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AERODYNAMIC AND STRUCTURAL ANALYSIS OF A SOLAR PANEL

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Abstract
In this study, wind loads on a ground-mounted solar panel was investigated numerically at different ground clearances and azimuth angles, and the results were compared with the experimental data. A 1:20 scaled solar panel model with 35° panel inclinations was designed for a chord Reynolds number of 6.4×10^4. The studies were performed for the azimuth angles between 0°–180° in 30° increments and ground clearances of 0 to 0.06 m. In the numerical analyses, Computational Fluid Dynamics was calculated with 3 different turbulence models. The results showed that higher ground clearances caused stronger vortex shedding fluctuations, higher velocity zones, and shedding frequencies, and shorter vortex scales behind the panel. The critical wind directions were determined as 30° and 150° in terms of overturning moments, while the maximum value of both the lift and drag coefficient were obtained at 180° azimuth angle. In addition, a hurricane scenario with a wind velocity of 33 m/s was created on a 1:1 scaled model and fluid-structure interaction simulation was performed. The numerical results of the aerodynamic loads were in a good agreement with the experimental results. 25 refs.
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Key Words: *Wind Loads, Solar Panel, Turbulence Models, Computational Fluid Dynamics (CFD), Fluid-Structure Interaction (FSI)*

Pages 203-212

EXPERIMENTAL INVESTIGATION OF A HYDRAULIC ENGINE MOUNT BY TAGUCHI METHOD

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Abstract
This study applied the design of experiment (DoE) to a hydraulic engine mount. Taguchi L16 orthogonal array was selected as an experimental plan, and various mounts were assembled and tested. The dynamic stiffness, K_d, values at 50 Hz frequency for ±0.1 mm vibration amplitude as the reference value were concluded. The best design combination, the priority order, and the contribution ratios of design parameters were determined by applying signal-to-noise ratio (*S/N*) and variance analysis (ANOVA). In the analyses, it was found that dynamic hardening, η, and fluid volume, *V*, were much more effective than other parameters on the K_d. Then, the regression analysis was applied to create two equations considering all parameters and only two effective parameters. It was obtained that K_d values calculated from the two equations were close to each other and in good agreement with the experimental results of the mounts in the DoE and the other two mounts not included in the DoE. This study has shown that analytical equations that give accurate results can be concluded for K_d via the Taguchi method.. 22 refs.
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Key Words: *Hydraulic Engine Mount, Dynamic Stiffness, Taguchi, ANOVA, Regression Analysis*

Pages 213-224

A NOVEL APPROACH FOR LOCATION PLANNING OF FAST-CHARGING STATIONS FOR E-BUSES

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Abstract
This study introduces a robust Electric Bus (EB) charging station planning model, facilitating the transition to a fully EB fleet in smart cities. The Binary Grey Wolf Optimization (BGWO) is implemented to choose suitable positions for fast-charging stations at established bus terminals in the city, considering the construction, operation maintenance, and travel costs of charging stations. The model also contains a novel repair mechanism and an objective function to ensure predefined constraints. The dataset, which includes the Adana province public transportation network of Türkiye, is used to simulate and analyse the model. We compare the proposed model with the recent metaheuristic optimization algorithms: Binary Dragonfly Algorithm (BDA) and Binary Harris Hawk Optimization (BHHO). The results indicate that the proposed approach has promising solutions for fast-charging station locations at a low cost in a reasonable time. 32 refs.
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Key Words: *Location Planning, E-Bus, Metaheuristic Algorithms, Fast Charging Station*

Pages 225-236

A SIMULATION-ORIENTED APPROACH TO THE DESIGN OF KANBAN INTEGRATED HEIJUNKA SYSTEM

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Abstract
Heijunka is a Japanese term that refers to a lean manufacturing approach used to reduce variability in production processes. Heijunka also known as production levelling was developed and implemented as a part of the Toyota Production System. The main purpose of Heijunka is to create a lean production process that is least affected by demand fluctuations. This method aims to decrease overproduction by aligning production plan with actual customer demand, avoiding bulk production in batches, and promoting a more balanced production flow. This paper presents a simulation-oriented approach to the design of a Kanban-controlled Heijunka system for the manufacture of automotive seal solutions. With the developed simulation model, the potential outputs of the planning pattern were estimated according to the demand fluctuations. Obtained results show that potential decreases in WIP stock levels and faster deliveries to the customers can be achieved. 23 refs.
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Key Words: *Lean Manufacturing, Heijunka, Kanban, Simulation Modelling*

Pages 237-248

THE IMPROVEMENT OF REWINDING WORKSHOP USING DISCRETE EVENT SIMULATION

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Abstract
The study investigates the efficiency optimization of the compressor rewinding workshop at King Abdulaziz University (KAU) using modelling and simulation analysis. The assessment starts with a base model showing current operations and identifies inefficiencies, including high completion and waiting times and overutilization of mechanics. Alternative scenarios, combining different numbers of mechanics and station resources, were analysed to identify the most effective configuration. The findings highlighted Scenario 9, including four mechanics and a single set of workstations, as the satisficing configuration. This scenario achieves a significant reduction in completion time (95.54 hours) and waiting time (43.77 hours) while balancing resource utilization (39.09 %).

