

CoPro: Large-scale production scheduling in the food industry

Project:

Improved energy and resource efficiency by better coordination of production in the process industries



COORDINATED PRODUCTION FOR BETTER RESOURCE

The goal of the CoPro project was to develop and to demonstrate methods and tools for process monitoring and optimal dynamic planning, scheduling and control of plants, industrial sites and clusters under dynamic market conditions, to provide decision support to operators and managers and to progress to automated closed-loop solutions to achieve an optimally energy and resource efficient production.

CoPro brought together 17 partners from 8 EU countries, including 5 industrial end users and 6 technology providing SMEs. The project developed solutions for the **plant-wide optimisation of large plants, for balancing production and consumption in industrial parks for industrial symbiosis**, and addressed **power plant scheduling** and **demand-side response**. It further developed online data analytics for **anomaly detection**, and **decision support** for plant operators and managers. The solutions can be integrated into the IT infrastructure of the plants via an **integration platform** that supports the connection to different IT systems. CoPro developed **model libraries**

for the efficient development of advanced optimisation-based solutions and techniques and software for **hybrid modelling** and **model management**.

The developments of CoPro were motivated by and applied to challenging use cases from different sectors of the process industries:

- (Petro-)chemical production;
- Cellulose fiber production;
- Production, formulation and packaging of consumer goods;
- Sterilisation and packaging of food.

CoPro demonstrated that significant savings of energy and resources are possible by using advanced technologies for monitoring, decision support, optimisation, and planning and scheduling.

The CoPro partners

Industrial end users and use case providers



Universities



Universidad de Valladolid



CERTH
CENTRE FOR
RESEARCH & TECHNOLOGY
HELAS



Sector:

Chemicals

Summary:

The Problem

- Food process industries are typically characterised by the production of multiple products using flexible multi-stage facilities under tight operating and design constraints.
- The optimal production scheduling of such a complex facility is a very challenging and demanding task, and existing solutions cannot generate schedules in computational times that are acceptable in industrial practice.
- This complexity forces production engineers to derive production schedules that underutilise the true potential of the facility.

- Frinsa in Ribeira, Spain, is one of the largest producers of canned fish in the European Union. On a weekly basis, more than 150 products need to be processed, following complex production recipes in a multi-stage and flexible plant.

The Solution

- An optimisation framework for the efficient plant-wide production scheduling of a full-size fish canning plant was developed in a collaboration between CERTH, Frinsa and ORSOFT.
- Near-optimal production schedules are generated automatically with very short computational times.
- Significant improvements in the coordination of production have been achieved.

Theme:

Plant-wide monitoring - SPIRE02-2016

Keywords:

Scheduling, Optimization, Food Industry, Decision support, Reduction of changeover and idle times

Type:

Case study

Other

Software

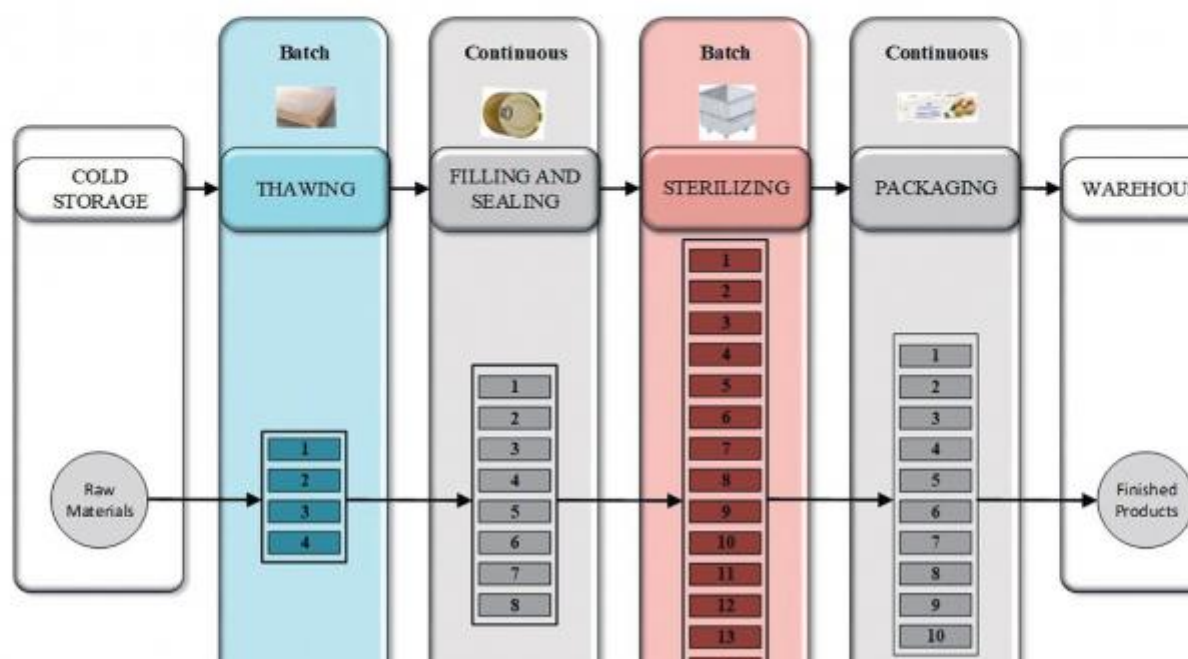
Poster

Resources

Link:

