ABSTRACTS

Valerii Stavytskyi, Oleksandr Bashta, Pavlo Nosko, Yurii Tsybrii
Determination of Hydrodynamic Power Losses in A Gearing

Despite the relatively numerous experimental studies, there are few published works on the topic of development of mathematical models that describe the hydrodynamic processes in gears. There is no generic analytical model that integrates all types of losses. The purpose of this work is to develop a modern generalised methodology for calculating the hydrodynamic power losses of high-speed gears. For each gear, partially or fully immersed into an oil bath, the power spent to overcome the hydromechanical resistance can be represented as the sum of the following: the Coriolis force moment arising from the radial movement of the oil in the tooth spaces of the rotating gear, the viscous friction forces moment on the periphery of the gear addendums in the oil bath and the viscous friction forces moment at the face of the gear in the oil bath. The hydrodynamic power losses due to the Coriolis force action, viscosity friction losses at the periphery of the gear and the viscosity friction at the face of the gear (both turbulent and laminar modes) were observed separately. From the mathematical simulation of the rotation processes when the gear is immersed into the oil bath, an analytical dependence was obtained. It allows predicting the influence of the geometrical parameters of the gearing on the hydrodynamic power losses. Analysis of the calculation results of the power losses due to the action of hydraulic resistance forces and results from experimental studies is provided for several gears with different hydromechanical parameters. The proposed method of calculating power loss due to hydromechanical resistance of the oil bath to the rotation of the gear gave results that were close to the experimental data. Acceptable coincidence of theoretical and experimental results allows recommending the received analytical dependencies for practical calculations of high-speed gears.

Krzysztof Sokół, Piotr Ptak
Experimental Evaluation of Circuit Board Components under Extreme Conditions

Designing products operating in harsh conditions is a challenging task. Years of experience, developed standards and good practices are crucial in achieving the intended result. The article shows a methodology for designing electronic systems based on the worst-case analysis (WCA) and comparing its outcomes with the experimental verification of an actual circuit through large-scale tests. The analysed diode-based semiconductor circuit is part of a temperature measuring system of industrial application. The objective of the design and analysis process is to achieve a reliable solution, which has all the required functionalities under actual, extreme operating conditions. The preliminary circuit design is developed using ideal components. The truth table, which represents customer requirements, is created to check the correct operation of the system. Simulation software, such as LTSpice, are used as the main tools to verify the correct functioning based on ideal or close-to-real component models. Next, based on the results of computer simulations, the WCA is conducted, considering all extreme (worst) operating environment parameters, such as, among others, ambient temperature or ageing. WCA results were verified through an experimental, large-scale measurement of the real system, with defined forward voltage as a function of the current flowing through the semiconductor at various ambient temperatures.

Hongli Cao
Design of a Fuzzy Fractional Order Adaptive Impedance Controller with Integer Order Approximation for Stable Robotic Contact Force Tracking in Uncertain Environment

Current research in robot compliance control is unable to take both transient contact force overshoots and steady-state force tracking problems into account. To address this problem, we propose a fuzzy fractional order (FO) adaptive impedance controller to avoid the force overshoots in the contact stage while keeping force error in the dynamic tracking stage, where traditional control algorithms are not competent. A percentage gain is adopted to map FO parameters to integer order (IO) parameters by their natural properties, and a fuzzy logical controller is introduced to improve the system stability. The simulation results indicate that the proposed controller can be made more stable than and superior to the general impedance controller, and the force tracking results also have been compared with the previous control methods

Paweł Bałon, Edward Rejman, Bartłomiej Kiełbasa, Robert Smusz
Using HSM Technology in Machining of Thin-Walled Aircraft Structures