The study underscores the value of simulation in streamlining complex workflows and demonstrates a cost-effective solution for improving operational efficiency. Practical implications include enhanced resource allocation and reduced maintenance delays, supporting KAU's efforts to maintain its extensive infrastructure. 17 refs.
(Received in December 2024, accepted in March 2025. This paper was with the authors 1 month for 1 revision.)

Key Words: *Compressor Rewinding, Discrete Event Simulation, DES, Operational Efficiency, Resource Optimization, Scenario Analysis*

Pages 249-260

SIMULATION-BASED OPTIMISATION FOR REDUCING WAITING TIMES IN THE EMERGENCY DEPARTMENT

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Abstract
The increasing number of admissions to emergency department (ED) has become a significant issue in both Turkey and globally. The reasons for the high preference for emergency departments include the fact that they are free of charge, they provide 24-hour service, they have easier access to doctors compared to outpatient clinics, and non-emergency patients can also apply. Additionally, the complex interactions between fluctuating workloads, unpredictable arrival rates, and limited resources make it difficult to optimise the flow in EDs. This complexity leads to overcrowded emergency services, long length of stay (*LOS*), and burnout among healthcare professionals. In this study, a simulation model was developed to optimise the unbalanced demand of the ED with unpredictable patient flows and resource constraints. Different scenarios were designed using Arena simulation software, and optimisation was performed on the Arena/OptQuest platform. As a result, performance improvement was achieved by reducing patient wait times and enhancing service delivery. 24 refs.
(Received in January 2025, accepted in March 2025. This paper was with the authors 1 week for 2 revisions.)

Key Words: *Emergency Department, Discrete Event Simulation (DES), Optimisation, Length of Stay, Constraint Theory*

Pages 261-272

INTEGRATED APPROACH TO DUE DATE ASSIGNMENT, JOB SEQUENCING AND MAGV DISPATCHING PROBLEMS

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Abstract
To ensure timely deliveries, it is essential to determine appropriate due dates and accurately estimate the flow time of orders. This study aims to identify an optimal policy for assigning due dates to orders by considering material handling system dispatching and machine priority rules in a workshop operating within a flexible production system. A total of 4032 simulation models were developed in the study, addressing six different problem areas: due date assignment, job sequencing, task determination for Multi-load Automated Guided Vehicles (MAGVs), delivery point selection, pickup point selection, and load selection. These models were evaluated using five distinct performance criteria. The results indicate that the Constant Due Date (CON) rule is the most effective for assigning due dates. Compared to other rules, the CON rule demonstrates an average improvement of 0.054 % in the number of outputs, 1.81 % in flow time, 3.85 % in lateness, and 2.35 % in deviation time. However, for earliness, the Jobs in Queue (JIQ) rule outperform other rules by 11.58 %. 34 refs.
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Key Words: *Due Date Assignment, Job Sequencing, Multi-Load AGV (MAGV), Priority Rules*

Pages 273-284

BARE-BONES PARTICLE SWARM OPTIMIZATION FOR EMERGENCY SCHEDULING IN PUBLIC EVENTS

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Abstract
Efficient scheduling of emergency resources is of great practical significance to ensure the smooth progress of large-scale events and maintain public safety. Therefore, this paper, firstly, proposes a novel emergency rescue system after public emergencies in large-scale sports events. In order to allocate resources, this paper establishes a single-objective model that minimizes the maximum delivery time (the injured waiting in place and being transported to the hospital) on the basis of considering the rescue effect. This paper proposes an improved bare-bones particle swarm optimization algorithm (IBBPSO) to solve the model. Through case analysis, it is found that compared with the bare-bones particle swarm optimization algorithm (BBPSO) and RBBPSO, the average optimization effect of IBBPSO is 62 % higher than that of RBBPSO and 23 % higher than that of BBPSO. IBBPSO has better performance in solving the resource allocation problem proposed in this paper. 24 refs.
(Received in January 2025, accepted in March 2025. This paper was with the authors 2 weeks for 2 revisions.)

