The Use of Simulation for Manufacturing Applications

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***Abstract*— This paper summarizes six presentations in a session of the track "Use of Simulation for Manufacturing Applications". The research work deals with the following key issues of this track:**

- **Modelling of process problems in manufacturing.**
- **Solutions of planning problems in manufacturing.**
- **Simulation of processes in manufacturing.**

This publication shows that the contributions in this track address research questions that are of high importance for industrial practice as well as current research directions such as stochastic optimization or the efficient search of large solution spaces.

Keywords: production planning and control, stochastic processes, scheduling algorithms, benchmark testing, scheduling, real world filter production.

I. INTRODUCTION

For manufacturing companies, the control of manufacturing processes is of essential importance. For many years, almost all companies have been using so-called Enterprise Resource Planning systems (ERP systems) for this purpose. In essence, almost all tasks in production - and beyond - are performed in close coordination with such ERP systems. Among other things, these systems name the next upcoming orders, record the progress of work by means of confirmation messages and determine production plans.

Essentially by parameterizing such an ERP system, it can be used in almost all existing companies. Therefore, it is not surprising that special problems in companies are not solved by such ERP systems. Such ERP systems then serve as a backbone for IT systems used to control companies and special solution tools, which are mainly offered by smaller software companies, are deployed in a company through a connection to such an ERP system.

As a result, more and more researchers are motivated to develop algorithms for industrial problems. Simulation techniques are often directly or indirectly integrated into these processes. To present examples of these aspects is the subject of this special track.

II. SUBMISSIONS

The first paper about "Solving Stochastic Resource-Constrained Multi-Project Scheduling Problems (SRCMPSP)" by Kühn et al. in [1] is an upcoming topic. Numerous variants, smaller batch sizes and shorter product life cycles lead to more uncertainty. In production planning and control (PPC), stochastic scheduling approaches are coming into focus. The schedule thus is determined during production without following a baseline schedule.

The presented research project Hybrid PPC deals with the development of robust heuristics for stochastic project scheduling. The purpose of the approach is a central, simulation-based generation of a decentralized control system.

As part of the research, benchmarking of SRCMPSP, evaluation strategies as well as heuristic and solution robustness are in the focus of investigation.

The second paper, "A New Simulation-Based Approach to Schedule Personnel Deployment Times in Decentrally Controlled Production Systems" by Schwemmer et al. in [2], deals with personnel planning during the fourth industrial revolution. According to the contribution, there will be a dilemma of workforce requirement planning in decentrally controlled production systems. Due to the missing baseline schedule, deducing concrete times of workforce requirement in advance is almost impossible. The paper presents a project, which will develop a simulation-based forecasting method to schedule workforce deployment times in decentrally controlled production systems. This method should ensure an efficient resource planning also in future. Thereby, it strives for company goals, as well as for goals of the individual employees.

The paper by Fabig et al. [3] focuses on the provision of model parameters for capacity planning. While vast amounts of data are gathered within Enterprise Resource Planning (ERP) systems, it still has to be utilized to assist planning processes in an automated manner. The proposed method enables to provide consistent input parameters for a discrete-event simulation on a daily basis. With regard to aircraft Maintenance, Repair and Overhaul (MRO) companies, it comprises the selection of comparable historical projects for analysis, the transformation and mapping of operation data by means of rule-based data wrangling and the characterization of maintenance workloads broken down into network activities and skills. Besides that, Fabig et al. present a quantitative characterization of the capacity planning problem in aircraft MRO based on statistical analyses of project samples conducted at a German third-party MRO provider.

The fourth publication by Herrmann in [4] is entitled by "Scheduling of a Real-World Filter Production with Lot-Size 1". In industrial practise, a travelling crane on the ceiling of a

factory hall transports products in process from one station to the next one in a production line. Due to space restrictions, there is no buffer between the stations. The production line at Fiedler Andritz can be seen as an example of such a problem class. Such restrictions reduce the set of feasible schedules even more than the no-buffer restrictions discussed in the literature in the case of limited storage. Since this scheduling problem is integrated in the usual hierarchical planning, the tardiness is minimised. Due to the high number of jobs as well as the goal of a simple algorithm, scheduling is always done by priority rules at the company site. The investigation is restricted to those priority rules, which are considered in literature as being very effective. The substitution of the net processing time, normally used in priority rules, by a simulated one delivers often significant better results. Further work might be more sophisticated search algorithms as well as further technological restrictions.

The paper of Selmair and Maurer [5] presents their work in progress for the development of an efficient charging & parking strategy. Their research aim is to develop a strategy that not only provides an efficient approach to charging AGV batteries, but also reduces traffic density in a highly utilised large-scale AGV system. Alongside the current state-of-the-art solution, three new allocation methods are introduced: Trivial+, Pearl Chain and a method based on the Generalised Assignment Problem (GAP). These four methods vary in their scope, in terms of number of vehicles considered, when calculating a decision for a specific vehicle. Furthermore, two types of availability rules for vehicles are introduced and evaluated. The combination with the allocation methods lay the foundation for future research. All allocation methods and availability rules are explained in detail and this is followed by a summary of the expected outcomes.

To analyse a system's behaviour and the efficiency of all strategies, a simulation study is proposed to finalise this research. Within a simulated industrial production area, each strategy will be simulated and the resulting decisions scrutinised thoroughly, and finally, the entire performance will be compared to all other strategies.

The last paper in this session, “Clock Pulse Modelling and Simulation of Push and Pull Processes in Logistics” by Simon et al. [6] is about a new technique to find Petri net models for a clock pulse spotted simulation of processes in logistics and production.

These models can be used to observe the raising and discharging of stocks in production in order to identify bottlenecks, to observe differences of push and pull strategies on the valued stocks, and to decide on strategic changes.

For this, however, significant preliminary tasks had to be conducted first which are also objective of the paper: a novel, web-based Petri net modelling and simulation environment called Process-Simulation.Center (P-S.C) has been developed since existing tools are not at the least able to handle such sophisticated models. And at the moment the tool worked properly, different approaches to model the described situation had to be compared.

A teaching laboratory for logistics has been chosen as a sample application. The simulation now helps students to scale up their personal observations in the lab with respect to time, amount and value.

The paper explains the situation in the laboratory, the novel features of the P-S.C that enable the modelling of these processes, and the finding of the model itself. Finally, its development led to another, different approach to describe the teaching processes by a so-called event triggered simulation that is shortly considered in contrast.

III. CONCLUSION

Several research results on the use of simulation in manufacturing, especially for processes and for the analysis of planning algorithms, are presented. Further research of the authors has already been mentioned. For the research community as a whole, the following key questions were identified.

- Finding a compromise between generation time for Composite Dispatching Rules and objective fulfilment.
- The worker will be a key factor of production scheduling in tomorrow's industry.
- Need for scheduling algorithms taken advantage of highly restrictive technological constraints
- More effective use of historical data for decision-making processes and for the automated parameterization of simulation models.
- Visualization of Simulation Results for the Optimization of Business and Production Processes.

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