ABSTRACTS

Emre Can, Mehmet Bozca
Optimising the Geometric Parameters of a Gear in a Tractor Transmission under Constraints Using KISSsoft

We optimise the speed gears in a tractor transmission with KISSsoft software under three constraints: input power torque, transmission system volume and the gear ratio for each speed. This study aimed to optimise the module, face width, gear quality, centre distance, number of teeth, helix angle, addendum modification coefficient and pressure angle for each speed while considering the above constraints based on an optimisation chart. Tooth bending stress, tooth contact stress, contact ratio and specific sliding were considered during optimisation. Additionally, the effects of changes in a module on the gear profiles, overlap ratio, number of teeth and weight of the gear pair were examined. Strength calculations of gear pairs that were optimised and defined for all geometric parameters with KISSsoft were calculated with the mathematical model described in ISO 6336, and results were then compared. Finally, backlash was minimised for all gear pairs as defined with geometric parameters, and all dimensions and tolerances were determined for gear inspection after manufacturing. A concept design was also presented. We conclude that both the KISSsoft results and mathematical model results are within the range of the target value.

Muzafar A. Kalwar
Geological and Geotechnical Assesment of Aggregates used in Nagar Parkar district Tharparkar Sindh Pakistan

This study aims to determine the geology of granite and evaluate the engineering properties of the samples to make recommen-dations for the construction industry. The study area is situated in the Nagar Parker complex in Pakistan, which is located in the extreme south-east of the Thar District and the desert of the Sindh Province, near the Run of Kutch (24° 15′–35 30′ N, 70° 40′–58 07′ E), and it covers ca. 500–1,000 km2. In this region, several Quaternary deposits, subordinate and dispersed Jurassic–Tertiary sandstones and clays are overlying the Nagar Igneous Complex basement. According to international standards, there are various possible aggregate sources. However, only a few of them have been reviewed for suitability reasons. Six quarries in Nagar Parker, Pakistan, were selected for evaluation as coarse aggregate in concrete construction and civil engineering works in this research. Although the aggregates from the six quarries are specified and already widely used in the Sindh Province, there is a lack of studies on their geological properties. The results of the presented research revealed that samples from Dhedvero, Karai, Nagarparkar, Mokrio, Dinsi and Wadlai meet all of the international standard requirements for aggregates. Geotechnical, petrographic and geochemistry laboratory tests were conducted in this research and included bulk density, water absorption, specific gravity test, index of flakiness and elongation, soundness aggregate test, crushing value aggregate, impact value aggregate and abrasion value of Los Angeles. Furthermore, chemical alkali-silica reaction potential test and petrographic examination were tested. As a result, we evaluated the properties of granite, which is a crystalline igneous rock with a visibly crystalline structure and texture, made up of feldspar, i.e., potash feldspar and oligoclase. The evaluated minerals are compatible with the standards of civil engineering works and can be used as a concrete aggregate. The evaluated three types of minerals included Dhedvero simple intrusion, Nagar pink granite and grey granite.

Thomas Koch
Microbiology of Metalworking Fluids: What We Know and Lessons to be Learnt

Water-miscible metalworking fluids are an essential component of many manufacturing processes. During their lifetime they are subject to per-manent changes in their physical and chemical characteristics. Due to their high content of water and their chemical composition in use, metalworking fluids (MWF) are prone to microbial life, i.e. the proliferation of bacteria and fungi. The microbial activity leads to significant changes in the chemical composition of the MWF, which can result in the loss of their technical properties. This paper briefly discusses the influences of microbial contamination on the technical quality of MWF and presents common monitoring systems for the detection of microorganisms. Finally, measures are described that can be taken to protect MWF from damage caused by high microbial loads in daily practice. In a short outlook, alternative research approaches are mentioned that aim at sustainable use of MWF.