Key Words: *Emergency Rescue System, Rescue Effect, Bare-Bones Particle Swarm Optimization, Emergency Medical Resource Scheduling*

Pages 285-296

CRACK GROWTH SIMULATION IN HYDRAULIC FRACTURING AND WATER-PRESSURE BLASTING TESTS

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Abstract
For the ineffective conventional methods for fracturing and permeability enhancement in low-permeability coal seams, costly field tests and difficult verifying the enhanced permeability effects, a novel method to increase coal seam permeability by combining the advantages of hydraulic fracturing and water pressure blasting in coal seams was proposed. Simulations and experimental validations of crack propagation and evolution characteristics in specimens were conducted through ABAQUS analysis and using a self-designed coupled fracture test system. Results show that pre-blasting water pressure inevitably causes cracks around boreholes, with damage increasing as water pressure rises. Compared with a water pressure of 0.5 MPa, a water pressure of 1.0 MPa causes 1.19 times more damage to the specimen. However, higher water pressure reduces explosive energy. Between 0.5–1.5 MPa, increased water pressure leads to a smaller fracture zone, slower crack propagation, and a peak then decline in main crack inclination. Experiments validate these simulation results, offering theoretical support for fracturing, permeability enhancement, and gas drainage in deep coal seams. 21 refs.
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Key Words: *Coal Seam, Hydraulic Fracturing, Water Pressure Blasting, Crack Propagation*

Pages 297-308

SIMULATION AND OPTIMIZATION FOR OIL AND GAS PLATFORM PLACEMENT IN MOUNTAINOUS REGIONS

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Abstract
Construction in mountainous regions involves substantial excavation and filling volumes. This study proposed an optimal location method for oil and gas platforms (OGPs) in mountainous regions. This method was based on multiple Particle Swarm Optimization (PSO). A geographic digital model was created for input elements such as residential areas, farmland, and roads. A total construction cost function was established, which incorporated excavation and filling costs, demolition compensation, and avoidance of key elements. A multiple PSO algorithm was developed to optimize platform location, corners, and elevation. This algorithm was validated using a real gas extraction platform. Results demonstrate that the geographic model accurately reflects surface features. The cost function has an error under 5 %, and it accurately represents location selection factors. The multiple PSO algorithm avoids local optima. Compared with actual location selections, the optimized solution reduces excavation by 40.4 %, filling by 35.3 %, and total costs by 27.3 %. This study provides a scientific basis for finding the optimal location for OGPs in mountainous areas. 20 refs.
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Key Words: *Oil and Gas Platforms, Mountainous Regions, Optimal Location, Cost Function, Multiple Particle Swarm Optimization*

Pages 309-320

THERMAL SIMULATION OF UAV LI-PO BATTERIES UNDER ABNORMAL AGEING CONDITIONS

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Abstract
The temperature changes under thermal, electrical and mechanical abuse conditions were simulated via COMSOL Multiphysics software on the basis of heat generation mechanisms and heat transfer processes to simulate the thermal behaviour of lithium-polymer (Li-Po) batteries for unmanned aerial vehicles (UAVs). The temperature changes of batteries under different abnormal ageing conditions were analysed, the temporal–spatial evolution patterns of temperature fields were revealed, and the dynamic evolution characteristics of thermal behaviour were obtained. Results show that the maximum temperature rise of batteries after charge–discharge cycles progressively intensifies as ambient temperature increases. Overcharging and nail puncture generate substantial heat, thereby inducing abrupt temperature surges in batteries, with peak temperatures of overcharged and punctured batteries reaching 105 °C and 300 °C, respectively. The obtained conclusions provide some theoretical references and decision-making foundations for controlling thermal runaway in lithium batteries under abnormal ageing conditions. 22 refs.
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Key Words: *Abnormal Ageing, UAV Li-Po Batteries, Thermal Simulation*

Pages 321-332

A NOVEL TRANSITIONAL ELEMENT-BASED APPROACH FOR PD-FEM COUPLING: THEORETICAL DEVELOPMENT

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Abstract
Peridynamics (PD) has emerged as a powerful computational method for modelling discontinuities, but its inherent surface effects and computational inefficiencies limit its standalone application. The Finite Element Method (FEM), while effective for boundary conditions, struggles with crack propagation modelling. This paper proposes a novel Transitional Element (TE)-based framework to seamlessly couple PD and FEM, ensuring computational compatibility and efficiency. By introducing a stiffness matrix correction approach, the TE mitigates interface inconsistencies and enhances accuracy. The proposed method preserves the strengths of both PD and FEM while significantly reducing computational cost. This framework lays a solid foundation for future applications in fracture mechanics and material failure analysis. 19 refs.
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Key Words: *Peridynamics, FEM, Coupling Model, Compatibility, Transitional Element, Stiffness Matrix Correction*

