CoPro: Optimal operation of sterilisation processes in food production

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

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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.

Sector:

Engineering

Summary:

The Problem

- Sterilisation is a crucial process in order to fulfill sanitary constraints in the food industries.
- At Frinsa, the sterilisation process is performed in a set of parallel batch sterilisation units that are placed between continuous processing lines.
- Being an energy-intense process, steam is a limited common resource for the sterilisers, and its availability influences their processing times.
- Due to food safety constraints, there is a maxi mum waiting time for every sterilisation process starting-time. Failure in proper coordination results in bottlenecks or impaired food

safety.

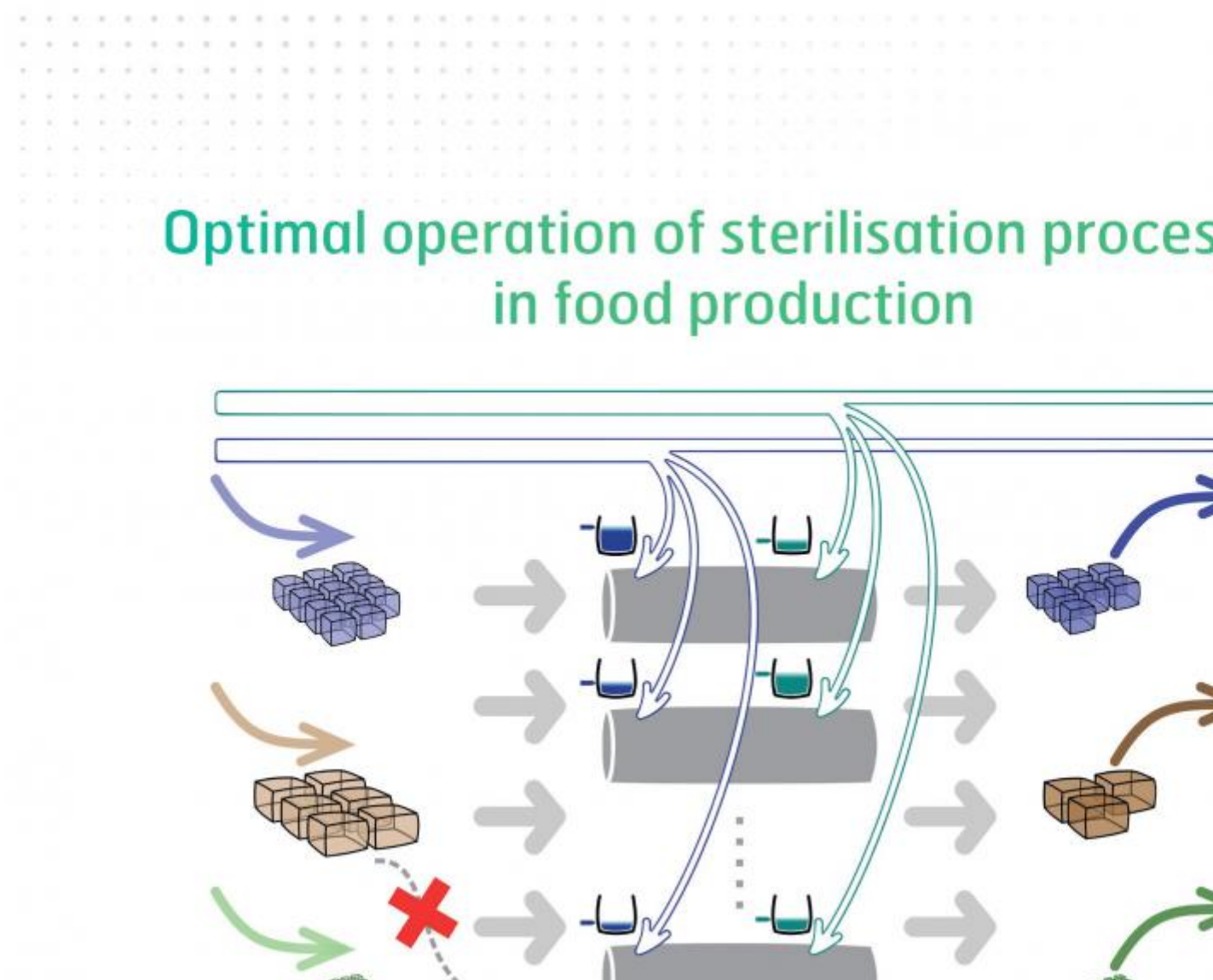
The Solution

- An on-line closed-loop scheduling tool was developed that gathers and distributes the carts with cans among the sterilisers, and schedules the sterilisation processes in real time.
- The solution was integrated within ASM MES system, adapting in real-time to the real state of the sterilisation section.
- An HMI was developed to communicate to the operators which actions to take.

