CoPro: Modelling concept and model library for large-scale optimisation in chemical plants

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

Non-ferrous metails

Steel

Water

Summary:

The Problem

- Modelling is a major step in constructing optimisation-based solutions.
- In large-scale optimisation of coupled chemical production sites, many models for plants and pieces of equipment have to be generated, implemented and maintained.
- Many possible choices for the level of detail and the objective increase the necessary effort to implement optimisation-based solutions.

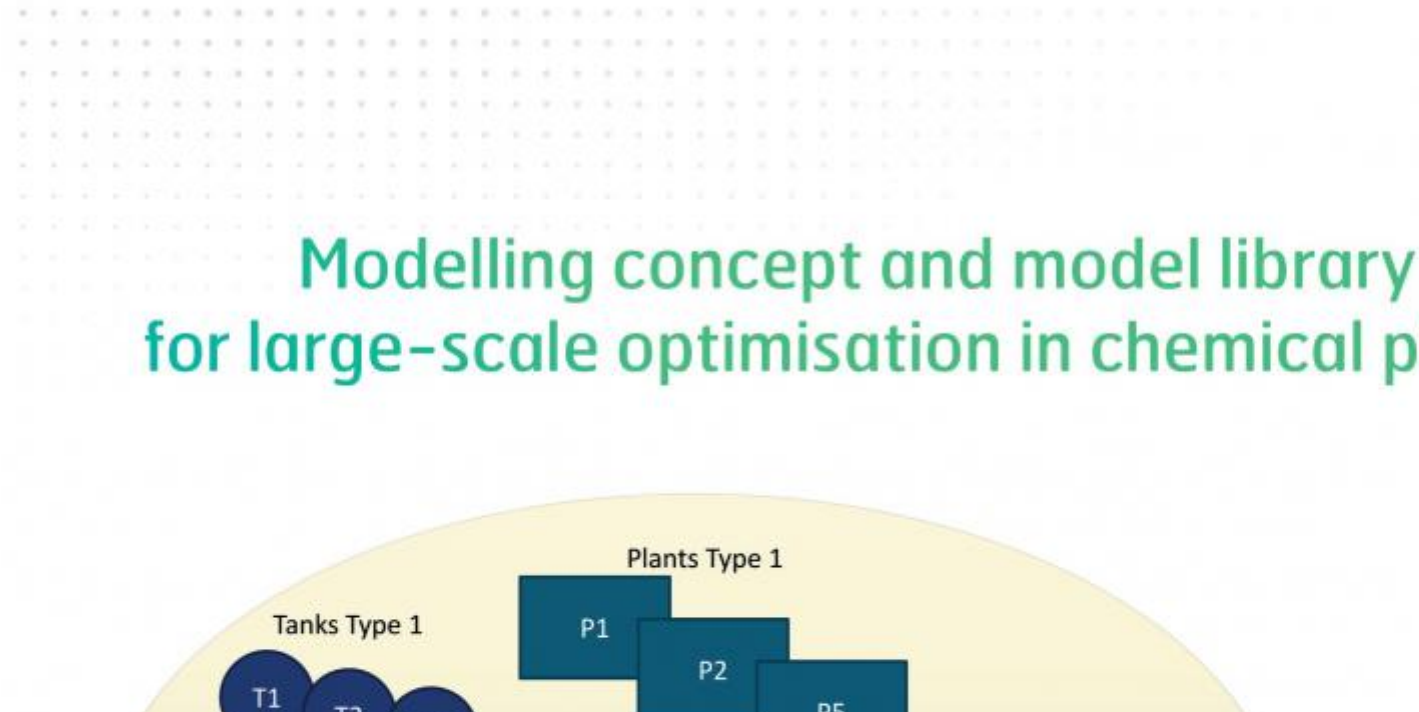
The Solution

- Development of generic plant and equipment models of different modelling depth that can be parameterised for the application at hand.
- A central database for model parameters as user front end.
- Automatic generation and solution of the optimisation problem from the stored model information and user generated input describing the optimisation scenario.

