CoPro: Thermal models for process optimisation in the canning industry

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:

Chemicals

Engineering

Summary:

Thermal processing often constitutes the main bottleneck of the plant, consuming 70% of the total production time and 60% of the energy of a standard canning factory. Innovative solutions are needed to:

- Minimise health risks derived from potential contamination by microorganisms.
- Reduce product quality losses.

- Increase efficiency by minimising production times and energy consumption.
- Comply with environmental constraints

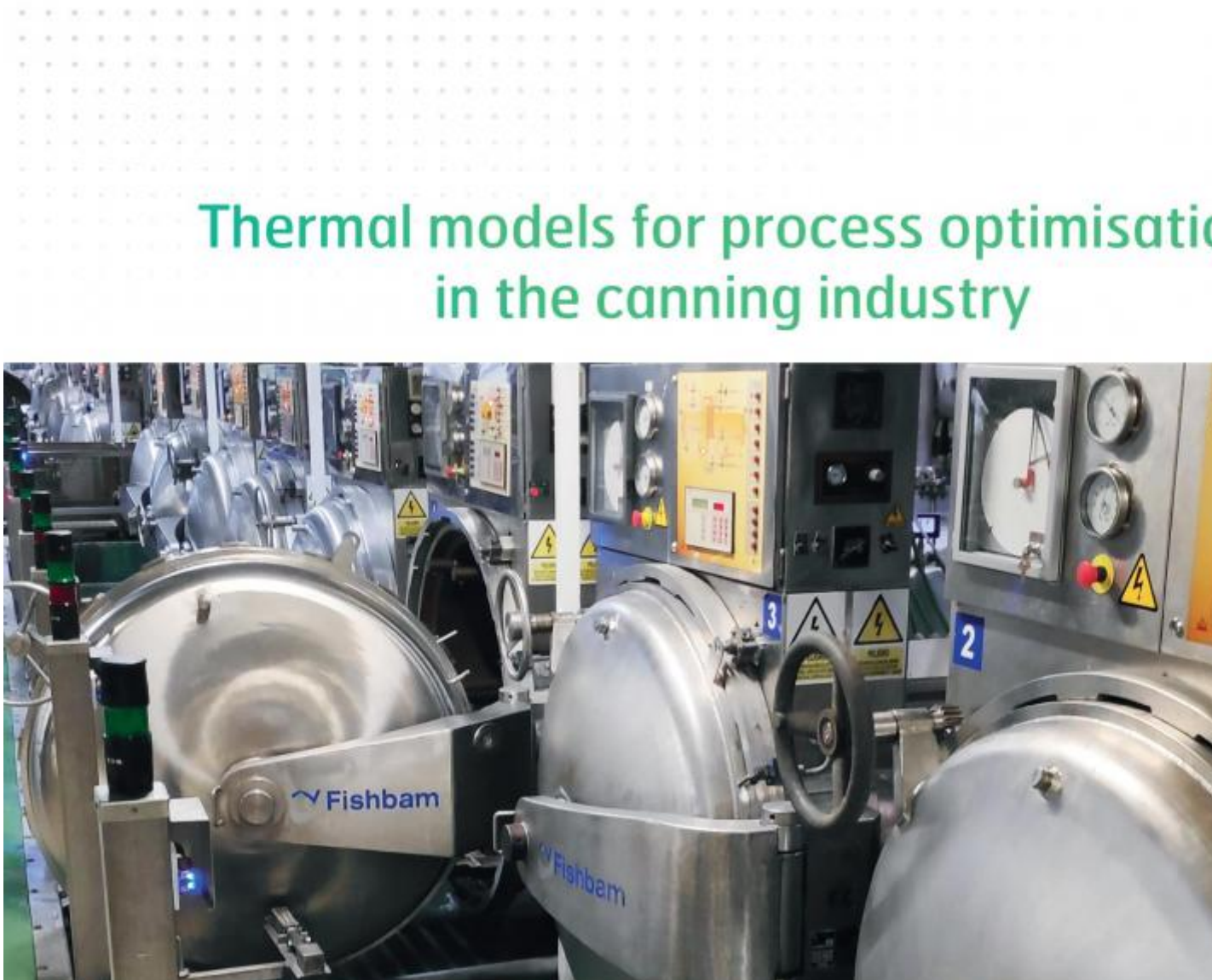
In attaining these objectives, thermal models are the essential elements upon which one can build software sensors and model predictive controllers to guarantee product safety and quality, or plant-wide scheduling solutions. Presently, we have at hand a library of thermal models to predict/infer:

- Temperature and pressure evolution in the retort.
- Temperature distribution within the product.
- Lethality, nutrient or colour degradation in the product.

