

**ONLINE E-KANBAN SYSTEM IMPLEMENTATION IN A MANUFACTURING COMPANY**

Trebuna, P.; Pekarcikova, M.; Kliment, M.; Kopec, J. & Svantner, T.

Technical University in Kosice, Faculty of Mechanical Engineering, Department of Industrial and Digital Engineering,  
Nemcovej 32, 04 200 Kosice, Slovakia  
E-Mail: miriam.pekarcikova@tuke.sk

**Abstract**

The article's goal was motivated by achieving the implementation of the continuous improvement process in the company in terms of establishing selected lean methods, techniques, and principles. The proposed methodology based on an expert approach makes it possible to find variant solutions and approach the optimization process according to the selected criteria and the implementation of such optimized solutions. The mentioned approach is based on modelling and analysis of Value Stream Mapping, detection, and optimization of the OEE indicator within the framework of specific projects taking place in the company, up to the introduction of the online Kanban. This will ensure the achievement of the company's targeted goal in productivity and efficiency. The verification of the proposed methodology is processed in a case study of the project of the production of steel structures of car seats in a specific company. Part of the output is also an economic evaluation of the impact of implementing the online Kanban and the algorithmizing of this process for successful and quick application in practice. 27 refs. (Received in June 2022, accepted in October 2022. This paper was with the authors 1 month for 3 revisions.)

**Key Words:** *VSM Analysis, e-Kanban, Algorithms, Process, Project*

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**SAMPLING SIMULATION IN PROCESS DISCOVERY**

Prasetyo, H. N.; Sarno, R.; Wijaya, D. R.; Budiraharjo, R. & Waspada, I.

Department of Informatics, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia  
E-Mail: Riyanarto@if.its.ac.id, hanung.207025@mhs.its.ac.id

**Abstract**

Process model resulting from small event log datasets can be easily done because currently available applications are relatively able to do so. However, when faced with event logs from big data, modelling will force the existing applications to work hard. So far, the steps used are sampling of event logs resulting from the system. The problem arising is that the sampling process must be done several times because it has to check the desired fitness value on the sample taken. If the fitness value has not been got, then the sample size is added and the fitness value at a certain iteration is calculated until the required fitness value is met. There are many steps to do with this mechanism. Thus, this paper proposes an alternative way to reduce the steps by using an appropriate sampling technique. The mechanism used is statistical-based sampling simulation in the event log datasets to determine which sampling method is stable in the process modelling. The simulation results show that the sampling method using Cluster Random Sampling with the error rate or Alpha of 1 % has a relatively stable process model and can represent the process model resulting from the event log population. 33 refs. (Received in July 2022, accepted in November 2022. This paper was with the authors 3 weeks for 1 revision.)

**Key Words:** *Process Mining, Process Discovery, Big Data, Sampling, Event Log*

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**OPTIMISATION VIA SIMULATION APPLIED TO REVERSE LOGISTICS: A SYSTEMATIC LITERATURE REVIEW**

Pinto, W. G. M.; Montevechi, J. A. B.; Miranda, R. de C.; Santos, C. H. & Pereira, A. B. M.

Institute of Production Engineering and Management, Federal University of Itajubá (UNIFEI),  
1303 BPS Avenue PO Box: 50, 37500-903 Itajubá, MG, Brazil  
E-Mail: wesleygmp@unifei.edu.br

**Abstract**

The objective of the study is to analyse the scientific production on optimisation via simulation (OvS) applied to reverse logistics. Therefore, a systematic literature review on this area was carried out based on articles published in the main scientific databases during the last 30 years. We analysed about 70 articles published in several journals, and the state of the art regarding the adoption of OvS in reverse logistics problems was explored. This article fills some important questions about the adoption of this approach and might be useful for researchers and professionals in their developments related to this research field. Finally, we highlight some issues and research opportunities. 35 refs. (Received in July 2022, accepted in November 2022. This paper was with the authors 1 week for 1 revision.)

