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Pages 5-16

POST-BUCKLING OPTIMISATION OF COMPOSITE STRUCTURES USING A FIREFLY ALGORITHM

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Abstract
In this work, a firefly algorithm was implemented and used to optimise composite structures in the post-buckling regime. In the first case studied, the goal was to maximise the post-buckling load of a rectangular plate subjected, independently, to shear load and uniaxial compression. The orientations of the layers served as design variables, while a maximal transverse displacement was considered as a constraint. Next, a reinforced flat panel was studied, with the goal of maximising the shear load in the post-buckling regime while constrained by the Tsai-Wu criterion. The design variables were the positions of the stiffeners and the orientations of the layers of the laminate. The degree of improvement in the maximum post-buckling load depended on the specific problem and ranged from 2.5 to 36 % compared to baseline designs. The selection of the structures chosen for the analyses ensured that the firefly algorithm was tested with progressively more challenging optimisation problems. The results suggested that the firefly algorithm could be used in the design of laminated composite structures. 26 refs.
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Key Words: *Laminated Composites, Post-Buckling, Stiffened Panel, Optimisation, Firefly Algorithm*

Pages 17-28

SIMULATIONS TO PREDICT PROCESS MODEL ALIGNMENT WITH STANDARD OPERATING PROCEDURE

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Abstract
The absence of a Standard Operating Procedure (SOP) can lead to many problems in operations within organisations. Process mining techniques can discover process models that reflect the actual behaviour of the process implementations by using event logs extracted from information systems. However, the process models discovered by process mining often have too many variations and deviations when compared to the actual SOPs of the processes. This study attempted to compare three prediction methods in finding a process model from process mining that has the closest properties to the actual SOP. The compared methods are Receiver Operating Characteristics (ROC), the four quality dimensions, and similarity measures for structural and behavioural similarities. For the experiment, we designed a synthetic SOP that served as a ground truth for evaluating the performance of the three prediction methods in this study. We used a synthetic event log extracted from a dummy information system we particularly built for this study to test the methods. This study's results can be useful, e.g. for auditors to save a lot of time from conducting extensive surveys when SOPs are not readily available. 29 refs.
(Received in May 2023, accepted in November 2023. This paper was with the authors 2 months for 2 revisions.)

Key Words: *Standard Operating Procedure, Behavioural Similarity, Four Quality Dimensions, Receiver Operating Characteristic, Structural Similarity*

Pages 29-40

SIMULATION-BASED APPROACH FOR MULTIPROJECT SCHEDULING BASED ON COMPOSITE PRIORITY RULES

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Abstract
This paper presents a simulation approach to enhance the performance of heuristics for multiproject scheduling. Unlike other heuristics available in the literature that use only one priority criterion for resource allocation, this paper proposes a structured way to sequentially apply more than one priority criterion for this purpose. By means of simulation, different feasible schedules are obtained to; therefore, increase the probability of finding the schedule with the shortest duration. The performance of this simulation approach was validated with the MPSPLib library, one of the most prominent libraries for resource-constrained multiproject scheduling. These results highlight the proposed method as a useful option for addressing limited time and resources in portfolio management. 34 refs.
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Key Words: *Simulation, Multiproject Scheduling, Heuristics, RCMPSP, MPSPLib*

Pages 41-52

INCREASING THE PRODUCTION CAPACITY OF BUSINESS PROCESSES USING PLANT SIMULATION

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Abstract
In the paper, we solved the problems regarding the improvement of the production process of allocating material to the inlet of a production hall using the Plant Simulation software in a selected company. The solved problematics are high costs for the shipping company, elimination of the necessity to transfer the semi-finished product from the external warehouse to the production hall and non-effective layout. We deal with the characteristics of the current state of the production process in the production company and create its model in Plant Simulation. Thereafter we propose solutions that can make that process more efficient. The software enables the comparison of complex production alternatives. 13 refs.
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Key Words: *Plant Simulation, Production Capacity, Production Process, 3D Model, Business Process*

