ABSTRACTS

Ramanuj Kumar, Surjeet S. Gour, Anish Pandey, Shrestha Kumar, Abhijeet Mohan, Pratik Shashwat, Ashok K. Sahoo
Design and Analysis of a Novel Concept-Based Unmanned Aerial Vehicle with Ground Traversing Capability

Unmanned aerial vehicle (UAV) is a typical aircraft that is operated remotely by a human operator or autonomously by an on-board microcontroller. The UAV typically carries offensive ordnance, target designators, sensors or electronic transmitters designed for one or more applications. Such application can be in the field of defence surveillance, border patrol, search, bomb disposals, logistics and so forth. These UAVs are also being used in some other areas, such as medical purposes including for medicine delivery, rescue operations, agricultural applications and so on. However, these UAVs can only fly in the sky, and they cannot travel on the ground for other applications. Therefore, in this paper, we design and present the novel concept-based UAV, which can also travel on the ground and rough terrain as an unmanned ground vehicle (UGV). This means that according to our requirement, we can use this as a quadcopter and caterpillar wheel–based UGV using a single remote control unit. Further, the current study also briefly discusses the two-dimensional (2D) and three-dimensional (3D) SolidWorks models of the novel concept-based combined vehicle (UAV + UGV), together with a physical model of a combined vehicle (UAV + UGV) and its various components. Moreover, the kinematic analysis of a combined vehicle (UAV + UGV) has been studied, and the motion controlling kinematic equations have been derived. Then, the real-time aerial and ground motions and orientations and control-based experimental results of a combined vehicle (UAV + UGV) are presented to demonstrate the robustness and effectiveness of the proposed vehicle.

Andreea S. Turiac, Małgorzata Zdrodowska
Data Mining Approach in Diagnosis and Treatment of Chronic Kidney Disease

Chronic Kidney Disease (CKD) is a general definition of kidney dysfunction that lasts more than 3 months. When CKD is advanced, the kidneys are no longer able to cleanse the blood of toxins and harmful waste products and can no longer support the proper functioning of other organs. The disease can begin suddenly or develop latently over a long period of time without the presence of characteristic symptoms. The most common causes are other chronic diseases – predominantly diabetes and hypertension. Therefore, it is very important to diagnose the disease in its early stages and opt for a suitable treatment – encompassing medication, diet and exercises – to attenuate its side effects. The purpose of this paper is to analyse and select those patient characteristics that may influence the prevalence of chronic kidney disease, as well as to extract classification rules and action rules that can be useful for medical professionals in efficiently and accurately diagnosing patients with CKD. The first step of the study was feature selection and evaluation of its effect on classification results. The study was repeated for four models – containing all available patient data, features identified by doctors as major factors in CKD and models with features selected using Correlation-based Feature Selection and Chi-Square Test. Sequential Minimal Optimisation (SMO) and Multilayer Perceptron had the best performance for all four cases, with an average accuracy of 98.31% for SMO and 98.06% for Multilayer Perceptron, results that were confirmed by taking into consideration the F1-Score, which, for both algorithms, was above 0.98. For all these models, the classification rules were extracted. The final step was action rule extraction. The paper shows that appropriate data analysis allows for building models that can support doctors in diagnosing a disease and, additionally, support their decisions on treatment. Action rules can be important guidelines for doctors. They can reassure the doctor in his diagnosis or indicate new, previously unseen ways to cure the patient.

Zbigniew Kamiński
Calculation of the Optimal Braking Force Distribution in Three-Axle Trailers with Tandem Suspension

Heavy agricultural trailers can be equipped with a three-axle chassis with a tandem axle set at the rear and one mounted on a turntable at the front. In such trailers, selection of the distribution of braking forces that meet the requirements of the EU Directive 2015/68, with regard to braking, largely depends on the type of tandem suspension used. The requirements for brake force distribution in agricultural trailers of categories R3 and R4 are described. On this basis, a methodology for calculating the optimal linear distribution of braking forces, characteristic of agricultural trailers with air braking systems, was developed. An analysis of the forces acting on a 24-tonne three-axle trailer during braking was performed for five different suspensions of the rear tandem axle. An optimization algorithm using the quasi Monte Carlo method was described, on the basis of which a computer program for selection of the linear distribution of braking forces was developed. The calculations were made for an empty and loaded trailer with and without the weight of the tandem suspension. The most uniform distribution of braking forces was obtained for two leaf spring with dynamic equalization and air suspension, in which the ratio of the braking force of the tandem axle and the total braking force varied between 22.9% and 25.5% for the different calculation variants. A large variation in the braking force distribution was achieved for the two leaf spring suspension, in which the ratio of tandem axle braking force and the total braking force ranged from 2.7% to 6.4% for the leading axle and from 27.8% to 36.2% for the trailing axle. The presented calculation methodology can be used in the initial phase of the design of air braking systems for three-axle agricultural trailers.