**Key Words:** *Optimisation, Simulation, Reverse Logistics, Systematic Literature Review*

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## SPEEDING UP PAST STOCK MOVEMENT SIMULATION IN SPORADIC DEMAND INVENTORY CONTROL

Huskova, K. & Dyntar, J.

Technical University of Liberec, Faculty of Economics, Voronezská 13, 460 01 Liberec 1, Czech Republic  
E-Mail: katerina.huskova@tul.cz

### Abstract

This paper is aimed at speeding up past stock movement simulation in sporadic demand inventory control making it more suitable to deal with large scale real life problems connected for example with stock management of spare parts used in the maintenance of production equipment. Thus, in continuous review, fixed order quantity inventory control policy, we suggest reducing number of simulated combinations of reorder point and replenishment order quantity replacing all combinations search with the local search. The local search is based on minimal and maximal reorder point coming from linear regression and bootstrapping. When simulating randomly generated intermittent data with increasing nonzero demand quantities the significant savings of computational time are reached while bringing up to 50 % of simulated timeseries to reach the best possible holding and ordering costs and another 40 % to reach the maximal deterioration of these costs up to 15 %. Upgraded simulation represents efficient, data driven and assumptions free approach to the sporadic demand stock management outperforming individual application of parametric forecasting methods. 29 refs.

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**Key Words:** *Spare Parts, Sporadic Demand, Inventory Control, Continuous Review, Fixed Order Quantity, Simulation*

## ANALYSIS OF THE INFLUENCE OF ACCUMULATOR CONFIGURATION ON STABLE LIQUID SUPPLY

Zeng, X. T. & Wang, D. L.

School of Mechanical Electronic and Information Engineering, China University of Mining and Technology – Beijing, Beijing 100083, China

E-Mail: wangdl@student.cumt.edu.cn

### Abstract

To improve the stability of liquid supply and solve the problems of pressure, flow pulsation, and hydraulic impact, this study established the mathematical model in the working process of an accumulator from the perspective of the accumulator station, with the liquid supply system of a fully mechanized working face as the research object, and established the simulation model of the entire liquid supply system using AMESim. The influence of the relevant parameters of the accumulator on the working process of a single pump in the working face was analysed, and the combination scheme of the accumulator station was optimized. Results demonstrate that the pump equipped with an accumulator can effectively improve the liquid supply performance of the system. For the liquid supply system of the working face, the accumulation station combination scheme of  $8 \times 63$  L and the initial accumulator charging pressure of 75 % of the working pressure could increase the stability of the system pressure and flow. The proposed research method provides evidence for achieving a stable liquid supply at the working face. 27 refs.

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**Key Words:** *Emulsion Pump Station, Accumulator, Stable Liquid Supply, Optimization Analysis*

## PROPOSAL OF A SOFTWARE TOOL FOR MANUAL ASSEMBLY OUTPUTS SIMULATION

Mares, A.; Vaclav, S. & Delgado Sobrino, D. R.

Technical University of Kosice, Faculty of Mechanical Engineering, Department of Automotive Production, Masiarska 74, 04001 Kosice, Slovak Republic

E-Mail: albert.mares@tuke.sk

### Abstract

Manual assembly operations are often the bottlenecks of production processes. Usually, in order to find out, what the throughput of these manual assembly operations will be, it is first necessary analysing them in the context of the workstation and the whole processes as well. For these analyses, one of the most useful tools is the use of simulation. Despite existing several complete software for these purposes, they often demand significant time and effort to create good simulations. Sometimes, however, it is just enough to simulate a few key aspects of the assembly process to get key results, which are often the base for immediate and/or further process improvement. In these cases, creating a special analytical tool that allows efficiently obtaining a sufficiently good solution to the given problem becomes a viable and convenient option. This paper presents an assembly simulation and analysis tool designed and created in Microsoft Excel by the authors. The tool is useful for quick analyses of assembly tasks without the need of having to engage in creating complex 3D models and extra analyses. The proposal is implemented into a practical case study, which allows verifying its validity. 24 refs.