Leander Marquardt, Heiner-Joachim Katke, Andreas Reinke, Niklas Kockskämper
Influence of Valve-Seat Angles to Operation Values and Emissions of Medium-Speed Diesel Engines

For the development of gas exchange for large diesel engines, a compromise has to be found between efficient valve-flow and the time between overhauls. On the one hand, large effective flow areas, especially during valve-overlap, are demanded. On the other hand, there are limitations of cylinder bore regarding the maximum diameter of inlet and outlet valves and the minimum distance (dead space) between valves and piston, as well as wear-related smaller seat angles. For large medium-speed diesel engines, a valve-seat angle of $\beta = 30°$ for inlet and outlet valves is a standard application. For engine-operation with clean fuels, a valve-seat lubrication (gasoil) or smaller seat angles (natural gas) need to be applied. With this presentation, the basic influence of different valve-seat angles on the operation values and emissions will be considered for the example of the single-cylinder research engine FM16/24. Using a self-developed testbed, experimental investigations into effective flow areas as a function of valve-lift at inlet and outlet valves have to be executed. With this input, different cycle calculations including T/C have to be carried out to determine deviances in specific fuel-oil consumption, exhaust-gas temperatures, NOx emissions and air/fuel ratio. The results will be discussed critically.

Krzysztof Oprzędkiewicz, Wojciech Mitkowski, Maciej Rosół
Fractional Order, State Space Model of the Temperature Field in the PCB Plate

In the paper the fractional order, state space model of a temperature field in a two-dimensional metallic surface is addressed. The proposed model is the two dimensional generalization of the one dimensional, fractional order, state space of model of the heat transfer process. It uses fractional derivatives along time and length. The proposed model assures better accuracy with lower order than models using integer order derivatives. Elementary properties of the proposed model are analysed. Theoretical results are experimentally verifed using data from industrial thermal camera.

Tadeusz Kaczorek, Andrzej Ruszewski
Standard and Fractional Discrete-Time Linear Systems with Zero Transfer Matrices

The transfer matrix of the standard and fractional linear discrete-time linear systems is investigated. Necessary and sufficient conditions for zeroing of the transfer matrix of the linear discrete-time systems are established. The considerations are illustrated by examples of the standard and fractional linear discrete-time systems.

Khalissa Saada, Salah Amroune, Moussa Zaoui, Amin Houari, Kouider Madani, Amina Hachaichi
Experimental and Numerical Study of the Effect of the Presence of a Geometric Discontinuity of Variable Shape on the Tensile Strength of an Epoxy Polymer

The presence of geometric discontinuity in a material reduces considerably its resistance to mechanical stresses, therefore reducing the service life of materials. The analysis of structural behaviour in the presence of geometric discontinuities is important to ensure the proper use, especially if it is regarding a material of weak mechanical properties such as a polymer. The objective of the present work is to analyse the effect of the notch presence of variable geometric shapes on the tensile strength of epoxy-type polymer specimens. A series of tensile tests were carried out on standardised specimens, taking into account the presence or absence of a notch. Each series of tests contains five specimens. Two notch shapes were considered: circular (hole) and elliptical. The experimental results in terms of stress–strain clearly show that the presence of notches reduces considerably the resistance of the material, where the maximum stress for the undamaged specimen was 41.22 MPa and the lowest stress for the elliptical-notched specimen was 11.21 MPa. A numerical analysis by the extended finite element method (XFEM) was undertaken on the same geometric models; in addition, the results in stress–strain form were validated with the experimental results. A remarkable improvement was obtained (generally an error within 0.06%) for strain, maximum stress, Young's modulus and elongation values. An exponential decrease was noted in the stress, strain, and Young's modulus in the presence of a notch in the material.

Krzysztof Magnucki, Joanna Kustosz, Damian Goliwąs
Effective Shaping of a Stepped Sandwich Beam with Clamped Ends

The aim of this work is to propose a sandwich beam with stepped layer thickness in three parts along its length. The total depth, width of the cross-section and its mass are constant. The beam is under a uniformly distributed load. The system of two equilibrium equations was formulated for each part based on the literature. This system was analytically solved for the successive parts of the beam and the functions of the shear effect and deflection were determined in them. The effective stepped layer thicknesses was determined on the basis of the adopted criterion for minimizing the maximum deflection of the beam. The example calculations were made for two elected beams. The effective shapes of these beams are shown in the figures. Moreover, FEM numerical calculations of the deflections of these beams are performed.