Technology Short Description: Large-scale production scheduling in the food industry

Large-scale production scheduling in the food industry



Large-scale production scheduling in the food industry

The problem

Exploiting unused potential

The facility of Frinsa del Noroeste S.A. under study produces up to 150 orders on a weekly basis, while the production process is very complex, comprising batch and continuous processes, and numerous shared resources. Furthermore, the plant illustrates tight design and operating constraints under significant demand variations. As a result, the generation of efficient schedules is an extremely demanding and complex task. Currently, production engineers generate weekly schedules using heuristic rules in order to reduce changeovers in each processing stage. This approach, however, leads to solutions which are too far from the optimum, since the synchronisation of the various production stages is not considered. Consequently, the full potential of the plant is not exploited.

Within CoPro, a solution has been developed that automates this process and assists production engineers in finding feasible and near-optimal schedules. The developed optimisation-based scheduling framework considers all production stages simultaneously, thus realising potential synergistic benefits through a fully coordinated approach.

The solution

Bringing scheduling theory to industrial reality

An efficient optimisation-based framework has been developed to derive optimal weekly schedules for complex multi-stage and multi-product food industrial facilities under generic recipe representations, such as the plant of Frinsa del Noroeste. The proposed framework consists of three main pillars: a) a batching algorithm to translate orders into batches to be processed, b) a mixed-integer linear programming model for the generation of optimal solutions and c) a decomposition algorithm to decrease the required computational time. In order to reduce the underlying computational complexity of the optimisation problem, an aggregated approach is proposed, in which the continuous processes are explicitly modelled, while feasibility constraints are imposed for the batch stage. Two mathematical models have been developed that can minimise

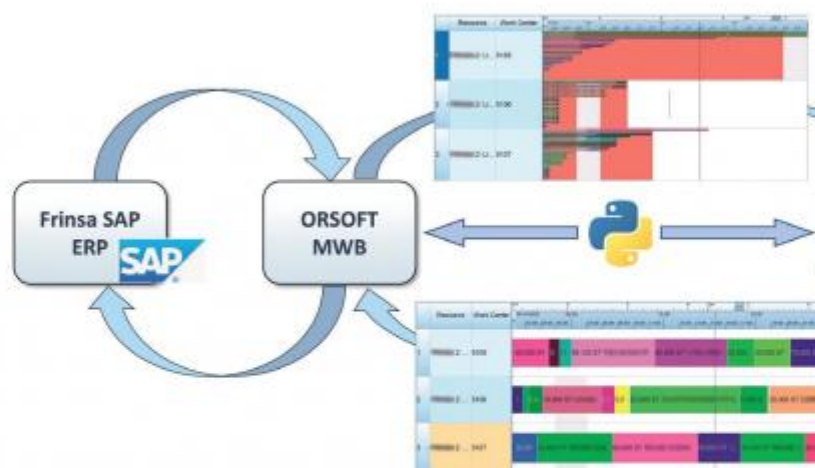


Fig. 1: The architecture of plant-wide production scheduling tool.

either the makespan or the changeovers, depending on the priorities of the decision-makers. All technical, operating and design constraints of the facility are considered, including the salient characteristics of the canned-food industry, such as assurance of the end products' microbiological integrity.

A challenging prerequisite set by the production engineers is that the total solution time should not exceed 30 minutes. This may be considered a relatively small period of time for weekly scheduling. However, such a low solution generation time will allow production engineers to run multiple what-if analyses and re-run the model whenever new information arrives in the plant, for example if the product demand changes. With short response times, the developed computer-aided tool will be more appealing to the production engineers and plant managers. In order to meet the computational limits, a custom order-based decomposition algorithm is employed. One of the advantages of the algorithm is that the decision-makers can easily change the level of decomposition based on the available time.

To evaluate the generated schedules, a computer-aided tool has been developed by CETH, Frinsa and ORSOFT. The Manufacturing Workbench (MWB) of ORSOFT is used as an intermediate between Frinsa's SAP ERP system and CETH's optimiser developed in the GAMS modelling platform. MWB receives in real-time production data from SAP ERP and sends them to the optimiser. The communication between MWB and GAMS is done through

PYTHON. In less than 30 min the optimisation process is completed and results are returned to MWB. MWB provides a visualisation of the results and sends the optimised plan back to SAP ERP.

Numerous results for real-life scheduling problems were validated and compared with the production engineers of Frinsa del Noroeste that were generated by the current heuristic optimisation tool compared to the schedules proposed by the production engineers. In particular, significant reductions in changeover times and production costs were achieved in all case studies.

The summary

Improving production scheduling

Smart engineering combined with the computational power of current optimisation makes the realisation of optimal solutions for real-life scheduling problems in the food process industries. This study demonstrated that automated scheduling solutions could exploit the full potential of the production facilities. The developed scheduling solution assists the decision-makers in realising schedules that reduce changeover and idle times.

The technology brings both technical and environmental benefits, since the generated schedules lead to better utilization of resources and consequently to a reduction in the energy consumption of the

The developers



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