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**Key Words:** *Assembly, Simulation, Time Analysis, Microsoft Excel, Software Tool*

**NOVEL DISPATCHING RULES FOR MULTIPLE-LOAD AUTOMATED GUIDED VEHICLES**

Isik, M.; Sahin, C. &amp; Hamidy, S. M.

University of Cukurova, Faculty of Engineering, Department of Industrial Engineering, 01330, Adana, Turkey

E-Mail: demirtasm@cu.edu.tr

**Abstract**

Managing the manufacturing systems and establishing scheduling is a dynamic process that must be handled properly in the event that unexpected events arise. Scheduling manufacturing systems requires not only considering the availability of machines, but also their material handling systems. In a dynamic manufacturing environment, dispatch rules are commonly used in scheduling machines and material handling systems. Multiple-load Automated Guided Vehicles (MAGVs) handle multiple loads. There is a discussion of problems associated with MAGVs, including task determination, delivery, pickup, and load selection. In this study, new rules for determining tasks, determining delivery routes, and selecting loads are proposed and investigated. The proposed rules are evaluated using simulation models with two performance criteria: makespan and lateness, in comparison with the rules presented in the literature as the best. According to the results, the proposed rules result in schedules with the shorter makespan and shorter lateness. 27 refs.

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**Key Words:** *Multiple-Load Automated Guided Vehicles (MAGVs), Dispatching Rules, Simulation*

**SIMULATION ANALYSIS OF TEMPERATURE FIELD OF TINPLATE IN THE QUENCHING**

Zhang, W. J.; Zhang, X. D.; Guo, Z. F.; Wang, J. H. &amp; Bai, Z. H.

National Cold Rolling Strip Equipment and Process Engineering Technology Research Center of Yanshan University,

Qinhuangdao, 066004, China

E-Mail: bai\_zhenhua@aliyun.com

**Abstract**

To reduce the defect of quench stain on tinplate's surface in the reflow section of the tinplating unit, based on the equipment and process parameters, the quench stain was analysed and the treatment strategy was proposed, which added nozzles to hasten the heat exchange of the strip into the quenching tank. A three-dimensional finite element model was constructed by Creo and ANSYS to reduce the correction rate of quench stain and reveal the temperature field of tinplate in quenching tank. The factors of quenching time, nozzle jet speed, nozzle angle, nozzle pressure, and nozzle size on the tinplate temperature field were analysed. Results show that the temperature field of the tinplate is relatively uniform when the nozzle jet speed of the nozzle is 1m/s, the nozzle angle is 15°, the nozzle pressure is 0.3 MPa, and the nozzle size is 5 mm. The quenching equipment is reformed to verify the result of the simulation. The defect correction rate of quench stain on the strip decreases from 1.79 % to 1.03 % in the tinplating unit, which meets the accuracy of the simulation analysis. The obtained conclusions provide a reference for treating quench stain in the tinplating unit. 27 refs.

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**Key Words:** *Tinplate, Quench Stain, Temperature Field, Finite Element*

**SIMULATION OF RE-ARRANGEMENT AND HEALING IN ROBOTIC COMPACT BIN-STORAGE SYSTEM**

Yener, F. &amp; Yazgan, H. R.

Department of Industrial Engineering, Engineering Faculty, Sakarya University, Esentepe Campus, Serdivan, Sakarya, Turkey

E-Mail: fyener@sakarya.edu.tr

**Abstract**

This paper proposes a simulation-based optimization method for the Robotic Compact Bin-Storage System (RCBSS). Storage Location Assignment Problem (SLAP) and Order Picking Problem (OPP) on the RCBSS are studied. Four different performance criteria are investigated in the re-arrangement and healing approach. These criteria are picking time, loading time, time spent for re-arrangement, and simulation duration. The simulation results show that the re-arrangement and healing approach effectively minimize the total cost and efficiency, and the designed algorithm efficiently solves the model. This study is expected to minimize the turnaround time, ordering delays, station occupancy time, and robot congestion. It also increases system throughput and customer satisfaction. The study results show that the re-arrangement approach provides much more favourable results for the RCBSS. 23 refs.

