Editorial: Special Issue 'Scheduling in Manufacturing Systems: New Trends and Perspectives'

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This special issue is dedicated to the celebration of the 55th anniversary of International Journal of Production Research and its relevancy in scheduling. The idea was to present the state-of-the-art in scheduling with respect to theoretical advances as well as practical relevancy in modern manufacturing and resource planning. Thus, the aim of this issue was to attract high-quality papers on most recent developments in modelling and solving scheduling problems in manufacturing systems which include parallel as well as multi-stage facilities, the wide area of logistics, supply chains or new applications. Potential authors were encouraged to submit their best recent research particularly in new and challenging scheduling areas leading to advanced perspectives in scheduling.

As possible current research topics, we suggested for instance grouping and sequencing operations in multi-stage systems, new scheduling approaches for flexible shops, new developments for scheduling with precedence constraints, batching and further technological constraints, assembly flow shop scheduling, scheduling with setup times/cost, just-in-time scheduling, new types of scheduling heuristics and approximation algorithms, scheduling under resource constraints, connections between scheduling and logistics, scheduling problems related to energy management, game theoretic aspects in scheduling, scheduling in segments of a supply chain, scheduling under uncertainty, online scheduling, or new scheduling applications in logistics, traffic, health care, mechanical and industrial engineering, human computer interaction.

We have received 56 submissions. After a careful refereeing, 12 papers have been selected for inclusion into this special issue. The first four papers deal with generalizations of classical single and multi-machine shop scheduling problems. Lai et al. [6] address the single machine problem of minimizing total weighted completion times with interval processing times. The authors introduce the optimality box as a stability measure of an optimal schedule and derive a linear time algorithm for calculating the optimality box for a given job sequence. Properties of an optimality box and a dynamic programming algorithm for constructing a job sequence

with the largest optimality box are presented. Computational results for finding a permutation with the largest perimeter of the optimality box are given for instances with up to 10,000 jobs.

Valledor et al. [12] consider a multi-objective rescheduling problem in a dynamic permutation flow shop environment with three types of disruption, namely arrival of new jobs, machine breakdowns and variations in the processing times of the jobs. A rescheduling architecture based on a predictive-reactive strategy and a new method for calculating the reactive schedule in each rescheduling period are suggested. In addition, a methodology with the use of multi-objective performance metrics is used to evaluate dispatching rules. The results demonstrate that the random rule provides a better behaviour than the other rules tested and also a lower ratio of non-dominated solutions in comparison with the apparent tardiness cost and first-in-first-out rules.

Meng et al. [8] investigate a two-stage machining and welding scheduling problem with minimizing the sum of the makespan values of the parts, denoted as total makespan. At stage one, several parts are processed as in a job shop scheduling problem and are then grouped into a single construction component at the subsequent welding stage. After presenting a mathematical model, the authors suggest an improved harmony search algorithm including a local search. It turned out that the new hybrid algorithm outperforms several conventional algorithms.

Bozek and Werner [1] study a flexible job shop scheduling problem with the additional inclusion of lot streaming and sublot size optimization. The authors suggest a two-stage algorithm, which first minimizes the makespan for the smallest sublots. Then the sublots are maximized in the second stage without increasing the makespan. In the second stage, two optimization criteria are used: the maximization of the sum of the sublot sizes of all operations and the maximisation of the number of operations that do not need to be split. For solving the problem, mixed integer linear programming, constraint programming and graph-based methods are used. The two developed optimisation approaches are compared for each

stage and objective, where benchmark instances with up to 20 jobs and 20 machines are considered.

The next two papers deal with particular manufacturing systems, inspired by real production systems. De Matta [3] considers a manufacturing process appearing in a drug packaging company. The problem requires to assign resources to production lines during the set-up to satisfy certain product specifications. For this problem, two mixed integer programming models and a Langrangian heuristic are given. The algorithm has been tested on real and randomly generated data. The results demonstrate that the suggested solution approach is both effective and efficient in finding good feasible solutions.

Prasad and Jayswal [10] study a reconfigurable manufacturing system which can change its capacity and functionality whenever required. For an Automotive Components company, a modified reconfigurable layout has been proposed for an assembly line, and scheduling is considered under the criteria reconfiguration effort, profit over cost and due date. Scheduling of the products is done using an integrated approach of the Shannon entropy and the Reference Ideal Method. In addition, a sensitivity analysis has been performed for this problem.

Foumani et al. [4] address a robotic automated storage and retrieval system, where a Cartesian robot picks and palletises items onto a mixed pallet for any order. The decisions to be made include finding an optimal sequence of the orders and also an optimal sequence of the items inside each order such that the total travel times are minimised. In the first phase, an avoidance strategy for the robot is developed which detects the occurrence of collision causing an unsafe handling of hazardous items and delivers a collision-free robot movement sequence. In the second phase, a cross-entropy method is applied which has been tested and compared with the solutions obtained by CPLEX. It turned out that CPLEX was only able to solve small instances, and for larger instances the author tested their algorithm against the

nearest neighbour heuristic. Some model extensions and future research directions are also discussed.

The next three papers deal with scheduling problems related to supply chains. Ivanov et al. [5] extend existing studies of supply chain scheduling and resilience analysis by an explicit integration of the recovery policy of an optimal schedule and supply chain resilience. The authors suggest a scheduling model that considers the coordination of recovery actions in the supply chain and also a resilience index by means of the concept of attainable sets which are a known tool in control theory. The computational algorithms presented are based on the presentation of an optimal control problem as a two-point boundary problem using the maximum principle and the necessary conditions of optimal control. Some managerial insights of the developed method are also given.

