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Optimal Scheduling and Operation of a Food Industrial Plant

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Highlights

- Optimal short-term scheduling of a real-life food industrial facility

1. Introduction

Current market trends and business globalization have steered industries towards large production volumes, complex alternative recipes and a larger product portfolio, thus leading to processes of increased complexity. Optimal production scheduling has a direct impact on the overall efficiency of processing facilities and can lead to increased productivity and minimal costs. Although a plethora of works study the optimal production scheduling problem [1], academic developments have been mostly tested on generic but small problem instances. This is mainly due to the computational complexity of real industrial problems, which easily become intractable. This gap between theory and industrial practice has been identified by the scientific community [2] and some recent works have successfully investigated medium to large problem instances [3]. In this work different solution strategies are proposed for a large real-life food industry.

2. Methods

The case of a canned fish production facility for a large-scale Spanish industry (Frinsa del Noroeste, S.A.) is considered. The first main goal is to develop an optimized weekly schedule, in order to minimize an objective metric (makespan, total production costs). Since no clear production bottlenecks exist, all three processing stages (filling and sealing, sterilization, packaging) of the facility need to be considered. The proposed methodology consists of three main pillars: a) a batching algorithm which translates the incoming product-orders to batches and lot-sizes; b) an MILP-model based on the general precedence framework; and c) a two-step (temporal and order-based) decomposition strategy. In order to extract a valid schedule, the MILP-model, which constitutes the core of the suggested solution strategy, consists of all the necessary timing, sequencing and allocation constraints. Additionally, plant-specific operational constraints are imposed by adding tight integer cuts in the model.

Furthermore, mathematical models are derived in order to describe the specific features of the sterilization process including product quality and safety, energy consumption and processing times. Quality is related to the surface colour of the canned tuna after the sterilization whereas safety refers to thermal destruction of harmful microorganisms. Such models are used in an optimal schedule of the sterilization processes based on the feasible scheduling solution obtained on the first step. Consumption of shared resources is also considered in order to prevent an overlapping in the demands that, for example, could make the previous solution unfeasible in the real implementations. This new optimization problem can focus on the features previously calculated with the realistic models, such as minimizing colour lost if the plant requires a special production, or increasing production by minimizing the sterilization process duration keeping the microorganism lethality over the security limit. The optimization focus on providing a real-time tool that helps the operator, which makes the horizon required to solve short, but increase the resolution speed requirements.

3. Results and discussion

The MILP model was implemented in GAMS 25.1 and solved using CPLEX 12.0. Optimality is reached for all iterations of the suggested solution strategy. Moreover, the problem is solved in a time acceptable by the company (1 hour). Compared to the real weekly schedule proposed by Frinsa, no overtime production during weekends was required.

Mathematical models for the sterilization process were developed. Order reduction techniques were implemented to increase simulation efficiency.

The sterilization optimal schedule is solved in a few minutes, which makes the solution suitable for launching the resolution each half an hour and obtaining a two hours prediction.

4. Conclusions

This work presents the optimization-based production scheduling and operation of a real-life food industry of high complexity. It was shown that the proposed strategy can schedule the plant under study and eliminate unnecessary overtime production.

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