Subtracting manufacturing technologies have entered that realm of production possibilities which, even a few years ago, could not be directly adapted to direct production conditions. The current machines, i.e. heavy, rigid cutting machines using high spindle speed and high feed speed, allow for manufacturing very thin and relatively long parts for use in the automotive or aerospace industry. In addition, the introduction and implementation of new 70XX aluminium alloys with high strength parameters, as well as monolithic diamond cutting tools for special machining, have had a significant impact on the introduction of high-speed machining (HSM) technologies. The main advantage of the applied manufacturing method is obtaining a very good smoothness and surface roughness, reaching even $Sz = 6–10\ \mu m$ and $Sa < 3\ \mu m$, and about four times faster and more efficient machining compared to conventional machining (for the beam part). Moreover, fixed and repeatable milling process of the HSM method, reduction of operational control, easy assembly of components and increase in the finishing efficiency compared to other methods of plastic processing (forming) are other benefits. The authors present a method using HSM for the manufacturing of aircraft parts, such as the chassis beam at the front of a commuter aircraft. The chassis beam assembly is made of two parts, front and rear, which – through a bolted connection – form a complete element replacing the previous part made using traditional technology, i.e., cavity machining, bending and plastic forming. The implementation of HSM technology eliminates many operations related to the construction of components, assembling the components (riveting) and additional controls during construction and assembly.

Ildar Sharifullin, Andrey Nosko, Eugene Safronov
Mathematical Model of the Pallet Motion on a Magnetic Brake Roller of a Gravity Flow Rack

The brake roller is one of the elements for the safe operation of gravity flow pallet racks. The brake roller of the magnetic (eddy current) type magnetic brake roller (MBR) is the most promising brake type. The working principle of the MBR is based on electromagnetic induction laws, according to which the braking of a conductor moving in the magnetic field is caused by the interaction of the conductor's eddy currents with the external magnetic field. In the paper, a mathematical model of the pallet motion on an MBR was developed. The equation of motion of the pallet on the MBR was derived. The calculation results were compared with the results of experimental studies of the pallet motion velocity on the MBR. For pallet speed under “drag peak” speed, the error of the mathematical model is <7.7%, and the error starts increasing once over the “drag peak” speed. Additional investigation of the coefficient of magnetic viscosity for speeds greater than the “drag peak” speed is required.

Roman A. Usenkov, Igor A. Popov, Yuri F. Gortyshov, Svetlana Y. Kokhanova, Ravil A. Latypov
Thermodynamic Calculation of a Rotary Engine With External Heat Supply Based on The Ideal Rallis Cycle

The design and kinematic scheme of the operation of a rotary external combustion engine with offset shafts have been developed. Expressions are obtained that make it possible to calculate the values of the increasing and decreasing functions of the working volume of the hot and cold cavities with a change in the angle of rotation of the rotor. An expression is obtained for calculating the compression ratio in the cold cavity of a rotary heat engine with an external heat supply. An expression has been determined that makes it possible to calculate the total torque of a rotary external combustion engine. A comparative analysis of the torque values of a rotary heat engine with an external heat supply and a Wankel engine is carried out. An assessment of the efficiency of an external combustion engine with offset shafts is carried out. Based on the thermodynamic calculations using ideal Erickson and Rallis cycles for a rotary external combustion engine, the processes occurring inside the hot and cold cavities of a heat engine are described. The thermodynamic condition parameters at the characteristic points of the cycle are determined and expressions are obtained that determine the thermal efficiency of the ideal Erickson and Rallis cycles in relation to the considered external combustion engine. A method for calculating the ideal cycle for an external combustion engine with offset shafts is presented.

Zoulikha Bouhamatou, Foudil Abedssemed
Fuzzy Synergetic Control for Dynamic Car-Like Mobile Robot

This paper aims to present the dynamic control of a Car-like Mobile Robot (CLMR) using Synergetic Control (SC). The SC control is used to make the linear velocity and steering velocity converge to references. Lyapunov synthesis is adopted to assure controlled system stability. To find the optimised parameters of the SC, the grey wolf optimiser (GWO) algorithm is used. These parameters depend on the best-selected fitness function. Four fitness functions are selected for this purpose, which is based on the integral of the error square (ISE), the integral of the square of the time-weighted error (ITSE), the integral of the error absolute (IAE) and the integral of the absolute of the time-weighted error (TIAE) criterion. To go further in the investigation, fuzzy logic type 2 is used to get at each iteration the appropriate controller parameters that give the best performances and robustness. Simulations results are conducted to show the feasibility and efficiency of the proposed control methods.