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**Key Words:** *Robotic Compact Bin-Storage System, Order Picking, Re-arrangement, Simulation*

## SIMULATION OF GUIDED CROWD EVACUATION SCHEME OF HIGH-SPEED TRAIN CARRIAGE

Zhang, X. Y.; Chen, G. P. & Shi, J. M.

School of Finance, Hainan Vocational University of Science and Technology, Haikou, 571126, China

E-Mail: zxy8708272022@163.com

### Abstract

To reduce the evacuation time of passengers in a high-speed train carriage (China Fuxing CR400BF train as an example), the evacuation time in three scenarios, namely, free evacuation and train crew-guided evacuation in case of an emergency under the full load status of second-class seats, was simulated and compared via Pathfinder simulation software. Then, the crowd flow rates at the front and rear exits of the high-speed train carriage were revealed. In addition, the crowd guidance scheme reaching the highest evacuation efficiency was formulated. Results show that the total time consumption under the free passenger evacuation status is 70.5 s. However, the time consumption can be reduced to 60.3 s when passengers close to the aisle are evacuated first under the effective command of the high-speed train crew. If passengers are evacuated successively from the seat row closest to the carriage exit, the evacuation time can be shortened to 58.8 s, thus harvesting the highest evacuation efficiency. The obtained conclusions provide a decision-making reference for improving the emergency evacuation strategy of high-speed trains in the face of emergencies. 22 refs.

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**Key Words:** *High-Speed Train Carriage, Evacuation, Crowd Guidance Scheme*

## MULTI-ROBOT PATH OPTIMIZATION AND SIMULATION FOR MULTI-ROUTE INSPECTION IN MANUFACTURING

Chai, G. F. & Xia, Y. Z.

College of Electrical and Information Engineering, Quzhou University, Quzhou 324000, China

E-Mail: chaig@qzc.edu.cn

### Abstract

The research of multiple inspection robots' path simulation planning helps to improve the inspection ability and efficiency of the multi-robot system. This paper studies the problem of cooperative optimization and simulation of multiple robots for multiple inspections in intelligent manufacturing. A dynamic simulation model of the inspection robot is used to construct the state equation of the multi-robot inspection simulation system. The square grid is used to decompose the intelligent manufacturing workshop area and simulate the workshop space. With reinforcement learning, a multi-robot patrol simulation system is created for full coverage path simulation planning. The results show the effectiveness of the system for cooperative optimization control and reasonable path planning. 24 refs.

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**Key Words:** *Intelligent Manufacturing, Multi-Route Inspection, Multi-Robot Cooperation, Patrol Path Optimization, Simulation Modelling*

## MODEL AND ALGORITHM FOR THE SKILL CAPACITATED VRP WITH TIME WINDOWS IN AIRPORTS

Zhao, P. X.; Dai, M. N.; Han, X.; Xu, C. & Du, C. C.

School of Management, Shandong University, Jinan 250100, China

E-Mail: pxzhao@sdu.edu.cn

### Abstract

The scheduling efficiency of airport ground support vehicles is an important factor affecting the on-time performance of flights. In this paper, the Skill Capacitated Vehicle Routing Problem with Time Windows is proposed and the corresponding algorithm is designed for main airport ground support vehicles. Firstly, we decompose the transit process of flights using simple temporal network and time decoupling to obtain the time windows of each ground support service. Secondly, a vehicle scheduling model is constructed according to the characteristics of each vehicle, which aims at minimizing the number of vehicles used and balancing the workload of each vehicle. Finally, the elitist genetic algorithm with large neighbourhood search is designed to solve the problem and is compared with the standard genetic algorithm. The effectiveness of the model and the algorithm is illustrated by a real data example from Beijing Capital International Airport. 20 refs.

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**Key Words:** *Airport Ground Support Vehicle, Collaborative Scheduling, Simple Temporal Network, Genetic Algorithm, Vehicle Routing Problem (VRP)*

## THE PLASTIC ZONE OF CLAY UNDER FOUNDATION LOAD: AN EXPERIMENTAL AND NUMERICAL ANALYSIS

Liu, X. H.; Jiang, S. Q.; Zeng, Y. Q.; Hu, W. D.; Gong, Y. & Chen, J. L.

