ABSTRACTS

Kacper Fiedurek, Paweł Szroeder, Marek Macko, Aneta Raszkowska-Kaczor, Marcin Borowicz, Natalia Puszczykowska
Introduction to Modelling the Correlation Between Grain Sizes of Feed Material and the Structure and Efficiency of the Process of Co-Rotating Twin-Screw Extrusion of Non-Flammable Composites with a PLA Matrix

Co-rotating twin-screw extrusion is an energy consuming process that is generally not fully optimised to a specific polymer. From the point of view of the efficiency of the extrusion process, the starting material should be characterised by small grain sizes in comparison to the screw channel area, small surface area to volume ratio and small internal friction between the pellets. To develop a model describing the effect of polylactide (PLA) grain size on the extrusion efficiency, a series of experiments with a twin-screw extruder were carried out during which the energy consumption; torque on shafts and temperature of the melt on the extruder die were monitored. As feed material, both the neat PLA with different grain sizes and the PLA with expandable graphite fillers and phosphorous-based flame retardants were used. Morphology and dispersion quality of the composites were examined using scanning electron microscopy (SEM); flammability, smoke production, mass loss and heat release rates were tested using cone calorimetry; and melt flow rate was determine using a plastometer. Moreover, the thermal properties of the obtained composites were determined using differential scanning calorimetry (DSC). The results show that the choice of the starting material affects both the efficiency of the extrusion process and the flame retardancy properties of the composite materials.

Silvia Maláková, Samuel Sivák
GPS Application in the Design of Gearboxes

The integrated geometrical product specification (GPS) system for workpiece geometry specification and verification is an improved engineering tool for product development and production. The goal of the GPS system is to provide tools for cost-effective management of variability in products and processes. This can be achieved by using a more precise way of expressing the functional requirements of the workpiece, complete and well-defined specifications and integrated verification approaches. The intended function of the product is ensured by controlling the geometry and material properties of the workpiece parts, which make up the product. GPS is a language just for checking geometry, and further development is based on computational mathematics and correct, consistent logic using general sets of rules that can be applied to all types of specifications. This article deals with the application of GPS rules in the design of gearboxes.

Daniel Kaczor, Krzysztof Bajer, Grzegorz Domek, Piotr Madajski, Aneta Raszkowska-Kaczor, Paweł Szroeder
Influence of Extruder Plasticizing Systems on the Selected Properties of PLA/Graphite Composite

Twin-screw extrusion is a crucial method for the direct inserting of carbon micro- and nanomaterials into a polymer matrix using a dry procedure. The study aimed to determine the influence of the parameters of the twin-screw extruder plasticizing system on the dispersion homogeneity and distribution of graphite filler in the polylactide polymer matrix and overall quality of the composite. As a filler, a graphite micropowder with a 5 μm lateral size of platelets was used at concentration of 1 wt.%. Three configurations of screws with different mixing intensity and various types segments were considered in the extrusion experiments. Morphology and chemical structure of the obtained composites were examined using scanning electron microscopy (SEM), Fourier transform infrared spectroscopy – attenuated total reflectance (FTIR-ATR) and Raman spectroscopy. Differential scanning calorimetry (DSC) and melting flow rate measurements (MFR) were used to asses thermal and rheological properties of the composites. Samples of the polylactide/graphite composites were also subjected to mechanical tests. The results show that the selection of the mechanical parameters of twin-screw extruder plasticizing system plays a key role in the preparation of the homogeneous PLA/graphite composites. Incorrect selection of the screw geometry results in poor mixing quality and a significant deterioration of the mechanical and thermal properties of the composites. Optimised mixing and extrusion parameters can be the starting point for the design of efficient twin-screw extruder plasticizing system for fabrication of PLA composites with carbon nanotube and graphene fillers.

