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PARKING SEARCH OPTIMIZATION IN URBAN AREA

Maric, M.; Gracanin, D.; Zogovic, N.; Ruskic, N. & Ivanovic, B.
University of Belgrade, Institute Mihailo Pupin, Belgrade, Serbia
E-Mail: gracanin@uns.ac.rs

Abstract
This study is a first step towards solving the parking search time optimization problem in urban area. By using adaptive multi-criteria optimisation model with system feedback for simulation of parking choice behaviour and drivers' preferences, presented by adequate utility function, we shown on real case that parking search time can by reduced by 70 %. We use publicly available demographic study as input data and Rockwell Automation Arena® 14 software for processing and modelling. Various categories of data were evaluated based on results from 2,057 interviews with parking users. Our comparison of two models, everyday driver behaviour model and adaptive experimental optimisation model, shows a great potential in reducing parking search time. The analysed results show that search time decreases with information availability about three main criteria: acceptable walking distance, price and driving time. 24 refs.
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Key Words: *Optimisation, Open Data, Parking Prediction, Parking Search Time, Driver Utility*

Pages 207-218

PRODUCTION SYSTEMS FLOW MODELLING USING DECOMPOSITION METHOD AND REQUIRED BUFFERS

Gingu (Boteanu), E. I.; Zapciu, M. & Cavalieri, S.
University POLITEHNICA of Bucharest, Faculty of Engineering and Management of Technological Systems, Machines and Production Systems Department, Bucharest, Romania
E-Mail: iuliana_boteanu@yahoo.com

Abstract
This paper aims to provide an introduction to the analytical modelling and the discrete-events simulation for a manufacturing system. A general method of constructing a Markov chain and the simulation with discrete events using Delmia Quest software, are presented. In the present paper, those interested can find a real case study: modelling and simulation of the headrest support manufacturing line. The scientific contribution of this paper consists in the development of a theoretical model implemented in a real case study. The theoretical model estimates the production rate of the line and then, using this model we can establish how many parts in the buffers are required in order to achieve a production rate of *X* parts per minute. In the first phase, the manufacturing line is analysed, then the Markov chains for subsystems with two machines and a buffer are constructed. As the Markov chains need more time to provide solutions in queues theory, they can be used only for small production lines. To find the production rate for all the system, it is necessary to apply the Markov chains and the decomposition method. Those methods are implemented in the C/C++ programming. To validate the analytical model, the discrete-event simulation with Delmia Quest software is used. The article presents some comparisons between modelling with Markov chains and simulation with Delmia Quest software and provides a method of optimization of the buffers for the case study. 20 refs.
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Key Words: *Modelling, Markov Chain, Decomposition Method, Simulation, Buffers Optimization*

Pages 219-228

ON CONFIGURATION-BASED OPTIMAL DESIGN OF LOAD-CARRYING LIGHTWEIGHT PARTS

Harl, B.; Predan, J.; Gubeljak, N. & Kegl, M.
Faculty of Mechanical Engineering, University of Maribor, Maribor, Slovenia
E-Mail: bostjan.harl@um.si

Abstract
This paper discusses some aspects of FEA-based design procedures driven by topology optimization methods. Within this scope the problem of ensuring the robustness and reliability of optimized load-carrying lightweight parts is addressed. To achieve this goal the engagement of the so called design configuration with subsequent topology optimization is proposed. Adequate configuration tools can be used to define a shell/lattice structure and subsequent topology optimization makes sure to remove the stress concentrations and lower the stress levels to a minimum. The numerical and experimental results of the presented example illustrate the importance of proper cell type and orientation selection, as well the importance of optimization, especially, if the underlying part is planned to be produced by 3D printing. 15 refs.
(Received in May 2016, accepted in January 2017. This paper was with the authors 3 months for 1 revision.)