Muhammad B. Hafeez, Marek Krawczuk, Hasan Shahzad
An Overview of Heat Transfer Enhancement Based Upon Nanoparticles Influenced by Induced Magnetic Field with Slip Condition via Finite Element Strategy

The mathematical model of heat generation and dissipation during thermal energy transmission employing nanoparticles in a Newtonian medium is investigated. Dimensionless boundary layer equations with correlations for titanium dioxide, copper oxide, and aluminium oxide are solved by the finite element method. Parameters are varied to analyze their impact on the flow fields. Various numerical experiments are performed consecutively to explore the phenomenon of thermal performance of the combination fluid. A remarkable enhancement in thermal performance is noticed when solid structures are dispersed in the working fluid. The Biot number determines the convective nature of the boundary. When the Biot number is increased, the fluid temperature decreases significantly. Among copper oxide, aluminium oxide, and titanium oxide nanoparticles, copper oxide nanoparticles are found to be the most effective thermal enhancers.

Michał Chlost, Michał Gdula
A New Method of the Positioning and Analysis of the Roughness Deviation in 5-Axis Milling of External Cylindrical Gear

Five-axis milling is a modern, flexible and constantly developing manufacturing process, which can be used for the machining of external cylindrical gears by means of cylindrical end mills and special disc mills on universal multi-axis machining centres. The article presents a new method of positioning the tip and the axis of the end mill and the disc cutter in order to ensure a constant value of deviation of the theoretical roughness R_{th} along the entire length of the tooth profile. The first part presents a mathematical model of the five-axis milling process of the cylindrical gear and an algorithm for calculating the R_{th} deviation values. The next section describes the positioning of the end mill and the disc cutter. Then, a new method for the empirical determination of the distribution of the involute root angle Δu_i and the data description by means of the interpolation function are presented and described. In the conducted numerical tests, the influence of the geometrical parameters of the cylindrical gear on the deviation R_{th} is determined, assuming a constant R_{th} value in the five-axis milling process.

Stanisław Noga, Edward Rejman, Paweł Bałon, Bartłomiej Kiełbasa, Robert Smusz, Janusz Szostak
Analytical and Numerical Analysis of Injection Pump (Stepped) Shaft Vibrations using Timoshenko Theory

The free transverse vibrations of shafts with complex geometry are studied using analytical methods and numerical simulations. A methodology is proposed for evaluating the results of a natural transverse vibration analysis as generated by finite element (FE) models of a shaft with compound geometry. The effectiveness of the suggested approach is tested using an arbitrarily chosen model of the injection pump shaft. The required analytical models of the transverse vibrations of stepped shafts are derived based on the Timoshenko thick beam theory. The separation of variables method is used to find the needed solutions to the free vibrations. The eigenvalue problem is formulated and solved by using the FE representation for the shaft and for each shaft-simplified model. The results for these models are discussed and compared. Additionally, the usefulness of the Myklestad–Prohl (MP) method in the field of preliminary analysis of transverse vibration of complex shaft systems is indicated. It is important to note that the solutions proposed in this paper could be useful for engineers dealing with the dynamics of various types of machine shafts with low values of operating speeds.

Krzysztof Nowik, Zbigniew Oksiuta
Experimental and Numerical Small Punch Tests of the 14Cr ODS Ferritic Steel

Nowadays, various small specimen test techniques have gained wide popularity and appreciation among researchers as they offer undoubtful benefits in terms of structural material characterisation. This paper focuses on small punch tests (SPTs) performed on small-sized disc specimens to assess the mechanical properties of 14Cr oxide dispersion strengthened (ODS) steel. A numerical model was established to support experimental data and gain deeper insight into complex strain states developing in a deformed specimen. Modern evaluation procedures were discussed for obtaining mechanical properties from the small punch force-deflection response and were compared with the literature. Applicability and universality of those relations at different test conditions were also studied. It appeared that different ball diameters used had negligible influence on yield point but strongly affected ultimate strength estimation. It was found that friction belongs to decisive factors determining strain distribution in samples, as dry conditions increase the peak strain and move its location farther from the punch pole.