Elżbieta Gawrońska, Robert Dyja, Maria Zych, Grzegorz Domek
Selection of the Heat Transfer Coefficient using Swarming Algorithms

The article presents the use of swarming algorithms in selecting the heat transfer coefficient, taking into account the boundary condition of the IV types. Numerical calculations were made using the proprietary TalyFEM program and classic form of swarming algorithms. A function was also used for the calculations, which, during the calculation, determined the error of the approximate solution and was minimalised using a pair of individually employed algorithms, namely artificial bee colony (ABC) and ant colony optimisation (ACO). The tests were carried out to select the heat transfer coefficient from one range. Describing the geometry for a mesh of 408 fine elements with 214 nodes, the research carried out presents two squares (one on top of the other) separated by a heat transfer layer with a κ coefficient. A type III boundary condition was established on the right and left of both edges. The upper and lower edges were isolated, and a type IV boundary condition with imperfect contact was established between

the squares. Calculations were made for ABC and ACO, respectively, for populations equal to 20, 40 and 60 individuals and 2, 6 and 12 iterations. In addition, in each case, 0%, 1%, 2% and 5% noise of the reference values were also considered. The obtained results are satisfactory and very close to the reference values of the κ parameter. The obtained results demonstrate the possibility of using artificial intelligence (AI) algorithms to reconstruct the IV type boundary condition value during heat conduction modelling.

Michał Bembenek, Andrzej Uhryński
The Use of Thermography to Determine the Compaction of a Saddle-Shaped Briquette Produced in an Innovative Roller Press Compaction Unit

The unit compacting pressure in the fine-grained material consolidation process in the roller press can reach >100 MPa and is a parameter that results, among other things, from the properties of the consolidated material and the compaction unit geometry. Achieving the right pressure during briquetting is one of the factors that guarantee the proper consolidation and quality of briquettes. The distribution of the temperature on the surface of the briquettes correlates with locally exerted pressure. The present work aimed to analyse the briquetting process of four fine-grained materials in a roller press equipped with saddle-shaped briquette-forming rollers based on images obtained from the thermography conducted immediately after their consolidation. The tests were carried out in a roller press that was equipped with forming rollers of 450-mm diameter and having a cavity with a volume of 4 cm^3, as described by patent PL 222229 B1. Two mixtures of hydrated lime with 9.1 wt% and 13.0 wt% water, a mixture of scale and a mixture of electric arc furnace (EAF) dust were used for the tests. In most mixtures, the highest temperatures were achieved in the middle-upper part of the briquettes. The briquettes from the EAF dust mixture heated locally the most on the surface up to 37.7 °C. The difference between the maximum briquette temperature and the ambient temperature was 20.2 °C.

Artem Artyukhov, Jan Krmela, Vladimira Krmelova, Dastan Ospanov
Vortex-Type Granulation Machines: Technological Basis Of Calculation And Implementation Roadmap

This work is devoted to describing the technological foundations and the main stages of calculating granulation machines with active hydrodynamic modes. The optimisation criterion is substantiated when choosing the design of the granulation machine. The work uses methods of analysis and synthesis, search for cause-and-effect relationships, theoretical and computer modelling, and experimental studies. The nodes of the vortex granulator directly influence the formation of a vortex fluidised bed, and the directional movement of granules of various sizes are determined. A technique for carrying out a computer simulation of the hydrodynamic operating conditions of a granulation machine in various operating modes with an assessment of the quality of granulated products (e.g., the production of porous ammonium nitrate) is proposed. The results of a computer simulation of the process of formation of a vortex fluidised bed are presented. A variant of the solution for developing an automation scheme for a vortex-type granulation machine is shown. A roadmap for introducing granulation technology in vortex-type granulation machines is described with details of the main stages. The prospects for improving the design of a vortex-type granulation machine and optimising the operation of a granulation plant to produce porous ammonium nitrate are outlined.

Paweł Sułkowicz, Robert Babiarz, Jan Burek, Jarosław Buk, Kamil Gancarczyk
A Method of Increasing the Accuracy of Low-Stiffness Shafts: Single-Pass Traverse Grinding without Steady Rests