Key Words: *Load-Carrying Part, Lightweight Design, Topology Optimization, Lattice Configuration*

Pages 229-240

FINITE ELEMENT ANALYSIS FOR RUTTING PREDICTION OF ASPHALT CONCRETE PAVEMENT UNDER MOVING WHEEL LOAD

Wang, Y.; Lu, Y. J.; Si, C. D. & Sun, T. C.
Key Laboratory of Traffic Safety and Control in Hebei, Shijiazhuang Tiedao University, Shijiazhuang, P. R. China
E-Mail: jtxwy@163.com

Abstract
In order to improve the accuracy of the finite element rutting prediction model and evaluate the influences of truck parameters (wheel set, axle set, vehicle travel speed, and tire pressure) on rutting, a modified 3D pavement model was built in this study. The new model adopted a moving wheel load to perform repeated loading on the pavement, and the strain-hardening formulation was used as the creep law of the asphalt mixture. Results indicate that the front axle of single-rear-axle truck is as important as the rear axle to pavement rutting. The dual-axle truck can more easily cause pavement rutting than the single-axle truck, and the dual-axle wheel load increases rutting by 33 %. Moreover, the vehicle running at a slow speed can increase pavement rutting by a large margin. When the movement speed of wheel load decreases from 80 km/h to 60 km/h, the rutting is increased by 60 %. The high tire pressure generates considerable depression. When the tire pressure increases from 0.70 MPa to 0.90 MPa, the maximum depression on pavement increases by 7 %. The conclusions provide a reference for the pavement design and shear resistance design of asphalt mixture. 22 refs.
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Key Words: *Rutting, Moving Wheel Load, Finite Element, Strain Hardening Formulation*

Pages 241-252

OPTIMIZATION VIA SIMULATION FOR INVENTORY CONTROL POLICIES AND SUPPLIER SELECTION

Gocken, M.; Dosdogru, A. T. & Boru, A.
Engineering and Natural Sciences Faculty, Department of Industrial Engineering, Adana Science and Technology University, Adana, Turkey
E-Mail: mgocken@adanabtu.edu.tr

Abstract
The need to explicitly select the best review model in inventory control system is greater than ever because managing and controlling inventories are difficult under intense competition. In this study, three important questions are answered in inventory control system: which review model (periodic or continuous) should be used; which objective function of review model should be used to increase competitiveness of the supply chain; how to find the optimal values of initial inventory, reorder point, and order-up-to level for each Distribution Centre (DC) and each Supplier. We proposed an Optimization via Simulation (OvS) approach to determine the best inventory control system with supplier selection and to obtain a remarkable amount of saving while increasing the competitive edge in a fully stochastic supply chain environment. According to the results, total supply chain cost can be improved at least 22 % and at most 66 % on average with proposed continuous review model. 23 refs.
(Received in August 2016, accepted in January 2017. This paper was with the authors 2 months for 2 revisions.)

Key Words: *Inventory Control System, (s, S) Policies, Optimization via Simulation*

Pages 253-262

A CONSTRAINT-BASED APPROACH FOR CLASSES SETTING-UP PROBLEMS IN SECONDARY SCHOOLS

Nogareda, A.-M. & Camacho, D.
Ecole Hôtelière de Lausanne, HES-SO, University of Applied Sciences Western Switzerland
E-Mail: ana-maria.nogareda@ehl.ch

Abstract
In this paper, we present the problem of allocating students to classes in Swiss secondary schools, where students have different profiles due to their level in some fields or to the options they attend. The pedagogical objective is to have a high diversity of profiles within a class and similarity between classes. In order to achieve this goal, the problem is modelled as a resource allocation problem (RAP), where students are resources, using a constraint satisfaction optimisation approach (CSOP). The RAP is then solved in two different ways, with a solver for CSOP, and with an ant colony optimisation algorithm (ACO). Eight real datasets are used to compare their performance. The ACO algorithm provides better solutions than the CSOP solver in a shorter time. Results show that the pheromones used in the ACO help to find better solutions in a much smaller amount of time. The short computation time enables the school's directors to simulate different compositions of their future classes before having the final results of the last exams. 29 refs.
(Received in August 2016, accepted in January 2017. This paper was with the authors 1 month for 2 revisions.)

