Online Scheduling via Simulation-Optimization for Multiproduct Batch Plants

Scheduling in the process industry determines the sequence and timing of operations to optimize objectives such as minimizing order tardiness and improving plant utilization. In research, scheduling problems are traditionally solved "batch-wise", i.e. for an idle plant and a given set of orders, production recipes and due dates, optimal schedules are computed. However, this does not reflect reality of production planning and scheduling which is a continuous process, where new orders arrive periodically or at unknown instances, the real operations take longer or shorter periods of time than specified in the recipes, pieces or equipment break down, or operations cannot be executed as planned because resources are not available. All these aspects could be covered by infinitely fast re-computation of optimal schedules whenever an event happens or new information becomes available, but this is practically impossible for realistic problems due to the required computation time.

In online or real-time scheduling, a continuous exchange of information between the scheduling system and the control system of the production plant is necessary. The scheduling model must be updated frequently to reflect the current state of the production system and of the orders. The scheduling algorithm must react to events and disturbances fast, but also utilize the available computing power such that the schedule is near optimal.

We present an online iterative simulation-optimization approach which is tailored to handle these challenges. It builds on our previous work on simulation-optimization using evolutionary algorithms, as described in [1]. The evolutionary algorithm continuously searches for better schedules while the simulation model is updated with the latest information so that the evaluation of each generation of solutions reflects the current situation. After a pre-specified reaction time, a new solution is available after major disturbances. While the first operations of this solution are started, the schedule is further improved continuously and each assignment and timing of an operation that has not been started is based on the currently best solution.

We validate our approach using a multiproduct, multistage batch plant from the pharmaceutical industry, as in the work of Kopanos et al. [2], and demonstrate that it can generate high-quality solutions in the presence of new order arrivals and disturbances. The results are compared with those provided by an idealized clairvoyant scheduler which has access to the full information before the schedule is computed. The influence of the choice of the reaction time after a disturbance which involves a compromise between a fast reaction and better decisions in the immediate future is studied in detail.

Keywords: Modelling and Simulation, Large Scale Design and Planning/Scheduling

References

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