Theme:
Plant-wide monitoring - SPIRE02-2016
Keywords:
Closed-loop scheduling; Real-time scheduling; Mixed continuous-batch process; Shared resources; Redundant equipment; Load allocation; Food safety constraints; MES system integration; Decision support system
Type:
Case study
Software
Poster

Resources

Link:
Technology Short Description: Optimal operation of sterilisation processes in food production



Optimal operation of sterilisation processes in food production

The problem

Steriliser scheduling: sharing steam and reacting to changes

At Frinsa, different can formats are produced concurrently every day. They must undergo a batch thermal treatment to achieve a specified micro-organism lethality threshold. The time-temperature profiles of sterilisation differ for the different types of cans, so the different sterilisation units work with different settings with steam as the common heat source. If several sterilisers consume steam at the same time, it may not be possible to follow the planned profile, due to the drop of pressure in the supply line, which results in changes of the batch cycle time.

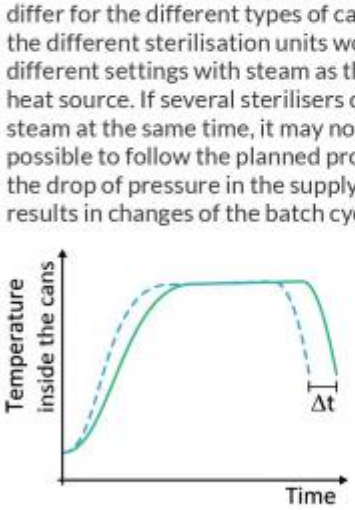


Fig. 1: Optimal time-temperature profile compared to the one that results if there is lack of steam.

While there is a weekly production plan that is generated by the ERP system, **in practice there are always changes and uncertainties in the arrival of the canned products.** Usually, the operators have to cope with these changes. The cans are introduced in carts, which are sorted, gathered and loaded in the sterilisers up to their maximum capacity. To prevent a decrease in the quality of the final product, there is a maximum waiting period before which the cans must be sterilised. The sterilisation processes have to be synchronised properly, avoiding surpassing the waiting periods for each set of cans and avoiding bottlenecks. The system has to cope with changes in: the arrival of carts, and the processing times in the sterilisers.

The solution

A real-time scheduling software for the sterilisation section

A closed-loop scheduling tool was developed that operates in real-time using a moving horizon approach. The prediction horizon covers a certain future time-interval, but only the actions that are computed by the optimiser for the next few minutes are implemented whereas the rest of the time horizon is included to prevent unfeasible situations. The forecast of the arrival of carts is included in the formulation, as well as the current state of the section, including the carts that are waiting to be sterilised and the state of the producing lines. To access the actual state of the plant, the solution connects to the database of the MES system, thus it is able to update the plant status information in real-time at every iteration.

The optimisation problem addresses two main challenges: the gathering of the carts and their assignment to the sterilisers, while considering quality and sanitary constraints; and the constraints on the shared resources. The carts are gathered in groups up to the maximum capacity of the sterilisers. Different formats can be mixed as long as their sterilisation profiles are similar.

The problem arose by the shared-steam concurrent consumption has been tackled following two different approaches: the first one constraints the maximum amount of resource available every time and supposes that the sterilisers perform properly; another one considers the alterations over the sterilisation profiles when some process coincide in time, but does not constraint the concurrent consumption. In both cases, models are used to predict the steam demand of the sterilisers for given profiles and the availability of steam. In addition, some models, developed by CSIC, are used to ensure that sufficient sterilisation has been obtained. The problem is formulated as a mixed-integer linear programming optimisation problem.

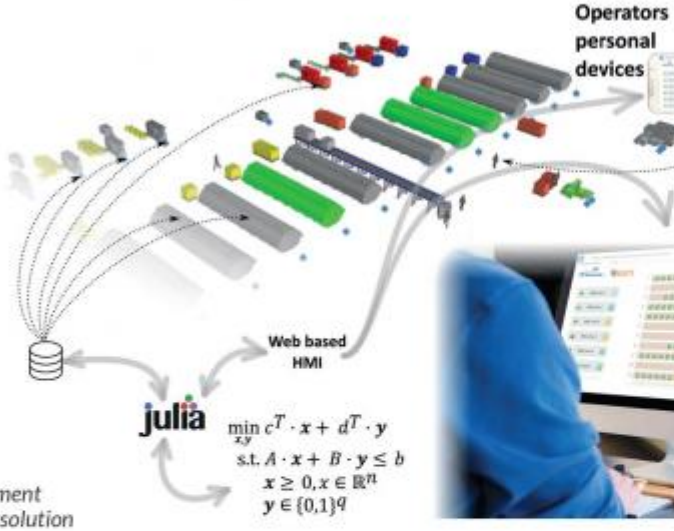


Fig. 2: Deployment scheme of the solution proposed.

It is coded using a high-level language.
The optimisation system is c ASM MES system. It collects about the progress of the pr including the sterilisation tra optical readers were installe to detect when which cart ha of the units in the producing sterilisers. In addition, the M collects information about th itself to forecast the arrival o

This data from the MES datab through a web service. The so gives the optimal schedule fo hours. This process is repeate minutes to adapt to unexpect and uncertainties. A crucial e visualisation to the operators an intuitive HMI has been de indicates the next actions to t

The summary

On-line scheduling

The sterilisation section in th plant creates a bottleneck fo of the plant. With the develo support system, the recomm offered to the operators imp productivity of the section b gathering and assignment of problem of sharing the steam addressed which would othe infeasible solutions. Due to t moving horizon solution and connection to the MES, the s online to all unpredicted situ

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