Key Words: *Resource Allocation Problem, Ant Colony Optimisation, Constraint Satisfaction Optimisation Problems*

Pages 263-274

USING HYBRID SIMULATION TO REPRESENT THE HUMAN FACTOR IN PRODUCTION SYSTEMS

Oliveira, M. L. M.; Montevechi, J. A. B.; Pinho, A. F. & Miranda, R. C.
Federal University of Itajuba (UNIFEI), Pinheirinho Itajuba, MG, Brazil
E-Mail: monaoli@yahoo.com.br

Abstract
Discrete-event simulation (DES) has been widely used in systems analysis. However, authors defend the idea that this kind of simulation does not properly represent the human element or the factors affecting its productivity. In Agent-Based Simulation (ABS), agents are intelligent, autonomous and proactive beings, which are features closely related to human behaviour. Therefore, ABS and DES were combined into one model to represent the human element as agents, who were subjected to one of the factors that affect their performance, the circadian rhythm. After statistical validation it was determined that the computer models integrating ABS and DES represent the productive systems under analysis with high level of confidence. A comparison between the model built and a DES model where operators are represented by resources was also performed. It was verified that the ABS/DES represents better the actual systems behaviour than the DES, showing a lower average of relative error. 35 refs.
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Key Words: *Agent-Based Simulation, Circadian Rhythm, Discrete-Event Simulation*

Pages 275-288

MAGNETIC SUSCEPTIBILITY DETERMINATION BASED ON MICROPARTICLES SEDIMENTATION ANALYSIS

Ravnik, J.; Cernec, D.; Hribersek, M. & Zadravec, M.
University of Maribor, Faculty of Mechanical Engineering, Maribor, Slovenia
E-Mail: jure.ravnik@um.si

Abstract
This paper deals primarily with the sedimentation of magnetic microparticles in the presence of an external magnetic field. Based on the analysis of raster images, taken during sedimentation process under the influence of magnetic field, the development of settling velocities occurring as a result of increasing magnetic force is measured. Basics of the magnetic field calculation of a disc neodymium permanent magnet are explained. Numerical particle tracking and particle size determination via image analysis is presented. On the basis of force balance equations for Lagrangian particle tracking and results of experimental tracking of particle positions during sedimentation with magnetic field turned on as well as off, the magnetic susceptibility of microparticles is determined. 14 refs.
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Key Words: *Sedimentation, Magnetic Microparticles, Magnetic Susceptibility, Image Analysis, Magnetic Field, Magnetic Flux Density*

Pages 289-301

IMPROVED ACO-BASED SWEEP COVERAGE SCHEME CONSIDERING DATA DELIVERY

Huang, P.; Lin, F.; Xu, L. J.; Kang, Z. L.; Zhou, J. L. & Yu, J. S.
College of Mechanical and Electrical Engineering, Sichuan Agricultural University, Yaan, P. R. China
E-Mail: lijiaxu13@163.com

Abstract
The newly introduced sweep coverage scheme uses mobile sensors to implement network coverage in wireless sensor networks (WSNs) and has attracted much attention from researchers. However, data buffer and moving speed of the mobile sensor are limited in sweep coverage. Thus, scheduling the minimum number of mobile sensors to efficiently implement dynamical network coverage while considering data delivery is still a challenging problem. To provide steady and efficient data gathering from sensors, an improved ant colony optimization-based sweep coverage (IACOSC) scheme supporting data delivery was proposed. In IACOSC, the artificial ants were used to create the initial coverage routes for points of interest. Then, a novel metric called route coverage efficiency was used to evaluate the routes. Finally, a local search algorithm based on route deletion and node insertion was employed to optimize these routes. Algorithm analysis shows that the time complexity of IACOSC is $O(n^3)$. Simulation results show that, compared with existing sweep coverage approaches considering data delivery, IACOSC significantly reduces the computational complexity and decreases the computation time by 50 % while reducing the mobile sensors by 16.73 % in the same network scenarios. The results obtained in this study can be applied to optimal deployment of WSN using the sweep coverage scheme. 25 refs.
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Key Words: *Wireless Sensor Network (WSN), ACO, Mobile Sensor, Sweep Coverage*