Pages 53-64

OPTIMISING WASTE MANAGEMENT COLLABORATION PROCESSES USING HYBRID MODELLING

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Abstract
The high amount of hazardous medical waste involves high risks, so optimising waste management processes is crucial. Some research proposes hybrid modelling that combines simulations and operation research approaches, and most hybrid modelling methods focus on optimising waste transport routes. This paper proposes hybrid modelling to optimise the number of workers with minimum asynchronous waiting time (*AWT*) and activity costs based on waste management collaboration processes. Hybrid modelling consists of an integrated discrete-event simulation, agent-based simulation and improved MCDM methods (MOORA and COPRAS). The cases of waste management processes under normal and overload conditions verify the performance of the proposed hybrid modelling. Improved MCDM methods save 27 % of MCDM processing time. The *AWT* and activity cost under normal condition using the hybrid modelling decreased by 38 % and 22 %, respectively. Hybrid modelling can minimise 74 % *AWT* and 31 % activity cost compared to the actual model under an overload condition. MOORA is better when reducing activity cost, and COPRAS is better when minimising *AWT*. 34 refs.
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Key Words: *Agent-Based Simulation, Collaboration Process, Discrete-Event Simulation, Hazardous Waste Management, Multi-Criteria Decision-Making, Time-Cost Optimisation*

Pages 65-76

THE IMPACTS OF THE PANDEMIC ON URBAN FREIGHT DELIVERIES: A CASE STUDY IN A BRAZILIAN CARRIER

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Abstract
The COVID-19 pandemic led to changes in shopping behaviour, resulting in higher than expected growth in e-commerce. All this influenced the expansion of freight transport in urban areas and had a significant impact on last-mile deliveries by carriers, whose demand increased significantly. The objective of this study was to analyse last-mile deliveries during the COVID-19 pandemic from the perspective of e-commerce freight carriers. This was done using a hybrid simulation model, i.e. discrete event simulation (DES) and agent-based simulation (ABS). An increase in the number of deliveries increased the number of kilometres travelled, fuel costs, CO_2 emissions, number of trips and vehicle utilisation. Comparative scenarios with delivery lockers are simulated, demonstrating improved operation for all simulated variables. The results of this study can be used to better plan e-commerce delivery operations during future pandemic events. 29 refs.
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Key Words: *Simulation, E-Commerce, Last-Mile Delivery, Urban Cargo Transportation, COVID-19, Hybrid Simulation Model*

Pages 77-88

WEAR SIMULATION OF THE CONVEYOR BELT TRANSFER CHUTE USING THE DEM

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Abstract
This paper presents a wear simulation-based performance evaluation of the conveyor belt transfer chute using the DEM (Discrete Element Method). Compared to known analytical and empirical wear models, DEM simulation can significantly increase the performance of wear analysis by enabling the analysis and optimization of highly complex geometries of material handling systems such as conveyor belt transfer chutes. Only the correct design of the conveyor belt transfer chute has the potential to significantly extend its service life, resulting in considerable cost savings. Based on the parametric analysis of different angles and radius in the upper head and lower section of the transfer chute, a new geometry of the transfer chute was proposed. The wear depth of the new conveyor belt transfer chute is compared with the wear resistant and low-carbon steel of the transfer chute along with the moderate and relatively high values of the solid granules mass flow. The results show that the wear depth of the transfer chute can be significantly reduced by using the wear-resistant steel compared to the low-carbon steel, which is significantly evident in high throughput rates of the solid granules mass flow. 26 refs.
(Received in September 2023, accepted in February 2024. This paper was with the authors 1 month for 1 revision.)

Key Words: *Bulk Material Flow, Discrete Element Method (DEM), Transfer Chute Wear Simulation, Archard and Relative Wear, Performance Analysis*

Pages 89-100

GENETIC LAW OF THICKNESS DISTRIBUTION OF STRIP STEEL DURING HOT ROLLING PROCESS

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Abstract
To solve the common issue of transverse thickness variation in finished strip steel during the seven-stand hot continuous rolling process, the deformation of rolls in the rolling process of beam Steel 700L and the genetic characteristics of plate thickness distribution were analysed by finite element simulation. Using actual process parameters from the production of beam Steel 700L, a dynamic rolling finite element model was established. The equivalent stress field between the working rolls and strip steel in each stand and the exit thickness distribution of beam Steel 700L were investigated. Results show that the equivalent stress indicates a gradual increase despite a decreasing reduction rate during rolling. Deviations in thickness between the centre and edges of the strip steel at the exit of each stand become apparent from the second stand onwards, demonstrating a hereditary phenomenon during the rolling process. A comparison of measured and simulated thickness reveals errors within 5 %, validating the accuracy of the simulation. The obtained findings provide a foundational understanding for addressing thickness defects in subsequent beam Steel 700L production. 19 refs.
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Key Words: *Seven Stands, Hot Continuous Rolling, Thickness Distribution, Finite Element*