Mohamed Belhorma, Aboubakar S. Bouchikhi
Multi-Objective Optimisation of the Electric Wheelchair Ride Comfort and Road Holding Based on Jourdain's Principle Model and Genetic Algorithm

The paper addresses the multi-body modelling of an electric wheelchair using Jourdain's principle. First, a description of the adopted approach was presented. Next, the mathematical equations were developed to obtain the dynamic behaviour of the concerned system. The numerical computation was performed with MATLAB (matrix laboratory: a high performance language of technical computing) and validated by MBD (Multi-Body Dynamics) for Ansys, a professional multi-body dynamics simulation software powered by RecurDyn. Afterwards, the model was treated as an objective function included in genetic algorithm. The goal was to improve the ride quality and the road holding as well as the suspension workspace. The multi-objective optimisation aimed to reduce the Root-Mean-Square (RMS) of the seat's vertical acceleration, the wheels load and the workspace modulus by varying the bodies' masses, the spring-damper coefficients and the characteristics of the tires. Acceptable solutions were captured on the Pareto fronts, in contrast to the relatively considerable processing time involved in the use of a random road profile generated by the power spectral density (PSD). During the process, the compatibility and the efficiency of Jourdain's equations were inspected.

Meriem Toumi, Mohamed Bouzit, Fayçal Bouzit, Abderrahim Mokhefi
MHD Forced Convection using Ferrofluid over a Backward Facing Step Containing a Finned Cylinder

In this paper, a numerical study of forced convection on a backward facing step containing a single-finned fixed cylinder has been performed, using a ferrofluid and external magnetic field with different inclinations. The partial differential equations, which determine the conservation equations for mass, momentum and energy, were solved using the finite element scheme based on Galerkin's method. The analysis of heat transfer characteristics by forced convection was made by taking different values of the Reynolds number (Re between 10 and 100), Hartmann number (Ha between 0 and 100), nanoparticles concentration (φ between 0 and 0.1) and magnetic field inclination (γ between 0° and 90°); also, several fin positions α [0°–180°] were taken in the counter clockwise direction by a step of 5. After analysing the results, we concluded that Hartmann number, nanoparticles concentration, Reynolds number and magnetic field angles have an influence on the heat transfer rate. However, the fin position on the cylinder has a big impact on the Nusselt number and therefore on heat transfer quality. The best position of the fin is at (α = 150°), which gives the best Nusselt number and therefore the best heat transfer, but the fin position at (α = 0°) remains an unfavourable case that gives the lowest Nusselt values.

Vladimir Morkun, Vitalii Tron, Vadym Zymohliad
Modelling of Iron Ore Processing in Technological Units Based on The Hybrid Approach

The process line of concentrating iron ore materials is considered as a sequence of connected concentration units, some of which partially return ore materials to the previous unit. The output product of the final concentration unit in the process line is the end product of the whole line. Characteristics of ore, such as distribution of ore particles by size and distribution of iron content by size classes, are considered. Processing of iron ore materials by process units (a cycle, a scheme) is characterised by a separation characteristic – namely the function of extracting elementary fractions depending on physical properties of ore particles. The results of fraction analysis of ore samples in different points of the process line provide an experimental definition of separation characteristics and numerical values of the Rosin–Rammler equation factors. To identify dependencies that cannot be analytically described, the hybrid approach accompanied by the Takagi–Sugeno fuzzy models, in accompaniment with triangular membership functions determining fuzzy sets in preconditions, are used. To identify fuzzy sets in rule preconditions, triangular membership functions are used. Introduction of a-priori data on iron ore concentration as constraints for model parameters is a promising trend of further research, since it enables increased accuracy of identification despite limited availability of experimental data.