Pages 302-312

A UNIVERSAL CAD SYSTEM FOR CUTTING STOCK PROBLEM

Kovacic, M. & Brezocnik, M.
Štore Steel d.o.o., Štore, Slovenia
E-Mail: miha.kovacic@store-steel.si

Abstract
In this research the universal system using CAD geometry for solving of cutting stock problem is proposed. The system consists of the three main modules: geometry definition module, objective definition module, and the search strategy module. In the first module the reference points and orientation of parts and stock are defined. In the second module some constraints such as the quantity of the desired type of parts to be placed on the stock can be taken into account. The third module contains the search strategy. For the purpose of this research, the genetic algorithm was used as the search method. For illustration of the generality of the proposed approach, three practical examples for solving orthogonally and irregularly-shaped cutting stock problems are presented. The parts which are to be cut from stock-material with minimal loss and also the stock-material itself are presented as CAD geometries without any kind of geometrical constraints (i.e., concavity, convexity, sections, and holes). In the presented approach the AutoCAD environment was used. The AutoLISP in-house developed system for cutting stock problem was integrated into the AutoCAD. The developed system is without any kind of geometrical constraints and thus highly applicable in the practice. The presented approach can be developed also in other CAD systems where the application programming interfaces (API) are available. 35 refs.
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Key Words: *CAD System, Cutting Stock Problem, Irregular Shapes, Genetic Algorithms, AutoCAD*

Pages 313-321

MULTI-OBJECTIVE SCHEDULING SIMULATION OF FLEXIBLE JOB-SHOP BASED ON MULTI-POPULATION GENETIC ALGORITHM

Zhang, W.; Wen, J. B.; Zhu, Y. C. & Hu, Y.
School of Information, Central University of Finance and Economics, Beijing 100081, China
E-Mail: zhuyanchun@bnu.edu.cn

Abstract
In view of the difficulty of obtaining the optimal solution to the multi-objective scheduling of flexible job-shop by the general genetic algorithm, this paper takes into account the shortest processing time and the balanced use of machines, and puts forward the multi-population genetic algorithm based on the multi-objective scheduling of flexible job-shop. The method attempts to minimize the longest make-span of workpieces, the load of each machine, and the total machine load through the overall process scheduling of the job-shop. Research results reveal that the proposed method is highly efficient in seeking the optimal machine allocation chain, and effective in avoiding the complex process of intermediate assignment, making it easier to obtain the said optimal solution. The feasibility and effectiveness of the proposed method are also validated by two instances. Compared with the conventional flexible job-shop scheduling algorithms, the proposed algorithm boasts better population quality, algorithm starting point, and initial expression. Besides, it is far better than other algorithms in terms of the initial solution quality and the convergence rate. Despite the local fluctuations in the early phase of the genetic process, the total machine load and the machine load variance are gradually declining and the curves start to converge after the 50^{th} generation. 18 refs.
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Key Words: *Flexible Job-Shop, Scheduling, Genetic Algorithm, Multi-Objective, Optimization*

Pages 322-333

ACCURATE MODELLING AND TRANSIENT MESHING ANALYSIS OF INVOLUTE SPUR GEAR BASED ON THE PRINCIPLE OF GEAR SHAPING

Zeng, Q. L.; Wang, K.; Wan, L. R. & Zhang, X.
College of Mechanical and Electronic Engineering, Shandong University of Science and Technology, Qingdao 266590, China
E-Mail: qlzeng@sdust.edu.cn

Abstract
The gear is one of the most widely used and vital parts having freeform surfaces. Accurate modelling and strength calculation are the basis of gear design and optimization. The traditional gear design and the existing finite element analysis methods cannot effectively solve these problems. Only a simple model can be established and the static strength analysis can be carried out at a certain meshing position. In this study, accurate equations of the tooth surfaces of a spur gear were derived based on the principle of gear shaping. Then, the parametric finite element modelling and simulation of the transient meshing of the spur gear have been realized using ANSYS software, and the stress distribution and variation trends of the gear during the meshing process have been analysed. Finally, the method is verified by simulation and comparison. The analysis results show that the effect of the tooth fillet surface on the strength of the gear is very large, and the bending stress and contact stress of the gear are nonlinear in the meshing process. The proposed method can accurately establish the model including the tooth fillet surface of the spur gear, and accurately analyse the strength of the spur gear pair. This makes up for the shortcomings of the existing method, and can be applied to other gear forms after appropriate modification. 19 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Spur Gear, Gear Shaping, Meshing Equation, Modelling, Transient Analysis*

