International Journal of Simulation Modelling – **Volume 19, Number 2**

Pages 185-196

USAGE OF DYNAMIC SIMULATION IN PRESSING SHOP PRODUCTION SYSTEM DESIGN

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Abstract
Production systems present a different complex consisting of interconnected sub-units. For their proper functioning, it is necessary to use approaches in the design process that will fully accept the interaction of individual units. A dynamic simulation is now a powerful tool for the need of designing production systems. However, in its application in practice, we often encounter various. This paper presents a framework for using dynamic simulation in production systems design. It describes suggested steps to take when we start the process of production systems design, mainly the process of data collection and simulation model building (current and future virtual systems). The article details framework usage and describes the most important challenges of each step. The proposed framework is then successfully applied to a real-life project of innovation of a production system in a pressing shop, where every step of the framework is documented with a working example and with described difficulties or outcomes that each step gave to the team. The result of the dynamic simulation application at the presented real example by the software Witness, the saving was 40.000 EUR. 33 refs.
(Received in August 2019, accepted in March 2020. This paper was with the authors 4 months for 3 revisions.)

Key Words: *Simulation, Modelling, Production Systems, Logistics*

Pages 197-208

FEM-BASED MODELLING OF ELASTIC PROPERTIES AND ANISOTROPIC SINTER SHRINKAGE OF METAL EAM

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Abstract
The fabrication of nearly fully dense metal parts via additive material extrusion processes is an auspicious alternative to powder-bed-based methods. After the extrusion of the material, the parts are debindered and sintered. Due to the process, the shrinkage of the parts and the material behaviour is orthotropic which causes problems to obtain the desired dimensional accuracy. Classical methods for simulating the sinter process are complex and demand the knowledge of various material parameters that have to be determined experimentally. This paper discusses analytical and numerical methods for predicting the effective properties of additively fabricated parts and presents a new and simple approach for the prediction of shrinkage, warpage and internal stresses caused by the sintering process based on a thermomechanical finite element analysis. The presented framework can be used to model the material behaviour without the need of extensive experimental data and is adaptable to various machines and materials. The proposed approach is exemplary shown. The results validate its functionality to predict sinter induced shrinkage and warpage as well as the locations of maximum internal stresses. 27 refs.
(Received in February 2020, accepted in April 2020. This paper was with the authors 1 week for 1 revision.)

Key Words: *FEA, Anisotropy Shrinkage, Sintering, Material Extrusion Additive Manufacturing, Metallic Components, Representative Volume Elements (RVE)*

Pages 209-218

STEEL WELDABILITY INVESTIGATION BY SINGLE AND DOUBLE-PASS WELD THERMAL CYCLE SIMULATION

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Abstract
Investigation of weldability by thermal cycle simulation of welding is an accelerated testing procedure that provides quantitative indicators of weldability in the heat-affected zone of the welded joint. This paper presents the research into weldability by weld thermal cycle simulation performed in single and double passes on the Smitweld 1405 simulator. Thermal cycle simulation of welding significantly shortens the process of selecting optimal welding parameters and attesting the welding procedure, and it also reduces total costs of weldability testing. The data obtained by this weldability testing method are repeatable and verifiable, so they can be used with sufficient reliability in selection of optimal welding parameters and in attesting of welding procedures. 29 refs.
(Received in February 2020, accepted in May 2020. This paper was with the authors 1 month for 1 revision.)

Key Words: *Weldability, Weld Thermal Cycle Simulation, Smitweld 1405, Heat-Affected Zone*

Pages 219-230

BATCH SIZE OPTIMIZATION OF MULTI-STAGE FLOW LINES IN TERMS OF MASS CUSTOMIZATION

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Abstract
As known, new paradigmatic manufacturing strategies, such as mass customization, bring many new challenges. One of them is batch size optimization since it allows lead time and cost reduction, what are the main preconditions of successful implementation of this strategy. This paper offers an effective solution to optimize batch sizes in order to minimize product lead times and maximize system throughput. Proposed solution considers the classic problem of sequencing a set of jobs that arrive in different combinations over time in a make-to-order (MTO) flow-shop type production. This paper is divided into the four main sections, starting with related work and proposed methodology. Then, approach to batch size strategy optimization is explained. The proposed method is presented through the case study, in the next main section. Finally, discussion and concluding remarks are provided. 35 refs.
(Received in February 2020, accepted in May 2020. This paper was with the authors 1 month for 1 revision.)