Zbyszko Klockiewicz, Grzegorz Ślaski
The Influence of Friction Force and Hysteresis on the Dynamic Responses of Passive Quarter-Car Suspension with Linear and Non-Linear Damper Static Characteristics

Vehicle passive suspensions consist of two major elements generating force – spring and passive damper. Both possess non-linear characteristics, which are quite often taken into account in simulations; however, the friction forces inside the hydraulic damper and the damping force's hysteresis are usually left out. The researchers in this paper present the results of examination of the influence of using complex damper models – with friction and hysteresis; and with linear and non-linear static characteristics – on the chosen dynamic responses of a suspension system for excitations in the typical exploitation frequency range. The results from the simulation tests of the simplified and advanced versions of the damper model – different transfer functions and their relation to the reference model's transfer functions – are compared. The main conclusion is that friction and hysteresis add extra force to the already existing damping force, acting similar to damping increase for the base static characteristics. But this increase is not linear – it is bigger for smaller frequencies than for higher frequencies. The research shows the importance of including non-linear characteristics and proposed modules in modelling passive dampers.

Michal Macias, Dominik Sierociuk
Finite Length Triple Estimation Algorithm and its Application to Gyroscope MEMS Noise Identification

The noises associated with MEMS measurements can significantly impact their accuracy. The noises characterised by random walk and bias instability errors strictly depend on temperature effects that are difficult to specify during direct measurements. Therefore, the paper aims to estimate the fractional noise dynamics of the stationary MEMS gyroscope based on finite length triple estimation algorithm (FLTEA). The paper deals with the state, order and parameter estimation of fractional order noises originating from the MEMS gyroscope, being part of the popular Inertial Measurement Unit denoted as SparkFun MPU9250. The noise measurements from x, y and z gyroscope axes are identified using a modified triple estimation algorithm (TEA) with finite approximation length. The TEA allows a simultaneous estimation of the state, order and parameter of fractional order systems. Moreover, as it is well-known that the number of samples in fractional difference approximations plays a key role, we try to show the influence of applying the TEA with various approximation length constraints on final estimation results. The validation of finite length TEA in the noise estimation process coming from MEMS gyroscope has been conducted for implementation length reduction achieving 50% of samples needed to estimate the noise with no implementation losses. Additionally, the capabilities of modified TEA in the analysis of fractional constant and variable order systems are confirmed in several numerical examples.

Mateusz Pietrala, Piotr Leśniewski, Andrzej Bartoszewicz
An ITAE Optimal Sliding Mode Controller for Systems with Control Signal and Velocity Limitations

In this paper, a sliding mode controller, which can be applied for second-order systems, is designed. Robustness to external dis-turbances, finite regulation time and a good system's behaviour are required for a sliding mode controller. In order to achieve the first two of these three goals, a non-linear, time-varying switching curve is introduced. The representative point (state vector) belongs to this line from the very beginning of the control process, which results in elimination of the reaching phase. The stable sliding motion along the switching curve is provided. Natural limitations such as control signal and system's velocity constraints will be taken into account. In order to satisfy them, the sliding line parameters will be properly selected. However, a good dynamical behaviour of the system has to be provided. In order to achieve that, the integral time absolute error (ITAE) quality index will be introduced and minimised. The simulation example will verify theoretical considerations.

Jamil A. Haider, Sana Gul, Jamshaid U. Rahman, Fiazud D. Zaman
Travelling Wave Solutions of the Non-Linear Wave Equations

This article focuses on the exact periodic solutions of nonlinear wave equations using the well-known Jacobi elliptic function expansion method. This method is more general than the hyperbolic tangent function expansion method. The periodic solutions are found using this method which contains both solitary wave and shock wave solutions. In this paper, the new results are computed using the closed-form solution including solitary or shock wave solutions which are obtained using Jacobi elliptic function method. The corresponding solitary or shock wave solutions are compared with the actual results. The results are visualised and the periodic behaviour of the solution is described in detail. The shock waves are found to break with time, whereas, solitary waves are found to be improved continuously with time.

Nidhish K. Mishra
Computational Analysis of Soret and Dufour Effects on Nanofluid Flow Through a Stenosed Artery in the Presence of Temperature-Dependent Viscosity

In this study, the Soret and Dufour effects in a composite stenosed artery were combined with an analysis of the effect of varying viscosity on copper nanofluids in a porous medium. Blood viscosity, which changes with temperature, is taken into account using the Reynolds viscosity model. The finite difference approach is used to quantitatively solve the governing equations. For use in medical applications, the effects of the physical parameters on velocity, temperature and concentration along the radial axis have been investigated and physically interpreted. The results are graphically displayed and physically defined in order to facilitate comprehension of the various phenomena that occur in the artery when nanofluid is present. It is observed that the Soret effect increases the rate of heat transfer but decreases the rate of mass transfer. The new study enhances knowledge of non-surgical treatment options for stenosis and other abnormalities, hence reducing post-operative complications. Additionally, current research may have biomedical applications such as magnetic resonance angiography (MRA), which provide a picture of an artery and enable identification of any anomalies, and thus may be useful