Dariusz Szpica, Marcin Kisiel, Jarosław Czaban
Simulation Evaluation of the Influence of Selected Geometric Parameters on the Operation of the Pneumatic Braking System of a Trailer with a Differential Valve

This article presents simulation models of trailer air brake systems in configurations without a valve and with a differential valve, thus demonstrating the rationale for using a valve to improve system performance. Simplified mathematical models using the lumped method for systems without and with a differential valve are presented. The proposed valve can have two states of operation depending on the configuration of relevant parameters. These parameters can include the length of the control pipe, the throughput between chambers in the control part of the valve and the forcing rise time. Based on the calculations, it was found that the differential valve with large control pipe lengths can reduce the response time of the actuator by 42.77% relative to the system without the valve. In the case of transition of the valve to the tracking action, this time increases only by 9.93%. A force rise time of 0.5 s causes the transition of the valve from the accelerating action to the tracking action, with 9.23% delay relative to the system without a valve. The calculations can be used in the preliminary assessment of the speed of operation of pneumatic braking systems and in the formulation of guidelines for the construction of a prototypical differential valve. In conclusion, it is suggested to use a mechatronic system enabling smooth adjustment of the flow rate between chambers of the control system of the differential valve.

Heorhiy Sulym, Andrii Vasylyshyn, Iaroslav Pasternak
Influence of Imperfect Interface of Anisotropic Thermomagnetoelectroelastic Bimaterial Solids on Interaction of Thin Deformable Inclusions

This work studies the problem of thermomagnetoelectroelastic anisotropic bimaterial with imperfect high-temperature conducting coherent interface, whose components contain thin inclusions. Using the extended Stroh formalism and complex variable calculus, the Somigliana-type integral formulae and the corresponding boundary integral equations for the anisotropic thermomagnetoelectroelastic bimaterial with high-temperature conducting coherent interface are obtained. These integral equations are introduced into the modified boundary element approach. The numerical analysis of new problems is held and results are presented for single and multiple inclusions.

Mehmet Aladag, Monika Bernacka, Magdalena Joka-Yildiz, Wojciech Grodzki, Przemysław Zamojski, Izabela Zgłobicka
Reverse Engineering of Parts with Asymmetrical Properties using Replacement Materials

Reverse engineering (RE) aims at the reproduction of products following a detailed examination of their construction or composition. Nowadays, industrial applications of RE were boosted by combining it with additive manufacturing. Printing of reverse-engineered elements has become an option particularly when spare parts are needed. In this paper, a case study was presented that explains how such an approach can be implemented in the case of products with asymmetric mechanical properties and using replacement materials. In this case study, a reverse engineering application was conducted on a textile machine spare part. To this end, the nearest material was selected to the actual material selection and some mechanical tests were made to validate it. Next, a replacement part was designed by following the asymmetric push-in pull-out characteristic. Finally, the finite element analysis with Additive Manufacturing was combined and validated experimentally.

Marcin Zastempowski, Andrzej Bochat, Lubomir Hujo, Juraj Jablonicky, Maciej Janiec
Impact of Cutting Units' Design on Biomass Cutting Resistance

The paper presents mathematical models describing the moments of resistance to cutting on the cutting drum shafts in the biomass cutting process. The mathematical procedures described in the paper have been verified on a test stand developed and constructed by the authors, which reflects real conditions of the process of cutting plant material into pieces of specified lengths. Experimental verification proved that the developed mathematical models are adequate for drums of both cylindrical and conical constructions. The value of the average error did not exceed 13%. Following the mathematical elaboration and verification studies, the authors carried out calculations for machines currently available on the market that are equipped with drum cutting units. The calculations were carried out for the most commonly cut material, i.e. for maize, straw and green plant materials. The obtained results confirm the complexity of the problem arising from a wide range of numerical values of cutting resistance, which is contained in the range of 400–1,800 nm. The compiled database can be practically applied in the selection of machines for specific field works, and the mathematical models developed and verified in the study can be applied at the stage of designing new designs of cutting drums used in forage harvesters.