The article presents a method of increasing the shape and dimensional accuracy of low-stiffness shafts manufactured in a single pass of a grinding wheel in traverse grinding. One-pass manufacturing is one of the ways for reducing machining time and increasing efficiency, thus lowering production costs. However, maintaining the necessary accuracy proves to be a challenge because the whole machining allowance has to be removed at once, leaving no room for errors that could be fixed in additional passes of the tool. It is especially true in finishing operations, such as traverse grinding. In addition, grinding the workpiece in a single pass of a grinding wheel leads to high forces, which cause elastic deformation of the part. The lower the stiffness of the part, the more difficult it is to achieve the required accuracy. As a result, there are many methods of improving the accuracy of grinding such parts, but they tend to be either expensive or reduce the machining efficiency. Thus, it is important to seek new methods that would allow improving the accuracy of the machining without reducing its efficiency. The proposed method does not require using steady rests and is based on the measurement of the normal grinding force component. Knowing the value of the grinding force when grinding with a set grinding depth, the elastic deformation of the machine tool–tool–workpiece system is calculated in each position of the grinding wheel. Based on the calculated deformation, the additional infeed of the grinding wheel is implemented in order to stabilise real grinding depth and to increase the accuracy of the produced part. The experimental tests were conducted to prove the effectiveness of the proposed method.

Kamil Krasuski, Janusz Ćwiklak, Mieczysław Bakuła, Magda Mrozik
Analysis of the Determination of the Accuracy Parameter for Dual Receivers Based on Egnos Solution in Aerial Navigation

The paper presents the results of research on the determination of the accuracy parameter for European Geostationary Navigation Overlay System (EGNOS) positioning for a dual set of on-board global navigation satellite system (GNSS) receivers. The study focusses in particular on presenting a modified algorithm to determine the accuracy of EGNOS positioning for a mixed model with measurement weights. The mathematical algorithm considers the measurement weights as a function of the squared inverse and the inverse of the position dilution of precision (PDOP) geometrical coefficient. The research uses actual EGNOS measurement data recorded by two on-board GNSS receivers installed in a Diamond DA 20-C airplane. The calculations determined the accuracy of EGNOS positioning separately for each receiver and the resultant value for the set of two GNSS receivers. Based on the conducted tests, it was determined that the mixed model with measurement weights in the form of a function of the inverse square of the PDOP geometrical coefficient was the most efficient and that it improved the accuracy of EGNOS positioning by 37%–63% compared to the results of position errors calculated separately for each GNSS receiver.

Noureddine Aimeur, Noureddine Menasri
Computational Investigation of vibration Characteristics Analysis for Industrial Rotor

During the operation of a rotor, various types of vibrations appear in this mechanical system and often limit the performance and endanger the safety of the operation. Therefore, dynamic analysis is essential because precise knowledge of the vibration behaviour is essential to ensure proper operation. This article presents a set of scientific techniques for the modelling and simulation of rotor vibrations. To work out the equations of the vibratory movement of the rotor, we used the energy approach of Lagrange. To achieve this, a model with one blading wheel carried by a shaft supported by two hydrodynamic bearings is chosen basedon the characteristics of the rotor studied (Fan 280 cement draft fan). It is an arduous task to manually ascertain the analytical resolution of the differential equations that characterise the vibratory behaviour of the rotor. The numerical approach employing the finite element method, programmed on the ANSYS software, made it possible to perform the vibration analysis of the rotor. First, the FAN 280 cement draft fan rotor is modelled using SolidWorks 3D software and reverse design using the coordinate measuring machine (CMM) for the design of the fins. Then, the modal characteristics of the fan rotor model were analysed using the finite element analysis (FEA) software ANSYS Workbench. Also, to study the effect of blade wear on critical speeds, the Campbell diagram was obtained. Finally, harmonic analysis was performed to determine the amplitude of the rotor vortex at critical speeds obtained with and without blade wear.

Roman Mediukh, Vira Mediukh, Vasyl Labunets, Pavlo Nosko, Oleksandr Bashta, Irina Kondratenko
Investigation of Structure Formation and Tribotechnical Properties of Steel Plasma Coatings after Chemical-Heat Treatment and Liquid-Phase Impregnation

The paper is focused on the studies of the microstructure development and physical and mechanical properties of metal-matrix composite coatings based on steel 11Cr18MoWCu deposited using plasma and galvanoplasma methods. The expediency of combining gas-thermal spraying processes of plasma coatings with open porosity up to 16%–18%, with their subsequent thermodiffusion saturation (chromium plating) or liquid-phase impregnation with eutectic alloys of previously applied Ni–B galvanic layer, is shown. The study of the tribotechnical properties of the proposed coatings showed a significant improvement in their performance under conditions of various types of intensive wear, as well as in corrosive environments.