Adam Szcześniak, Zbigniew Szcześniak, Leszek Cedro
Synthesis of Pneumatic Systems in the Control of the Transport Line of Rolling Elements

This paper presents the synthesis of a pneumatic control system for a selected configuration of the transport path for the delivery of rolling elements to spiral storage in inter-operational transport. The sequential control system sets the state of the manifolds to ensure a flow of workpieces to serve the subsequent storage. The essential module of the control system is the memory block. It is developed based on a storage filling sequence graph. The filling level of the storages can be monitored in one or two points using sensors. The rolling element displacement control sensors work together with appropriately designed systems to execute the delay of the rising and falling edge input signal. By using a two-level control of the filling level of the storages, it is possible to control the emptying status of the storages as a function of the technological time of removal of the items from the storage between the two control points. Control systems were synthesised and verified using Festo's FluidSim computer programme.

Aastha Aastha, Khem Chand
Soret and Dufour Effects on Chemically Reacting and Viscous Dissipating Nanofluid Flowing Past a Moving Porous Plate in the Presence of a Heat Source/Sink

This study performed a numerical investigation of the Soret and Dufour effects on unsteady free convective chemically reacting nanofluid flowing past a vertically moving porous plate in the presence of viscous dissipation and a heat source/sink. The equations directing the flow are non-dimensionalised, modified to ordinary differential equations and emerging equations are resolved computationally by using the bvp4c function in MATLAB software. The results obtained from this analysis indicate that the resulting velocity of the nanofluid increases with increasing Grashof number, mass Grashof number and porosity parameter. An increase in the Dufour number increases the fluid temperature, whereas the concentration profile declines with the increase in the Schmidt number. It is also observed that the skin friction coefficient, Nusselt number and Sherwood number increase with increasing magnetic field parameter, Eckert number and Schmidt number, respectively. The present study reveals the impact of Soret and Dufour effects on heat and mass transfer rates in chemically reacting and viscous dissipating nanofluids.

Roman Król, Kazimierz Król
Multibody Dynamics Model of the Cycloidal Gearbox, Implemented in Fortran for Analysis of Dynamic Parameters Influenced by the Backlash as a Design Tolerance

In this study, dynamical parameters of the cycloidal gearbox working at the constant angular velocity of the input shaft were investigated in the multibody dynamics 2D model implemented in the Fortran programming language. Time courses of input and output torques and forces acting on the internal and external sleeves have been shown as a function of the contact modelling parameters and backlash. The analysis results in the model implemented in Fortran were compared with the results in the 3D model designed using MSC Adams software. The values of contact forces are similar in both models. However, in the time courses obtained in MSC Adams there are numerical singularities in the form of peaks reaching 500 N for the forces at external sleeves and 400 N for the forces acting at internal sleeves, whereas in the Fortran model, there are fewer singularities and the maximum values of contact forces at internal and external sleeves do not exceed 200 N. The contact damping and discretisation level (the number of discrete contact points on the cycloidal wheels) significantly affect the accuracy of the results. The accuracy of computations improves when contact damping and discretisation are high. The disadvantage of the high discretization is the extended analysis time. High backlash values lead to a rise in contact forces and a decrease in the force acting time. The model implemented in Fortran gives a fast solution and performs well in the gearbox optimisation process. A reduction of cycloidal wheel discretisation to 600 points, which still allows satisfactory analysis, could reduce the solution time to 4 min, corresponding to an analysis time of 0.6 s with an angular velocity of the input shaft of 52.34 rad/s (500 RPM).

Zbigniew Kneba, Jacek Kropiwnicki, Jakub Hadrzyński, Maciej Ziółkowski
Forecasting Biogas Formation in Landfills

The aim of the present research was to develop a mathematical model for estimating the amount of viscous gas generated as a function of weather conditions. Due to the lack of models for predicting gas formation caused by sudden changes in weather conditions in the literature, such a model was developed in this study using the parameters of landfills recorded for over a year. The effect of temperature on landfill gas production has proved to be of particular interest. We constructed an algorithm for calculating the amount of the produced gas. The model developed in this study could improve the power control of the landfill power plant.