Theme:
Plant-wide monitoring - SPIRE02-2016
Keywords:
Canning industry, thermal models, food safety, quality optimization, minimum sterilization time, model predictive control
Type:
Software
Document
Poster

Resources

Link:
Technology Short Description: Thermal models for process optimisation in the canning industry



Thermal models for process optimisation in the canning industry

The problem

Improving plant operation policies

Currently, the food industry is undergoing a radical transformation programme (Industry 4.0) that aims at smart systems for decision making. Thermal treatment, in its various forms (sterilisation, pasteurisation or cooking) still remains one of the widest employed processing steps in the food industry, with a direct impact on the final product quality.

The primary aim of thermal processing is that of destroying or inactivating potentially harmful spores or microorganisms, possibly at the expense of inducing quality losses due to degradation of nutrients or sensory parameters (e.g. colour or texture). For each product format, regulations require a certain commercial lethality to be above the reference by heating the product under a pre-defined constant (CRT) or variable (VRT) retort time-temperature profile.

Lack of precise information on temperature distribution into the product, kinetics of colour change or nutrient degradation prevents any fair compromise between product safety, quality and productivity. In fact, the latter performance indicators are often sacrificed for the sake of safety via severe thermal treatments or product re-processing. Consequences include additional energy expenditures, production delays and a detrimental effect on product quality, with a negative impact on sales prices.

The solution

A multipurpose library of thermal processes

Mathematical models are key to process understanding and design, data reconciliation or inference of process variables not directly available to measurements. In addition, they are essential elements of process optimisation, control and scheduling.

The library of dynamic models we have just developed is capable of capturing the relevant process features of a canning thermal plant. The library includes the following components:

- Efficient modules to describe the evolution of temperature and pressure in steam and superheated water sterilisation retorts.
- Modules of PDEs (Partial Differential Equations) to compute the temperature evolution within different foodstuffs and product formats
- A set of thermal kinetic modules to predict lethality and typical quality parameters such as texture or vitamin content can be incorporated, as well. In overcoming the computational burden associated with the solution of partial differential equations in complex domains, data-driven reduced order models are employed to describe the temperature and quality/safety parameters inside the product. Models are implemented in standalone simulation software packages that are suitable for integration within model calibration environments or real time decision support systems.

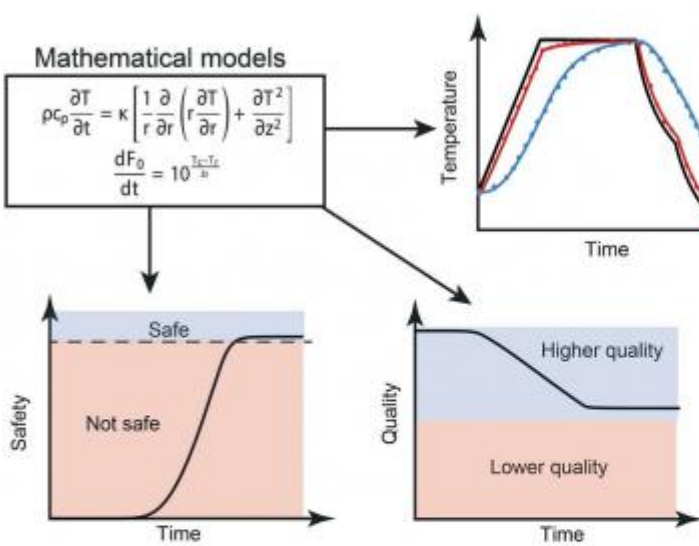


Fig. 1: Mathematical models as a tool for the prediction of safety and quality indicators

Fig. 2: Classical spatial domain for a RO-200 can

The modularity of the newly developed components offer to the plant manager or process engineer the opportunity to build up a virtual representation of the critical processes of the factory (the so-called digital twin) that is capable of recreating its operation. Although not limited to, typical applications entail:

- On-line estimation of commercial lethality at the coldest point of the product during each sterilisation cycle, from measurements of the retort temperature. The estimation algorithm can be extended to quality parameters as well, thus ensuring safety and quality standards while minimising over-processing.
- Computation of optimal CR time-temperature profiles quality retention, minimise temperature while satisfyi required commercial letha new product or format, opt can be computed off-line ir considered an operation de Alternatively, profiles can b on-line on a real-time imple modified in response to pla such as steam supply or su drops.
- Computation of optimal sc to assign different product batch units and to determi of processing. Efficient mo possible to adapt the opera to unexpected changes tha in different units of the fac

The summary

Smart systems for f safety and quality

The optimisation of thermal on the availability of a digital capable of representing plan quantifying safety, quality ar Our modelling technology pr efficient dynamic models tha of capturing the relevant fea processes. The models are us and can be combined and int simulation and optimisation build software sensors, mode controllers or plant schedulin

The developers

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