Liu et al. [7] present an integrated model for the multi-resource constrained production planning and truck scheduling problem in a manufacturing supply chain, where production units can produce different types of products and coordinate with a resource manager. After formulating a mixed integer programming model and presenting some analytical properties, a heuristic based on Lagrangian relaxation is derived which uses several enhancements. The computational results for 720 instances demonstrate that their heuristic has a better performance than CPLEX, both with respect to the objective function value and the CPU time.

Motivated by a real production problem, Chen et al. [2] investigate the problem of coordinating the supplier selection and project scheduling, more precisely they consider a project network consisting of several concurrent projects which are independent in operation but subject to shared suppliers and a final quality inspection. For this problem, a mixed integer linear programming model and a heuristic based on mathematical programming are suggested. It decomposes the problem into sub-problems which are solved in an iterative way.

The authors demonstrate the computational effectiveness of their algorithm by numerical examples with up to 25 projects, each of them consisting of up to 11 activities.

Nasiri et al. [9] deal with the incorporation of supplier selection and order allocation into the vehicle routing and multi-cross-dock scheduling problem. The authors present a mixed integer linear programming model for the problem of minimizing total costs, and the sensitivity of the model on the key parameters of the objective function is investigated. The authors suggest a two-stage solution algorithm and compare the results on small instances with the exact solution. They also consider a real-world case of urban freight transport in Tehran city.

Qu et al. [11] propose a single cumulative sum scheme for simultaneously detecting the size and time interval of an event. The authors compare their new scheme against three other schemes. It turns out that the new chart is rather powerful, and it can be applied in industries and also non-industrial fields.

We hope that the readers of this special issue can find new inspirations for their current research which may lead to innovative approaches for classical and new scheduling problems and applications in the future. The guest editors wish to thank all authors for submitting their papers, whether accepted or not accepted for publication, to our special issue. The guest editors also wish to thank the referees for their support in the preparation of this special issue. We are also grateful to Taylor & Francis, the editorial staff of the journal and in particular Prof. Alexandre Dolgui for the pleasant cooperation.

References

[1] Bozek, A.; Werner, F.: Flexible Job Shop Scheduling with Lot Streaming and Sublot Size Optimisation, *International Journal of Production Research*, DOI: 10.1080/00207543.2017.1346322, 21 pages.

[2] Chen, W.; Lei, L.; Wang Z.; Teng, M.; Liu, J.: Coordinating Supplier Selection and Project Scheduling in Resource-Constrained Construction Supply Chains, *International Journal of Production Research*, DOI: 10.1080/00207543.2018.1436782, 15 pages.

[3] de Matta, R.: Scheduling a Manufacturing Process with Restrictions on Resource Availability. *International Journal of Production Research*, DOI: 10.1080/00207543.2017.1384583, 18 pages.
[4] Foumani, M.; Moeini, A.; Haythorpe, M.; Smith-Miles, K.: A Cross-Entropy Method for Optimising Robotic Automated Storage and Retrieval Systems, *International Journal of Production Research*, DOI: 10.1080/00207543.2017.1456692, 23 pages.
[5] Ivanov, D.; Dolgui, A., Sokolov, B.: Scheduling of Recovery Actions in the Supply Chain with Resilience Analysis Considerations, *International Journal of Production Research*, DOI: 10.1080/00207543.2017.1401747, 18 pages.
[6] Lai, T.C.; Sotskov, Y.N.; Egorova, N.G.; Werner, F.: The Optimality Box in Uncertain Data for Minimising the Sum of the Weighted Job Completion Times, *International Journal of Production Research*, DOI: 10.1080/00207543.2017,1398426, 27 pages.
[7] Liu, C.; Xiang, X; Zheng, L.; Ma, J.: An Integrated Model for Multi-Resource Constrained Scheduling Problem considering Multi-Product and Resource-Sharing, *International Journal of Production Research*, DOI: 10.1080/00207543.2017.1363428, 21 pages.
[8] Meng, R.; Rao, Y.; Zheng, Y.; Qi, D.: Modelling and Solving Algorithm for Two-Stage Scheduling of Construction Component Manufacturing with Machining and Welding Process *International Journal of Production Research*, DOI: 10.1080/00207543.2017.1349949, 13 pages.
[9] Nasiri, M.M.; Rahbari, A.; Werner, F.; Karimi, R.: Incorporating Supplier Selection and Order Allocation into the Vehicle Routing and Multi-Cross-Dock Scheduling Problem, *International Journal of Production Research*, DOI: 10.1080/00207543.2018.1471241.
[10] Prasad, D.; Jayswal, S.C.: Reconfigurability Consideration and Scheduling of Products in a Manufacturing Industry, *International Journal of Production Research*, DOI: 10.1080/00207543.2017.1334979, 20 pages.
[11] Qu, L.; He, S.; Khoo, M.B.C.; Castagliola, P.: A CUSUM Chart for detecting the Intensity Ratio of Negative Events, *International Journal of Production Research*, DOI: 10.1080/00207543.2017.1398423, 15 pages.
[12] Valledor, P.; Gomez, A.; Priore, P; Puente, J.: Solving Multi-Objective Rescheduling Problems in Dynamic Permutation Flow Shop Environments with Disruptions, *International Journal of Production Research*, DOI: 10.1080/00207543.2018.1468095, 15 pages.

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