technische universität dortmund

Fakultät Bio- und Chemieingenieurwesen

LS für Systemdynamik
und Prozessführung

Master Thesis

Simulation Optimization based Production Scheduling of Industrial Make-and-Pack Processes

Introduction and Motivation

Make-and-pack processes are a type of production environment that is frequently encountered in the pharmaceutical and food and beverages industry. Characteristic for make-and-pack processes is that a moderate number of intermediates are packed into a large variety of final products that are produced on several parallel lines. The final products often only differ in the type and size of the packaging, the packaging design and the labeling or in small differences in the product ingredients. This type of processing environment has certain implications: The products undergo the same sequence of production stages, a buffer may or may not decouple the production stages, and the demand profile has to be met with tight due dates. All of the above characteristics require a highly flexible production environment. [1]

The market environment of the consumer goods industry is becoming increasingly competitive and satisfying rapidly growing product demands is key to keep the customer loyalty high and therefore maintain longterm profitability. Coping with the growing product demand is a challenge that the production plant under consideration (see Fig. 1) currently faces. Due to the decoupling of the two production stages by an intermediate buffer, the utilization of the plant capacity can be maximized. However, this is only the case if the routing of products from the formulation stage to packing stage is done with care. This is due to the fact, that the processing rate of the packing lines can be larger or smaller than the processing rate of the formulation lines, depending on the product. Thus the bottleneck of the plant can be the formulation stage or the packing stage depending on which products are currently manufactured.

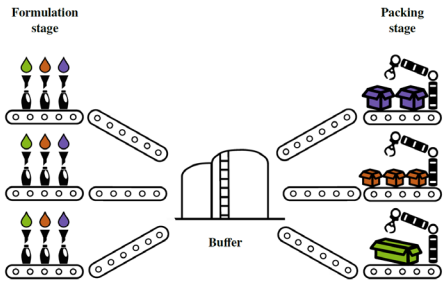

Figure 1: Decoupled layout of the consumer-goods production plant with decoupled production stages and intermediate buffer.

In industrial practice, production scheduling is usually done by experienced employees who create the production schedules for the next few days or weeks, in many cases completely manually. Therefore, a genetic algorithm-based scheduling solution, that was already applied to several other case studies [3] will be extended to be applicable to this case study as well. Genetic algorithms are stochastic optimization algorithms, that simulate natural evolution to improve a set of solutions over time. In this approach handles the available degrees of freedom, such as sequence to generate production schedules from these high-level scheduling decisions. In a previous work a schedule builder, that takes the peculiarities

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of the above make-and-pack process into account, generates a Gantt-chart and returns the performance metrics of the schedule, was already developed. The core task of this work is to couple the schedule builder to the existing evolutionary algorithm framework, to obtain a tailored optimization suite for the make-and-pack process under consideration. Further improvements of the reliability and obtainable solution quality are usually possible by appending a local search procedure to the evolutionary search [5]. In addition, the burden of long-lasting tuning of the numerous parameters of the evolutionary algorithm can be mitigated by transforming the evolutionary algorithm into an evolutionary strategy, which automatically adapts the parameters during the search procedure [4].

Steps

- Familiarization and literature survey: Fundamentals of metaheuristics, modeling and simulation with INOSIM, related existing approaches, case study.
- Connecting and tailoring the existing genetic algorithm (C#) to the schedule builder (Python)
- Development of a local search approach.
- Evaluation and extension of the evolutionary strategy.
- Comparison of the genetic algorithm-based optimization approach with the literature results based on MILP approaches [2].
- Systematic investigation of solution quality, reliability, and sensitivity of the developed approaches.
- Documentation of the approach and results in a master thesis document.

Requirements

- Motivation to perform theoretical work in a math-related field
- Programming skills, preferably in C# or any other object-oriented language and/or python

Literature:

[1] I. Harjunkoski et al. Scope for industrial applications of production scheduling models and solution methods. In Computers and Chemical Engineering 62, 2014, pp. 161 – 193.
[2] C. Klanke, V. Yfantis, F. Corominas, S. Engell, Short-term scheduling of make-and-pack processes in the consumer goods
industry using discrete-time and precedence-based MILP models, Computers and chemical engineering (in press), 2021
[3] C. Klanke, D. Bleidorn, C. Koslowski, C. Sonntag, S. Engell, Simulation-based Scheduling of a Large-scale Industrial Formulation Plant Using a Heuristics-assisted Genetic Algorithm, GECCO '20: Proceedings of the 2020 Genetic and Evolutionary Computation Conference Companion (in press), 2021
[4] H.-G. Beyer, H.-P. Schwefel, Evolution Strategies, Natural Computing, 1, 3-52, 2002
[5] H. Ishibuchi, T. Yoshida, T. Murata, Balance Between Genetic Search and Local Search in Memetic Algorithms for Multiobjective Permutation Flowshop Scheduling, IEEE Transactions On Evolutionary Computation, 7, 2, 204-223, 2003

Start and duration: ASAP, 6 months full time

Contact

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