Pages 101-112

ANALYSIS OF FLOW STRAIGHTENER ON THE INTERNAL FLOW FIELD OF THREE-PHASE JET FIRE MONITORS

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Abstract
To explore the influence of the flow straightener (FS) on the internal flow field of the three-phase jet fire monitor (TPJFM), this study conducted an analysis of the flow characteristics within the TPJFM. Through numerical simulations based on ANSYS/FLUENT, the velocity, turbulent kinetic energy, pressure, velocity uniformity, and outlet performance of the internal flow field of the TPJFM were evaluated for different FS installation positions, installation angles, and structures. Results show that, the structural form of the FS significantly influences the internal flow field. The advanced rectification capability of the FS can immediately return the fluid in the grid to a laminar flow state. However, the exchange of kinetic energy between the regions increases turbulent kinetic energy and reduces outlet velocity. The FS blade and symmetry plane of the powder pipe overlap can effectively reduce the turbulence kinetic energy generated by the powder pipe. Reasonable FS parameters can enhance the flow characteristics of the flow field and improve jet performance. These findings could serve as an important reference for designing an optimized TPJFM structure. 20 refs.
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Key Words: *Three-Phase Jet Fire Monitor, Flow Characteristics, Flow Straightener, Internal Flow Field*

Pages 113-124

THE USE OF SIMULATIONS IN INVESTMENT DECISION-MAKING AND FINANCING

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Abstract
The economic efficiency and financial stability of a significant investment project can directly affect the success and long-term viability of the company. The proposed approach innovatively integrates Monte Carlo simulation techniques into traditional investment and financing decision-making. The investment assessment is based on simulations. The evaluation process begins by determining the economic efficiency of the project and its financial stability using the financial criterion Net Present Value (*NPV*) for different project financing variants – expressed by different ratios between own resources and external resources. This is followed by a risk assessment of the input variables affecting the *NPV*. The profitability is maximized by optimizing the production program using the OptQuest tool. The maximum loan interest rate using simulations at different interest rates is determined in the last step. The proposed approach is practically unknown and not applied in business practice. The risk assessment inclusion in investment decision-making and long-term financing should become an integral part of business practice. 31 refs.
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Key Words: *Economic Efficiency of Investments, Monte Carlo Simulation, Risk, Optimization*

Pages 125-136

DESIGN OF ORCHARD FERTILIZER-SOIL MIXING DEVICE BASED ON DISCRETE ELEMENT METHOD

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Abstract
Given the uneven distribution of fertilizers of traditional orchard furrowing fertilizer spreaders, a spiral fertilizer mixing device based on furrowing fertilization was designed. The key components of the fertilizer mixing device were designed by analysing the force and movement of the particles in the proposed device. With the help of the discrete element software, an orthogonal combination test of secondary rotation was conducted for the fertilizer mixing device, with the blade angle and rotation speed of the screw auger as the test factors and Lacey index as the test index. Results shows that, when the spiral angle of the auger blade is 18° and the rotation speed of the auger is 104 r/min, the Lacey index of the fertilizer-soil mixture is 0.8 at a furrow soil thickness of 20 cm. When the soil thickness is 40 cm, the Lacey index of the fertilizer-soil mixture is 0.76, and the errors, with predicted values, of the model are 13.04 % and 9.52 %. The uniformity of the fertilizer-soil mixture of the device meets the operating requirements of furrowing fertilization and can provide a significant reference for improving the uniformity of fertilizer-soil mixtures for furrowing fertilization in orchards. 21 refs.
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Key Words: *Fertilizer-Soil Mixing, Spiral Stirring, Lacey Index Evaluation Method, Discrete Element Method*

Pages 137-148

COLLABORATIVE PRODUCTION SCHEDULING WITH MULTI-ENTERPRISE IDLE CAPACITY SHARING

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Abstract
This paper proposes a digital twin enhanced approach for optimizing collaborative production scheduling in multi-enterprise manufacturing systems. A multi-objective model is developed incorporating practical constraints such as limited time windows, different production capacities, and transportation considerations. To solve the model, an Improved Non-dominated Sorting Genetic Algorithm (INSGA-II) is designed with specialized operators and strategies. The digital twin simulation is enriched with Multi-objective Decision Making based on Interaction Structures (MDIS) to obtain higher-quality solutions. Experiments demonstrate that the MDIS digital twin approach reduces manufacturing lead times and costs while improving utilization and quality compared to standard methods. This research provides an effective optimization framework to leverage cloud manufacturing resources across organizations. 18 refs.
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Key Words: *Capacity Sharing, Idle Time Window, Differential Manufacturing Services, Collaborative Production Scheduling, INSGA-II*