Ryszard Szczebiot, Roman Kaczyński, Leszek Gołdyn
Numerical Criterion for the Duration of Non-Chaotic Transients in ODEs

The paper proposes an original numerical criterion for the duration analysis of non-chaotic transients based on the Euclidean norm of a properly defined vector. For this purpose, transient trajectories, prior to their entering a small neighbourhood of the limit cycle, are used. The vector has been defined with its components constituting the lengths of the sections, which connect the origin of the coordinate system with appropriately determined transient trajectory points. The norm of the vector for the analysis of non-chaotic transients has also been applied. As an assessment criterion of transients, the convergence of the norm to small neighbourhood of the limit cycle with the assumed accuracy is used. The paper also provides examples of the application of this criterion to the Van der Pol oscillators in the case of periodic oscillations.

Andrzej Kazberuk
Application of the Deformation Fracture Criterion to Cracking of Disc Specimens with a Central Narrow Slot

Using the method of singular integral equations, the elastic-plastic problem for cracked Brazilian disk was solved. Based on the Dugdale model and deformation fracture criterion, the relationships between critical load, notch tip opening displacement and length of the plastic strips were established. Also, the comparison between the present solution for the finite domain and the known solution obtained for the semi-infinite notch in the elastic plane was performed.

Adam Adamowicz
Determination of Thermal Diffusivity Values Based on The Inverse Problem of Heat Conduction – Numerical Analysis

This paper presents a discussion on the accuracy of the method of determining the thermal diffusivity of solids using the solution of the inverse heat conduction equation. A new measurement data processing procedure was proposed to improve the effectiveness of the method. Using the numerical model, an analysis of the sensitivity of the method of thermal diffusivity determination to changes in operational and environmental parameters of the test was carried out. The obtained results showed that the method was insensitive to the parameters of the thermal excitation impulse, the thickness of the tested sample, and the significant influence of convection cooling on its accuracy. The work was completed with the formulation of general conclusions concerning the conditions for determining the thermal diffusivity of materials with the use of the described method.

Wojciech Horak, Barbara Stępień, Bogdan Sapiński
Experiment and Analysis of the Limit Stresses of Magnetorheological Fluid

This paper presents the results of a rheological test of a commercial magnetorheological (MR) fluid (MRF-132DG). The research includes the problem of measuring and interpreting limit stresses under conditions close to the magnetic saturation of the fluid. Four different limit stresses were determined, two related to the yield point and two related to the flow point. Methods for determining limit stresses, especially due to excitation conditions, were also analysed. The aim of this study is to determine the effect of selected parameters on the values of limit stresses of the selected MR fluid. An additional objective is to highlight the problems of defining and interpreting individual limit stresses in MR fluids, particularly in the context of selecting the values of these stresses for the purpose of modeling systems with MR fluids.

Rached Miri, Mohamed A. Abbassi, Mokhtar Ferhi, Ridha Djebali
Second Law Analysis of MHD Forced Convective Nanoliquid Flow Through a Two-Dimensional Channel

The present study deals with fluid flow, heat transfer and entropy generation in a two-dimensional channel filled with Cu–water nanoliquid and containing a hot block. The nanoliquid flow is driven along the channel by a constant velocity and a cold temperature at the inlet, and the partially heated horizontal walls. The aim of this work is to study the influence of the most important parameters such as nanoparticle volume fraction ($0\% \leq \phi \leq 4\%$), nanoparticle diameter ($5\ nm \leq dp \leq 55\ nm$), Reynolds number ($50 \leq Re \leq 200$), Hartmann number ($0 \leq Ha \leq 90$), magnetic field inclination angle ($0 \leq \gamma \leq \pi$) and Brownian motion on the hydrodynamic and thermal characteristics and entropy generation. We used the lattice Boltzmann method (LBM: SRT-BGK model) to solve the continuity, momentum and energy equations. The obtained results show that the maximum value of the average Nusselt number is found for case (3) when the hot block is placed between the two hot walls. The minimum value is calculated for case (2) when the hot block is placed between the two insulated walls. The increase in Reynolds and Hartmann numbers enhances the heat transfer and the total entropy generation. In addition, the nanoparticle diameter increase reduces the heat transfer and the irreversibility, the impact of the magnetic field inclination angle on the heat transfer and the total entropy generation is investigated, and the Brownian motion enhances the heat transfer and the total entropy generation.