[4] C. Yuetao, W. Yianfu, H. Beiqing Study on Printability of Plastic Water-based gravure ink, The 6th international conference on imaging science and hardcopy ICISH', 2008, 200-203.

[5] Z. Wenhua, H. Beihai, Q. Xiaokun, Z. Lijuan: Influences of ink-Jet Printing Papers on digital Proofing Performances The 6th international conference on imaging science and hardcopy ICISH', 2008, 146-150.
[6] H. Kipphan, Handbook of Print Media. Springer – Verlag: Berlin-Heidelberg-New York, 2001.

Experimental research of the damping characteristics of the fatigue stand caused by changes in material properties

Roland PAWLICZEK[1,a,*], Tadeusz LAGODA[1,b], Marta KUREK[1,c] and Grzegorz ROBAK[1,d]

[1]Faculty of Mechanical Engineering, Opole University of Technology,

Mikolajczyka st. 5, 45-271, Opole, Poland

[a]r.pawliczek@po.edu.pl, [b]t.lagoda@po.edu.pl, [c]ma.kurek@po.edu.pl, [d]g.robak@po.edu.pl

*the corresponding author

Keywords: fatigue test, harmonic oscillator, damping, cyclic properties.

Abstract. The paper presents the results of research on changes in the damping characteristics of the MZGS100 fatigue test stand [1,], [2]. The work of the stand is influenced by the type of material and shape of the tested samples, where different material properties and stiffness affect the dynamic characteristics of the stand [3]. In fatigue tests of materials, the effect of changing the properties of the material subjected to fatigue loads for the so-called cyclically unstable materials, is well known [4], [5]. It is important to assess the impact of changes in properties during the test on the work of the test stand. Fatigue tests were carried out for three materials: S355J0 steel, 2017A-T4 aluminum alloy and CuZn40Pb2 brass. The tests were carried out under fatigue bending loads for the number of failure cycles in the low-cycle range, where plastic strains appear in the material. During the investigation, the test was interrupted and the impulse response of the stand at various stages was recorded and the change in system response was assessed. In the initial stage, each of the tested materials showed a weakening in relation to the starting material. It was observed that in the case of brass, the damping curve of the system changed continuously, and the damping factor of the system increased by 23%. In the case of steel, practically no changes were noticed, while the aluminum alloy showed changes of 9%. In the final stage of the test for steel and aluminum alloy, a change in the frequency of natural vibrations was observed, which indicates a decrease in the system stiffness caused by the weakening of the specimen`s cross-section. This effect was not noticed for brass samples, which together with the change of the damping coefficient indicates a cyclical change of the material properties.

References

[1] H.Achtelik, M. Kurek, A. Kurek, K. Kluger, R. Pawliczek, T. Łagoda, Non-standard fatigue stands for material testing under bending and torsion loadings, AIP Conf. Proc. 2029 (2018) 020001 doi: 10.1063/1.5066463

[2] R. Pawliczek, Modernization of the fatigue test stand control system using the idea of a virtual instrument, 15th International Conference Mechatronic Systems and Materials (Bialystok, Poland), IEEE Xplore, 2020, pp. 1-6, doi: 10.1109/MSM49833.2020.9201702.

[3] T. Lagoda, M. Kurek, G. Robak, R. Pawliczek, Influence of the specimen's material and shape on behavior of the fatigue test stand MZGS100, The 13th Int. Conf. Mechatronic Systems and Materials (MSM – 2017) – Abstract, (2017) 69-70

[4] S. Mrozinski, M. Piotrowski, Effect of Strain Level on Cyclic Properties of S355 Steel, Fatigue Failure And Fracture Mechanics XXVI, AIP Conf. Proc., 1780 (2016) 020005

[5] Kurek, M. Kurek, T. Lagoda, Stress-life curve for high and low cycle fatigue, Journal of Theoretical and Applied Mechanics, 57(3) (2019) 677-684

Investigations of Vibro Acoustic Separation of Heterogeneous Liquids

Karina SUBATKEVIČIENĖ[1,a] *, Ina TETSMAN[1,b]

[1]Vilnius Gediminas Technical University, J. Basanavičiaus st. 28, 03224 Vilnius, Lithuania,

[a]karina.subatkeviciene@vilniustech.lt, [b]ina.tetsman@vilniustech.lt

*the corresponding author

Keywords: coagulation, dispersed systems, dispersed phase, vibro acoustic, water pollution.