Michaela Zeißig, Frank Jablonski
Numerical Investigation of Production-Related Characteristics Regarding their Influence on the Fatigue Strength of Additively Manufactured Components

In order to further enhance the application of additive manufacturing (AM) processes, such as the laser powder bed fusion (L-PBF) process, reliable material data are required. However, the resulting specimen properties are significantly influenced by the process parameters and may also vary depending on the material used. Therefore, the prediction of the final properties is difficult. In the following, the effect of residual stresses on the fatigue strength of 316L steel, a commonly used steel in AM, is investigated using a Weibull distribution. The underlying residual stress distributions as a result of the building process are approximated for two building directions using finite element (FE) models. These imply significantly different distributions of tensile and compressive residual stresses within the component. Apart from the residual stresses, the impact of the mean stress sensitivity is discussed as this also influences the predicted fatigue strength values.

Lukas Peters, Rüdiger Kutzner, Marc Schäfer, Lutz Hofmann
Ability of Black-Box Optimisation to Efficiently Perform Simulation Studies in Power Engineering

In this study, the potential of the so-called black-box optimisation (BBO) to increase the efficiency of simulation studies in power engineering is evaluated. Three algorithms (“Multilevel Coordinate Search” (MCS) and “Stable Noisy Optimization by Branch and Fit” (SNOBFIT) by Huyer and Neumaier and “blackbox: A Procedure for Parallel Optimization of Expensive Black-box Functions” (blackbox) by Knysh and Korkolis) are implemented in MATLAB and compared for solving two use cases: the analysis of the maximum rotational speed of a gas turbine after a load rejection and the identification of transfer function parameters by measurements. The first use case has a high computational cost, whereas the second use case is computationally cheap. For each run of the algorithms, the accuracy of the found solution and the number of simulations or function evaluations needed to determine the optimum and the overall runtime are used to identify the potential of the algorithms in comparison to currently used methods. All methods provide solutions for potential optima that are at least 99.8% accurate compared to the reference methods. The number of evaluations of the objective functions differs significantly but cannot be directly compared as only the SNOBFIT algorithm does stop when the found solution does not improve further, whereas the other algorithms use a predefined number of function evaluations. Therefore, SNOBFIT has the shortest runtime for both examples. For computationally expensive simulations, it is shown that parallelisation of the function evaluations (SNOBFIT and blackbox) and quantisation of the input variables (SNOBFIT) are essential for the algorithmic performance. For the gas turbine overspeed analysis, only SNOBFIT can compete with the reference procedure concerning the runtime. Further studies will have to investigate whether the quantisation of input variables can be applied to other algorithms and whether the BBO algorithms can outperform the reference methods for problems with a higher dimensionality.

Jacek Kropiwnicki, Tomasz Gawłas

Estimation of the Regenerative Braking Process Efficiency in Electric Vehicles

In electric and hybrid vehicles, it is possible to recover energy from the braking process and reuse it to drive the vehicle using the batteries installed on-board. In the conditions of city traffic, the energy dissipated in the braking process constitutes a very large share of the total resistance to vehicle motion. Efficient use of the energy from the braking process enables a significant reduction of fuel and electricity consumption for hybrid and electric vehicles, respectively. This document presents an original method used to estimate the efficiency of the regenerative braking process for real traffic conditions. In the method, the potential amount of energy available in the braking process was determined on the basis of recorded real traffic conditions of the analysed vehicle. The balance of energy entering and leaving the battery was determined using the on-board electric energy flow recorder. Based on the adopted model of the drive system, the efficiency of the regenerative braking process was determined. The paper presents the results of road tests of three electric vehicles, operated in the same traffic conditions, for whom the regenerative braking efficiency was determined in accordance with the proposed model. During the identification of the operating conditions of the vehicles, a global positioning system (GPS) measuring system supported by the original method of phenomenological signal correction was used to reduce the error of the measured vehicle's altitude. In the paper, the efficiency of the recuperation process was defined as the ratio of the accumulated energy to the energy available from the braking process and determined for the registered route of the tested vehicle. The obtained results allowed to determine the efficiency of the recuperation process for real traffic conditions. They show that the recuperation system efficiency achieves relatively low values for vehicle No. 1, just 21%, while the highest value was achieved for vehicle No. 3, 77%. Distribution of the results can be directly related to the power of electric motors and battery capacities of the analysed vehicles.