Key Words: *Mass Customization, Scheduling, Flow Shop, Batch Sizing, Due Date, Makespan*

Pages 231-242

MECHANICAL PERFORMANCES ANALYSIS OF TENSION-TORSION COUPLING ANCHOR CABLE

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Abstract
To reveal the tension-torsion coupling effect of the anchor cable, the three-dimension computational model was built. The mechanical performances of the anchor cable under tension-torsion coupling were studied by the analytical analysis and simulation verification on the model, and the coupling coefficient of the tension-torsion was proposed to define the percentage of the tensile force used for untwisting. The axial stress, shear stress and plastic development of the cross-section of the anchor cable were analysed also. Results show that the influence of the torsion of the anchor cable on the tensile force cannot be ignored. The tension-torsion coupling coefficient and the torque both increase with the increase of the diameter and the lay angle of the anchor cable. The maximum equivalent stress of the cross-section of the pulling anchor cable appears in the contact area of the inner and outer wires, and is larger under the free rotation than that under the restricted rotation condition. With the increase of the lay angle, the elastic modulus and the bearing capacity of the anchor cable decrease. The obtained conclusions can provide a reference for the similar practice of the anchor cable. 20 refs.
(Received in February 2020, accepted in May 2020. This paper was with the authors 1 month for 1 revision.)

Key Words: *Anchor Cable, Simulation Modelling, Tension-Torsion, Equivalent Stress, Rotation*

Pages 243-254

MATERIAL FLOW OPTIMIZATION THROUGH E-KANBAN SYSTEM SIMULATION

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Abstract
The digital evolution of lean thinking increases visibility along the whole value chain. It spreads and intensifies the potential of Supply Chain Collaboration in the network through the digitalization of orders, tracking deliveries and supplies in real-time, optimizing material and informational flows, and streamlining delivery time. Industry 4.0 transforms the business by creating a favourable environment for implementing well-known technologies from JIT/JIS and Kanban. The article aimed to map and create a simulation model of the production-assembly process and to propose the introduction of Kanban logic into material flow control. The implementation of the Kanban system and the testing of variant solutions using the simulation software Tecnomatix Plant Simulation made it possible to find the optimal solution. 24 refs.
(Received in February 2020, accepted in May 2020. This paper was with the authors 1 week for 1 revision.)

Key Words: *E-Kanban, Modelling, Simulation, Visibility, Digitalization*

Pages 255-266

SIMULATION OPTIMIZATION FOR THE INVENTORY MANAGEMENT OF HEALTHCARE SUPPLIES

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Abstract
This article covers the inventory management of healthcare supplies problem. Based on the mathematical programming model set out by [1], a causal model and a flow chart were developed to outline the simulation model, which was to be later applied to a highly specialized medical institution that performs high-risk heart surgery, such as catheterizations and angioplasties. With this simulation model, a purchases plan with 21 healthcare supplies was obtained that contemplates all the problem's restrictions: purchasing policy (safety stock, available budget); the warehouse's physical reality (warehouse capacity); characteristics of supplies (useful life, service level); and suppliers (price, capacity and size of lots or rounding value). Different indicators were also considered, such as service levels, costs of purchases, stockouts costs and inventory maintenance costs. The results obtained with the simulation model came very close to the mathematical programming results, but the computing times were considerably shorter. 31 refs.
(Received in March 2020, accepted in May 2020. This paper was with the authors 2 weeks for 1 revision.)

Key Words: *Simulation Optimization, Inventory Management, Supply Chain Management, Healthcare Logistics, System Dynamics*

Pages 267-278

GEOGRAPHY OF THINGS BASED FLOOD RISK INSURANCE MODELLING

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Abstract
The systems for managing urban and suburban areas are increasingly becoming data producers and subsequently data consumers. There are several possible approaches to integrated management and exception handling in these areas. One of the approaches is the Smart City concept using the Geography of Things (GoT) technological framework. In this paper, we offer a GoT based model for the assessment of risk which is suitable for financing, a model which is best suited for risk management and which contributes to the Smart City concept. The proposed model is based on combining the social community, built environment, Internet of Things sensor systems, series of the existing data, public utilities and economic services, and potential hazard in the spatial context of the modern Smart Community. The final output of the proposed model is the information about the price of risk of the endangered area, which is necessary for further decision-making and Smart City management. 24 refs.
(Received in March 2020, accepted in May 2020. This paper was with the authors 1 month for 2 revisions.)