Theme:
Plant-wide monitoring - SPIRE02-2016
Keywords:
Site-wide optimization, production planning, demand side management, logistics planning, inventory management, petrochemical industry, model library
Type:
Other
Software
Poster

Resources

Link:
Technology Short Description: Modelling concept_model library_large-scale optim_chemical plants



Modelling concept and model library for large-scale optimisation in chemical plants

The problem

High effort for the development and maintenance of optimisation-based solutions

Projects for optimisation-based decision support systems in the process industry usually require a significant amount of time and effort to incorporate all relevant dependencies and constraints into a system-wide model. In case of the overall performance of coupled plants, where the data sources are spread over multiple organisational entities, this effort is even higher. However, many plants and pieces of equipment can be described by similar models, thus a reuse of input-output behaviour models is possible.

The required level of detail governs the amount of data that is needed for building the model and influences the resulting optimisation problem. If a large set of parameters is needed to describe the behaviour of the plant and the constraints, the modelling and maintenance effort increases, but detailed modelling may be a key requirement for the usability of the solution. Additionally, choosing a proper objective function is essential for the usefulness of the result of the optimisation. The objective function must represent the various user targets, such as reducing the raw material consumption, increasing production yield, and avoiding unwanted situations.

The solution

A modular approach for auto-generated, customised optimisation models

To decrease the time that is needed to develop large-scale optimisation solutions in chemical plants, TU Dortmund developed a database of predefined equipment and plant models together with a tailored software routine for the automatic generation of large-scale optimisation problems from the individual models, the network topology, and the description of the optimisation scenario.

The model database offers a set of model archetypes that describe plants, tanks, and logistic connectors. The level of detail varies between different archetypes within each category and due to the availability of parameters for each archetype. To incorporate multiple optimisation targets, an economic objective functions is used, which includes the cost of raw materials, energy and the revenue from product streams as well as penalties, e.g., for start-up and shut-down. The possibility to assign a cost term to all model components keeps the approach flexible and adaptable to a large number of applications.

Currently, the database contains plant models with linear relations between the main product stream and all dependent streams. The models incorporate restrictions of switching the plant mode from on to off via the transient states start-up and shutdown, each with individual cost terms, and timing constraints to prevent frequent switching (see Fig. 1). A more complex plant can be split into parallel structures that can change their load and be switched on and off individually while the overall plant is running. For tanks, the basic model describes the mass balance together with upper and lower limits as constraints. Tank types with different constraints on the filling and discharging behaviour were identified and modelled. Together with models for external logistics, it was possible to model the ammonia network in the INEOS in Köln use case, resulting in a mixed-integer linear program which can be solved in reasonable computation times depending on the choice of the temporal resolution and of the planning horizon. Where necessary, quadratic or general nonlinear terms can be added to generate novel model archetypes.

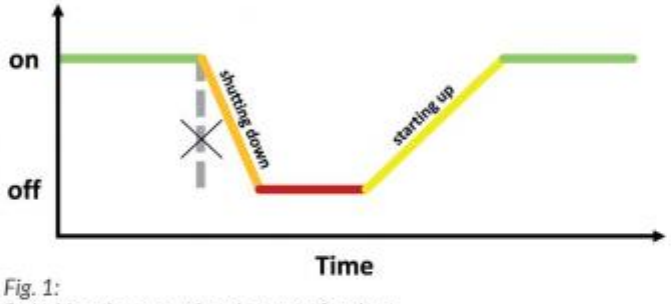


Fig. 1:
Switching the operational status of a plant

To find the optimal operation the user needs to supply the information on the optimisat together with the model info scenario information consist initial tank levels, plant state schedules. The tool offers th communicate with other soft repositories via Leikon's Inte the planner can specify the s familiar interfaces with auto real-time production data su for initial values.

With the application of the m concept and of the model libr number of production sites, plant and equipment types w adding novel model archetyp parameters when new equip has to be included. This expa model library will further dec deployment time for future a of large-scale optimisation in industry.

The summary

Overcoming the mo bottleneck

The novel modelling concept model library for large-scale of processing plants accelera development of optimisation production planning solution the knowledge from previou of the modelling concept by model library to cover an inc equipment and operational c This contributes to the distri optimisation-based producti systems across the process i sustainable and cost-efficien

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