Pages 333-344

MICRO-TEXTURE OPTIMIZATION FOR TITANIUM CUTTING TOOLS VIA SIMULATION

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Abstract
This study presents optimization of micro-texture parameters for titanium alloy cutting tools to enhance machining performance. A two-dimensional finite element model was developed in the ABAQUS environment, incorporating the Johnson-Cook constitutive model to simulate the cutting process of Ti6Al4V (TC4) titanium alloy. The effects of micro-texture width, spacing, depth, and distance from the tool edge on cutting force and temperature were systematically investigated using an orthogonal experimental design. Simulation results demonstrated that micro-textured tools significantly reduced cutting forces and temperatures compared to non-textured tools, with optimal parameter combinations achieving reductions of up to 72.6 % in cutting force and 189 °C in temperature. Range analysis revealed the hierarchical influence of micro-texture parameters: distance from the edge had the greatest impact on cutting force, while texture width most strongly affected temperature. The study reveals critical mechanical-thermal trade-offs in micro-textured tool design, necessitating multi-objective optimization to guide high-performance titanium machining applications. 21 refs.
(Received in January 2025, accepted in May 2025. This paper was with the authors 6 weeks for 2 revisions.)

Key Words: *Micro Texture Tool, Parameter Optimization, Cutting Force, Cutting Temperature*

Pages 345-356

AN INTEGRATED TRAJECTORY OPTIMIZATION AND SIMULATION FOR A CONSTRUCTION ROBOT

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Abstract
This paper presents a path planning and motion optimization framework for concrete pouring construction robots (CPCR) operating in environments with multiple obstacles. At first, this proposed method introduced a highly efficient path using an improved Rapidly Exploring Random Tree Star (RRT*) algorithm. To improve safety, a pseudo-distance-based obstacle avoidance correction method was applied. Then, the corrected path was refined using B-spline interpolation to ensure continuity and smoothness. To achieve a time-efficient and dynamically feasible trajectory, a Crested Porcupine Optimizer (CPO) was employed for trajectory time allocation. The optimization objective balances total time and average acceleration through a cost function. Simulation results on the model of CPCR verified the effectiveness of the proposed method. The final trajectory was collision-free, smooth in joint space, and time-optimized. The integration of pseudo-distance-based correction and CPO-based trajectory optimization demonstrates potential for real-time motion planning tasks in large-scale robotics systems and complex environments. 23 refs.
(Received in February 2025, accepted in May 2025. This paper was with the authors 1 month for 2 revisions.)

Key Words: *Trajectory Optimization Simulation, Pseudo-Distance Obstacle Avoidance, Crested Porcupine Optimizer, Construction Robot Modelling*

Pages 357-368

CONTROL OPTIMIZATION OF TURBOCHARGED DIRECT INJECTION MILLER CYCLE HYBRID ENGINE

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Abstract
Hybrid internal combustion engines need to optimize fuel consumption while increasing engine power, to achieve higher overall fuel economy and total range while ensuring charging performance. This paper takes a turbocharged direct injection Miller cycle hybrid engine as the research object, utilizing GT-Power to establish a one-dimensional simulation model. Through this model, the influence of the intake valve closing (IVC) advance angle on engine performance and combustion is studied. The results showed that in the high load region, the advance of IVC brought significant decrease in exhaust temperature, AI50 and ignition angle, which resulting in a significant increase in combustion speed, a decrease in ignition delay and combustion duration angle. In the end, with advanced IVC angle, the brake thermal efficiency increased 4.5 %. Meanwhile, the research outcome can be used to guide the calibration and shorten the development time. 35 refs.
(Received in February 2025, accepted in May 2025. This paper was with the authors 5 weeks for 2 revisions.)

Key Words: *Miller Cycle, Combustion Simulation, Thermal Efficiency, Intake Efficiency*

Pages 369-380

REAL-TIME RESOURCE OPTIMIZATION IN LEAN PRODUCTION USING DEEP REINFORCEMENT LEARNING

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Abstract
In the transition to intelligent systems, lean production faces challenges from high-mix, low-volume manufacturing and frequent disturbances. Traditional resource allocation methods are inadequate for these dynamic environments. Deep Reinforcement Learning (DRL) offers a solution but often lacks alignment with lean principles and is hard to interpret, limiting effective human-machine collaboration. This study introduces an interpretable DRL approach for dynamic resource allocation in lean production. Utilizing a Markov decision process, the model includes a state space with resource efficiency, system balance, and inventory status, and a reward function targeting waste reduction and efficiency. The approach uses a Temporal Convolutional Network (TCN) to capture temporal dependencies and employs visualization tools like Global Average Pooling (GAP) and Class Activation Mapping (CAM) to trace decisions to specific waste elimination goals. This integrated learning process enables real-time decision verification by on-site managers, offering a practical solution for complex production settings and enhancing integration of DRL with lean management. 19 refs.
(Received in March 2025, accepted in May 2025. This paper was with the authors 3 weeks for 2 revisions.)

Key Words: *Deep Reinforcement Learning, Interpretability, Lean Production, Resource Allocation, Markov Decision Process*