Key Words: *Geography of Things, Geographic Information System, Smart City, Flood, Insurance Modelling, Urbanisation*

Pages 279-290

CAVITATION SIMULATION OF CENTRIFUGAL PUMP WITH DIFFERENT INLET ATTACK ANGLES

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Abstract
The impeller passage of low-specific-speed centrifugal pump is long and narrow. As cavitation occurs, the cavity blocks the passage abruptly, resulting in performance deterioration. Numerical simulation and a hydraulic test were conducted on a low-specific-speed centrifugal pump at three different inlet attack angles (8 º, 0 º, and −8 º) to clarify the influence of inlet attack angle on cavitation evolution in the impeller. The cavity distribution in the cavitation flow field and the blade loading distribution were analysed. Results showed that as the cavitation number decreased, the cavity initially emerged on the suction surface of the blade leading edge then extended rapidly to the impeller outlet along the blade surface. Meanwhile, the cavity spread to the pressure surface from the suction side under the influence of the re-entrant jet. Pump performance sharply deteriorated as the cavity grew to about 1/3 of the blade length. The loading on the blade close to the tongue was higher than that on the other blades regardless of whether cavitation occurred or not, and the zero-loading zone at the complete cavitation stage occupied about 3/5 of the length of flow passage. 25 refs.
(Received in March 2020, accepted in May 2020. This paper was with the authors 3 weeks for 1 revision.)

Key Words: *Centrifugal Pump, Cavitation, Numerical Calculation, Blade Loading, Inlet Attack Angle*

Pages 291-302

DESIGN AND INVESTIGATION OF MACHINE TOOL BED BASED ON POLYMER CONCRETE MIXTURE

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Abstract
Presented paper is focused on the modelling and description of the proposal of composite frame construction of the new CNC machine, which is designed for progressive machining of products made of powder materials produced by the additive Direct metal laser sintering technology. In the introduction of the article, the uniqueness of the created bed design of the machine tool based on the mixture of polymer concrete is emphasized through general knowledge. Subsequently, the paper determines the properties of the polymer concrete mixture, which forms the basic material of the machine tool bed, describes the design of the CAD solution and the complex strength analysis at the determined load of 950 N with the subsequent interpretation of the results. Within the stress analysis, the Von Mises combined voltage is in the range of 0.2 - 0.4 MPa, thus meeting the required values of the formed material. In order to ensure the complexity of the evaluation of the proposed design solution, the results achieved by modal analysis are also presented in the paper. The conclusion of the article provides an overall summary of the achieved results and describes the further direction of research. 29 refs.
(Received in April 2020, accepted in May 2020. This paper was with the authors 2 weeks for 1 revision.)

Key Words: *Polymer Concrete, Bed Machine, Stress Analysis, Modal Analysis*

Pages 303-312

MATHEMATICAL MODELLING AND SIMULATION OF A NOVEL HYDRAULIC VARIABLE VALVE TIMING SYSTEM

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Abstract
This paper explores deep into the mathematical modelling and simulation of a novel hydraulic variable valve timing (VVT) system. Considering the structure of the target system and the influencing factors of valve motions, the mathematical models were established for oil compressibility, pressure loss of pipeline, oil cylinder of cam, oil cylinder and buffer mechanism of the valve, oil cylinder of regulator, and the oil supply. On this basis, a simulation model was established on AMESim to analyse and optimize the motion parameters of the hydraulic VVT system. Finally, the simulated results were compared with early test results. The comparison shows that the simulated results are in good agreement with the test results, indicating that our simulation model is highly reliable. The research findings lay a solid basis for parameter analysis and optimization of VVT systems. 28 refs.
(Received in October 2019, accepted in February 2020. This paper was with the authors 3 months for 1 revision.)