Abstract. Combating water pollution, including effective treatment methods, is one of the key challenges faced by highly developed countries. However, all growing volumes of wastewater consumption, which are among the most "dirty" and are characterized by a complex composition of aggressive pollutants of organic and inorganic origin. It is the growing volumes of wastewater consumption and the content of various pollutants in them that dictate the need to transform technologies and introduce all the newest scientific advances in engineering and technology. It is the acceleration of intensification that makes it possible to transform the technological process.Thus, the increase in costs pays off by the efficient and economical use of all resources.One of the promising areas of technology development is a detailed study of the formation processes of stable dispersed systems with a liquid dispersed environment and a liquid dispersed phase - emulsions, as well as the mechanisms of their separation into constituent components. It should be noted that the emulsions obtained during the technological process sometimes do not delaminate for a long time. This often introduces a certain complexity for the implementation of further manufacturing operations with the product. A necessary factor for the separation of the formed emulsion is the process of enlargement and subsequent precipitation of particles of the dispersed phase - coagulation. For stable emulsions, the process of natural coagulation under the influence of gravitational force does not give a significant effect. To intensify this process, it is necessary to use certain chemicals or intense mechanical impact. The phenomenon of the emergence of the effect of coagulation in a liquid dispersed medium under the influence of ultrasonic vibrations of low intensity is known. Inhomogeneous liquid systems with more or less coarse fragmentation of the dispersed phase are prone to decomposition under the influence of gravity alone, while if the density of the dispersed phase is greater than the density of the dispersion medium, suspended particles settle to the bottom of the vessel and, conversely, if the density of the dispersion environment is greater than the density of suspended particles, the latter float up. The sedimentation rate of suspended particles depends on both their density and the degree of dispersion, and the sedimentation will proceed the slower, when the smaller the particles of the dispersed phase have and the smaller the difference in the densities of both phases. In practice, the method of settling and decantation is used mainly in relation to the decomposition of suspensions, namely, coarse and thin suspensions. Separation of inhomogeneous liquid systems can also be carried out under the influence of centrifugal forces; in this case, a much more intense separation occurs than under the action of gravity forces.

References

[1] M. Fossen, R. Arntzen, P. Hemmingsen, J. Sjöblom, J. Jakobssonet, J. Dispersion Sci. Technol. 27 (2006) 453–461.

[2] T. Frising, C. Noïk, C. Dalmazzone, J. Dispersion Sci. Technol. 27 (2006) 1035–1057.

[3] G.D. Pangu, D.L. Feke, Ultrasonics 46 (2007) 289–302.

[4] Y. Gan, A. Xu, G. Zhang, Y. Li, H. Li, Phase separation in thermal systems: a Lattice Boltzmann study and morphological characterization, Phys. Rev. E 84 (2010) 4547.

EDUCATION

Advanced ICT solutions in a distance vocational education and training in the field of robotics

Zbigniew PILAT[1,a *[0000-0002-4553-1695]], Polyxeni ARAPI[2,b], Nikos PAPPAS[2,c], Mirosław OMIELJANOWICZ[3,d], Norbert PROKOPIUK[4,e] and Mart TAMRE[5,f]

[1] ŁUKASIEWICZ - Industrial Research Institute of Automation and Measurements PIAP, Warsaw, Poland

[2] Technical University of Crete, Laboratory of Distributed Multimedia Information Systems and Applications (TUC/MUSIC), Chania, Greece

[3] Bialystok University of Technology, Faculty of Computer Science, Bialystok, Poland

[4]Warsaw University of Technology, Faculty of Power and Aeronautical Engineering,

[5]Tallinn University of Technology, School of Engineering, Tallinn, Estonia

[a]zbigniew.pilat@piap.lukasiewicz.gov.pl, [b]xenia@ced.tuc.gr, [c]nikos@ced.tuc.gr, [d]m.omieljanowicz@pb.edu.pl, [e]norbertprokopiuk@gmail.com, [f]mart.tamre@ttu.ee

*the corresponding author

Keywords: vocational education and training VET, distance learning, robotics, ICT in education, augmented reality, virtual reality.

Abstract. Automation and robotization (A&R) is often the main driving force behind the development of advanced manufacturing, including the transformation of the company towards the Industry 4.0 model. Effective implementation and effective use of A&R solutions is possible only if the company has good prepared and educated employees. It applies to all levels, from the direct operation of machines and processes, through mid-level technical staff, to the management level. Nowadays, education of young staff, as well as training of those currently employed, requires the implementation of new solutions and methods of vocational education and training.

Access to effective and attractive educational activities and vocational training in the field of robotics faces many barriers. The problem concerns both students of technical secondary schools, students of professional development courses, students of universities and employees of industrial companies. One of the limitations is access to practical exercises with the robot, where demonstration of its operation is possible. Currently, an education unit or industrial company that wants to train its employees must send them to a training center equipped with robotic training stations or organize such a training cell at its own. It is costly, time-consuming and limits access to training for many potential recipients. The pandemic that has prevailed for over a year has significantly aggravated these problems. Laboratories are closed, travel opportunities for both participants and training staff are limited. For this reason, there is an increasing demand for all forms of distance learning, including vocational training.

One of the goals of the MILAN (Erasmus +) project was to develop and pre-test such a new approach that uses distance learning methods supported by advanced ICT solutions. Now, after the outbreak of the pandemic, this part of the project seems to be gaining in importance. The article presents the preliminary results of the project, including an online education and training platform that integrates a series of e-learning courses on Robotics and a multimedia library. Beyond traditional multimedia objects (such as photos, videos etc.), the library includes 3D objects and simulations that the student can experience in AR or VR. The functionality implemented in the platform and the technologies selected make possible

integrating those multimedia objects at any part of a course and providing web-based immersive AR/VR experiences, which can be delivered from the platform and the browser without needing to install any native applications (although this is also possible). Thus, a wide range of devices are supported, from computer stations equipped with AR / VR systems and headsets to popular mobile devices, e.g. smartphones.