Pages 334-342

RESEARCH ON INDUSTRIAL ASSEMBLY LINE BALANCING OPTIMIZATION BASED ON GENETIC ALGORITHM AND WITNESS SIMULATION

Wang, Y. & Yang, O.
School of Electronics and Communication Engineering, Shenzhen Polytechnic, Shenzhen 518055, China
E-Mail: wyang@szpt.edu.cn

Abstract
With the rapid development of the industry sector, the assembly line has also experienced development, whose rationality determines the production efficiency of industrial production. In this paper, in order to address the balancing issue of assembly lines for industrial production, a combinatorial optimization method is proposed for the optimization and implementation of the assembly line based on the improved genetic algorithm (GA) and system simulation. By being applied to the assembly line of a company's chiller, our method is proved practical and effective. 20 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *GA, Witness Simulation, Assembly Line, Balance Problem, Combinatorial Optimization*

Pages 343-356

SIMULATION AND ANALYSIS OF BALL-END MILLING OF PANEL MOULDS BASED ON DEFORM 3D

Yang, L. & Zheng, M. L.
The Key Lab of National and Local United Engineering for “High- Efficiency Cutting & Tools”,
Harbin University of Science and Technology, Harbin 150080, P. R. China
E-Mail: minli@hrbust.edu.cn

Abstract
Automobile panel moulds are assembled pieces with various surface features, making it difficult to predict the machining properties in ball-end milling process. In this paper, Deform 3D finite element analysis software is used to simulate the ball-end milling of multi-hardness assembled moulds, and to analyse the distribution patterns of milling forces, stress fields and temperature fields in the transition regions of the multi-hardness assembled moulds. Subsequently, milling of sine surface moulds is simulated, and the effects of milling parameters on the thermal performance of sine surfaces are analysed. Finally, the multi-hardness assembling and milling experiment and the sine surface mould milling experiments are conducted to verify the effectiveness of the Deform 3D finite element simulation method. 19 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Ball-End Milling, Panel Mould, Simulation, Deform 3D*

Pages 357-367

THE ALGORITHM AND SIMULATION OF MULTI-OBJECTIVE SEQUENCE AND BALANCING PROBLEM FOR MIXED MODE ASSEMBLY LINE

Yang, B.; Chen, W. & Lin, C.
School of Electromechanical Engineering, Baoji University of Arts and Sciences, Baoji, China
E-Mail: chenwei@sisu.edu.cn

Abstract
In order to solve the balancing problem of product processing in a mixed flow assembly line, a modified genetic algorithm is proposed to optimize the instantaneous load and average load in the assembly line. An improved discrete particle swarm optimization algorithm is used to address the disordered and inefficient sequencing problem in processing products in an assembly line. Through a comprehensive consideration of the operating sequence, minimum production cycle, and the average load and instantaneous load of all workstations, the optimal solution was obtained and its load balancing conditions were studied. Based on the final solution and simulation results, the optimal solution was selected as the assembly line balancing alternative. The sequencing analysis result shows that by introducing the modified discrete PSO algorithm in the sequencing solution seeking in a mixed mode assembly line, the disordered and inefficient multi-objective sequencing problem can be effectively solved. According to the simulation result and calculated result, we set the ratio of the number of workstations to transmission rate as 10 and the product launch intervals as 45 s. Compared to the traditional algorithm, the improved algorithm has a smaller targeted function value, much shorter distance between the optimal solution and the ideal solution, and greater convergence capability. 17 refs.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: *Mixed Flow Line, Multi-Objective, Genetic Algorithm, Particle Swarm Algorithm, Balance, Sequence*