Key Words: *Hydraulic Variable Valve Timing (VVT) System, Mathematical Modelling, Simulation, AMESim*

Pages 313-322

BLOCKING FLOW SHOP SCHEDULING BASED ON HYBRID ANT COLONY OPTIMIZATION

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Abstract
This paper attempts to solve blocking flow shop scheduling problems (BFSSPs) with the aid of swarm intelligence. After briefly introducing the BFSSPs, two single population growth models were compared. Between them, the logistic model was selected to derive the co-evolution model among multiple populations. Then, a dynamic hybrid ant colony optimization (ACO) strategy was proposed based on the competition among populations. The hybrid ACO divides the ant colony into an elite population, k search populations and a mutant population. The three populations, with the help of a swap local search algorithm, evolve and interact with each other interactively until the algorithm converge to the optimal solution. The feasibility of the hybrid ACO was verified through simulations on Taillard's classic examples. This research provides a good reference for applying swarm intelligence in job-shop scheduling. 32 refs.
(Received in November 2019, accepted in February 2020. This paper was with the authors 2 months for 1 revision.)

Key Words: *Blocking Flow Shop Scheduling Problem (BFSSP), Ant Colony Optimization (ACO), Swarm Intelligence Algorithm, Swap Local Search Algorithm*

Pages 323-333

CONSTRUCTION AND SIMULATION OF MULTI-OBJECTIVE RESCHEDULING MODEL BASED ON PSO

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Abstract
Job-shop scheduling is critical to the normal operation of the production process. However, there is not yet a robust rescheduling strategy for dynamic job-shop scheduling problems (DJSPs), which is disturbed by multiple random dynamic events. To make up for the gap, this paper classifies dynamic events by scheduling strategies, and details the hypotheses and constraints of dynamic job-shop scheduling. Then, a multi-objective rescheduling model was established to minimize the maximum completion time and maximum machine load of DJSPs. The model was solved by the particle swarm optimization (PSO). Finally, our model was proved effective and robust through MATLAB simulations. The research results provide a reference for the application of swarm intelligence in the field of the JSP. 24 refs.
(Received in October 2019, accepted in February 2020. This paper was with the authors 3 months for 1 revision.)

Key Words: *Job-Shop Scheduling Problem (JSP), Particle Swarm Optimization (PSO), Dynamic Events, Multi-Objective Rescheduling*

Pages 334-345

ASSEMBLY RELIABILITY MODELLING TECHNOLOGY USING FUNCTION DECOMPOSING AND LSSVM

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Abstract
Assembly reliability is an important part of product quality, which greatly affects the reliability level of whole machine. Because of the limitations of FMEA and FTA, they are not suitable for assembly reliability of complex mechanical equipment. A new functional decomposition method for whole machine (FDWM) is proposed for assembly reliability modelling in this paper. Firstly, by decomposing the whole machine into function and connection function of main components, the success tree model for whole machine (STWM) can be established. Secondly, a hybrid method by combining modified grey relation and least squares support vector machine (MGR-LSSVM) is proposed to improve the accuracy of STWM model. Lastly, the proposed method is applied to the assembly reliability analysis for feed mixer. The results show that the FDWM method is feasible for assembly reliability modelling, and the MGR-LSSVM method has a higher accuracy, and is efficient for the reliability analysis. 34 refs.
(Received in November 2019, accepted in March 2020. This paper was with the authors 2 months for 1 revision.)

Key Words: *Assembly Reliability, Reliability Modelling, STWM Model, Modified Grey Relation, LSSVM*

Pages 346-356

TEMPERATURE FIELD OF OPEN-STRUCTURED ABRASIVE BELT RAIL GRINDING USING FEM

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Abstract
Abrasive belt rail grinding in open-loop structure (ABRG-O) has been recently proposed. However, its frictional heat leads to the risk of rail burning. In order to explore this grinding heat accumulation process, a 3D finite element model (FEM) of multi-abrasive scratching was established to analyse the grinding temperature field on the rail surface. The simulation results showed that the grinding temperature field was initially in the rectangular shape divided by chip grooves and then gradually became a strip shape with higher temperature in the middle. The increasing grinding force enlarged the magnitude and area of the temperature field. The force loaded at the centre of the grinding plate led to a more evenly distributed and longer high-temperature region. With the increase in chip grooves, the peak temperature rose. The study provides the theoretical basis for improving the grinding plate design and the intelligent setting of rail grinding mode. 20 refs.
(Received in November 2019, accepted in March 2020. This paper was with the authors 1 month for 1 revision.)

Key Words: *Rail Grinding, Belt Grinding, Temperature Field, Abrasive Scratching, FEM*