Pages 149-160

A CO-SIMULATION MODEL FOR THE OPERATING MECHANISM OF A HIGH-VOLTAGE CIRCUIT BREAKER

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Abstract
The reliability of high-voltage circuit breakers (HVCBs) depends critically on the dynamic characteristics of their hydraulic operating mechanisms (OMs). However, previous analyses have been limited to discrete components due to the lack of models capturing multi-physics couplings. This paper proposes a novel co-simulation approach for hydraulic OMs that enables system-level analysis. Specifically, the hydraulic system is modelled using the lumped parameter method, and the transmission mechanism is modelled via finite element analysis. The subsystem models exchange inputs and outputs through shared memory, realizing coupling without compromising simulation performance. Experiments on a 550 kV HVCB validate that the model accurately captures OM transient responses. The co-simulation framework has diverse capabilities, including predicting dynamics under varied operating parameters and quantifying stress distributions and response evolution patterns. Overall, this paper proposes an advanced multi-physics analysis capability for hydraulic OMs to support reliability-oriented design and optimization. 20 refs.
(Received in August 2023, accepted in January 2024. This paper was with the authors 2 months for 1 revision.)

Key Words: *Operating Mechanisms, Hydraulic System, Transmission Mechanism, Co-Simulation*

Pages 161-171

A CO-EVOLUTIONARY BASED SIMULATION MODEL FOR LOGISTIC ORGANIZATION

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Abstract
This study addresses the inefficiencies in logistic activities of rail vehicle manufacturing enterprises due to a lack of effective co-evolutionary mechanisms. The research introduces a novel approach using social network analysis and complex network techniques to simulate the co-evolution of logistics organizations. This model, incorporating both static structure analysis and dynamic network reorganization, offers a practical pathway for evolving logistic organization networks. The study's relevance is underscored by applying it to real-world simulations within CRRC Corporation Limited's subsidiaries, enhancing the collaborative efficiency and safety of logistic networks. 24 refs.
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Key Words: *Logistic Organization, Evolution Pathway, Complex Network, Social Network Analysis, Railway Rolling Stock Manufacturers*

Pages 172-183

DEEP LEARNING FOR INTELLIGENT PRODUCTION SCHEDULING OPTIMIZATION

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Abstract
In the era of Industry 4.0 and intelligent manufacturing, optimizing production scheduling is crucial for enhancing efficiency and economic returns, amidst complex challenges. Traditional scheduling methods often struggle with the demands of intelligent production, particularly in managing complex systems and uncertainties. This study aims to refine production scheduling in intelligent manufacturing using advanced deep learning techniques, proposing an optimized simulation model that considers key factors such as workshop failure rates, workpiece path selection, layout, and utilization rates. Additionally, it introduces a cutting-edge scheduling approach based on multi-agent deep reinforcement learning, incorporating an attention mechanism in an advantage actor-critic framework, complemented by a global reward function to improve production outcomes. This research not only offers a new avenue for optimizing intelligent production scheduling but also provides a valuable simulation tool, contributing significantly to the intelligent transformation of manufacturing. 15 refs.
(Received in October 2023, accepted in February 2024. This paper was with the authors 1 month for 2 revisions.)

Key Words: *Intelligent Production Scheduling, Deep Learning, Simulation Optimization, Multi-Agent System, Reinforcement Learning, Attention Mechanism*

Pages 184-195

FAULT PREDICTION IN HIGH-EFFICIENCY PETROLEUM MACHINERY PRODUCTION

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Abstract
This paper introduces a fault diagnosis and prediction framework for petroleum machinery production systems, addressing the need for more efficient and reliable fault handling in the face of complex signals. Utilizing the Complete Ensemble Empirical Mode Decomposition (CEEMD) and permutation entropy, it extracts signal features to analyse system dynamics. An Adaptive Variational Mode Decomposition (VMD) and optimized Extreme Learning Machine (ELM) simulation model enhances diagnostic accuracy through signal processing and fast learning capabilities. This approach not only elevates fault diagnosis precision but also supports the maintenance and health management of petroleum machinery systems, offering significant theoretical and practical benefits. 17 refs.
(Received in October 2023, accepted in February 2024. This paper was with the author 3 weeks for 1 revision.)

Key Words: *Petroleum Machinery Production Systems, Fault Prediction, Signal Processing, CEEMD, VMD, ELM*