College of Civil Engineering and Architecture, Hunan Institute of Science and Technology, 414000, Yueyang, China

E-Mail: yqzeng@hnist.edu.cn

### Abstract

In order to study the generation and distribution of plastic zone of cohesive soil foundation with the change of foundation pressure and foundation width, particle image velocimetry testing technology and discrete element method are used to study the dynamic distribution characteristics of plastic zone of cohesive soil, foundation failure mode and corresponding foundation bearing capacity values. By using particle image velocimetry testing technology, the plastic zone of clay under different foundation load is obtained, in which the ultimate foundation bearing capacity can be taken as 120 kPa. The development law of foundation plastic zone simulated by UDEC is highly consistent with that of foundation plastic zone based on PIV test. Through the parameterized numerical simulation test of the foundation plastic zone, this paper discusses the variation law of foundation plastic zone with the changes in the foundation load and the width of foundation, which can be used to study the dynamic development process of plastic zone of the shallow foundation. The research has important guiding significance for evaluating the range of foundation plastic zone in foundation design. 21 refs.

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**Key Words:** *Plastic Zone, Foundation Bearing Capacity, Particle Image Velocimetry, Discrete Element Method*

## DESIGN AND SIMULATION OF A MULTI-SPECIFICATION AND SMALL FLOW FLEXIBLE STORAGE SYSTEMS

Hu, Y. M.; Li, D. D. & Zhou, L.

Department of Logistics School, Postgraduate of Logistics Engineering, Yunnan University of Finance and Economics, Yunnan, China

E-Mail: huyimin1998@163.com

### Abstract

This paper conducts innovative research on the stand-alone equipment and warehousing mode in the automated warehousing system to address the automatic warehousing of various specifications of products in small and medium-sized enterprises in China. The research proposes a new type of robotic storage device and storage method. Furthermore, the proposed storage scheme is simulated, and the results show that the scheme is feasible. In addition, the system layout was optimized based on the simulation results. This research proposes a new solution for the automatic storage problem of multi-specification and low-traffic products and, at the same time, proposes new storage devices and models, which enrich the research in the field of automatic storage. 32 refs.

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**Key Words:** *Flexible Storage, Multi-Variety, Multi-Specification, Small Flow, Multi-Specification Rack, Interchangeable Fork Stacker*

## A PERFORMANCE STUDY ON STRUCTURAL PARAMETERS OF CENTRE-AXLE-TRAILER COMBINATIONS

Zhou, Q. H.; Qiu, Y. H.; Liu, H. S. & He, Y.

School of Mechanical-Electronic and Vehicle Engineering, Beijing University of Civil Engineering and Architecture, Beijing 102627, China

E-Mail: zhouqinghui@bucea.edu.cn

### Abstract

Compared with rigid-trucks, centre-axle-trailer (CAT) combinations significantly improve fuel economy and reduce greenhouse-gas emissions. However, with respect to rigid-trucks, CAT combinations exhibit lower lateral stability at high speeds, and display poorer path-following off-tracking (*PFOT*) at low speeds. This study intends to address these problems. To this end, eigenvalue analysis and simulation were conducted to evaluate the directional performance of CAT combinations considering the variations of typical structure parameters. To coordinate the trace-off between the lateral stability in terms of rearward amplification (*RWA*) and *PFOT* of CAT combinations, a CAT design with a variable-length drawbar was proposed. The drawbar length may be altered under different operating conditions, e.g., low-speed curved-path negotiations and high-speed evasive manoeuvres. The proposed variable-length drawbar is feasible in design and cost-effective in implementation. The insightful results derived from this study provide useful guidelines for the design CAT combinations to improved directional performance. 25 refs.

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**Key Words:** *Rearward Amplification (RWA), Dynamic Stability, Path-Following Off-Tracking (PFOT), Manoeuvrability, Centre Axle Trailer, Numerical Simulations*