Oleh Knysh, Ivan Rehei, Nazar Kandiak, Serhij Ternytskyi, Bohdan Ivaskiv
Experimental Evaluation of Eccentric Mechanism Power Loading of Movable Pressure Plate in Die-Cutting Press

The paper reports experimental research on torques during cardboard cutting in the die-cutting press with eccentrics in the drive of the movable pressure plate. To conduct the research, an experimental bench with eccentrics in the drive of the die-cutting press is designed and manufactured. The manufactured experimental device for the research on cardboard blanks provides the possibility of getting dependencies of loadings at different parameters of the die-cutting process. The experimental approach envisages the use of the strain gauge measurement method and the wireless module for data collecting, as well as the software for its processing, for getting trustworthy results with minimum faults. The method gives an opportunity to study the torque values during the cardboard-cutting efforts on the drive shaft. The paper shows changes in the torque value on the drive shaft during the kinematic cycle with and without the use of cardboard blank. The angle of the drive shaft rotation during the cutting process was evaluated at selected values of the cardboard thickness. The relationship between the linear cutting efforts and the cardboard thickness, its fibre direction, cutting rule type and rotational speed of the drive shaft is elaborated. This kind of data is approximated by a logarithmic function (logarithmic curve), at R^2 from 0.90 to 0.98. The thickness of the cardboard significantly influences the value of the linear cutting effort at all the studied parameters.

Samrawit A. Tewelde, Marek Krawczuk
Nonlinearity Effects Caused by Closed Crack in Beam and Plate: A Review

The effect of nonlinearity is high sensitivity in damage detection, especially for closed cracks and delamination. This review illustrates the results of several researchers dealing with nonlinear effects caused by the closure of cracks in the structure, i.e., beam and plate structures. Early detection of damage is an important aspect for the structure and, therefore, continuous progress is being made in developing new and effective methods that use nonlinear effects for early detection of damage and barely visible cracks, i.e., closed cracks and delamination, as well as for the determination of crack size and location. After analysing various methods, the merits, drawbacks and prospects of a number of nonlinear vibration methods for structural damage detection are discussed, and recommendations are made for future researchers.

Mateusz Kukla, Maksymilian Rachel
Numerical Model and an Analysis of Inertial Accumulator Operation under Selected Working Conditions

The aim of this paper was to create a computational model that will enable the evaluation of the operation of a conventional inertia accumulator. This is an issue that is relevant as storage of energy is becoming increasingly important, in particular when it comes to generating electricity from renewable sources. In the course of the conducted works, an analytical model was developed based on the available literature, and then, it was introduced into the environment for numerical calculations. Four variants resulting from different geometrical parameters of the flywheel were adopted successively. On this basis, a series of simulations were performed, which allowed for obtaining the characteristics of the analysed solutions. As a consequence, a number of characteristics related to the mechanical power and energy of the simulated kinetic energy accumulators were obtained. The test results therefore provide a basis for comparing kinetic energy accumulators with different geometries and drive solutions.

Radosław Patyk, Łukasz Bohdal, Szymon Gontarz
Experimental and Numerical Investigations and Optimisation of Grain-Oriented Silicon Steel Mechanical Cutting Process

The process of mechanical cutting of magnetic materials has many advantages in the form of high efficiency with reduced process costs in relation to other cutting technologies; no thermal stresses in the material, which significantly deteriorate the magnetic properties; or the possibility of shaping materials taking into account long cutting lines. In industrial practice, it is very difficult to ensure appropriate conditions for the cutting process and its proper control. Currently, there are no data on the selection of technological parameters of the mechanical shear slitting process of grain-oriented silicon steel in terms of the obtained cutting surface quality and the obtained magnetic properties of the workpiece. The article presents the possibilities of forecasting the characteristic features of the cut edge and selected magnetic properties of grain-oriented silicon steel. For this purpose, proprietary numerical models using FEA (Finite Element Analysis) were used. Then, experimental studies were carried out, and the optimisation task was developed. The developed results enable the correct selection of technological parameters of the process, ensuring the appropriate quality of the cut edge of steel and minimal interference with the magnetic properties.