CoPro: Large-scale optimisation of production and logistics 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

- INEOS in Köln operates a large number of production plants that are linked by streams of intermediates and carriers of energy.
- The overall performance and efficiency of the site depends on the coordination of the individual plants and the coordination of external logistics via barges, trains and pipelines.
- An example of such site-wide integrated optimisation is the ammonia network of INEOS in Köln.

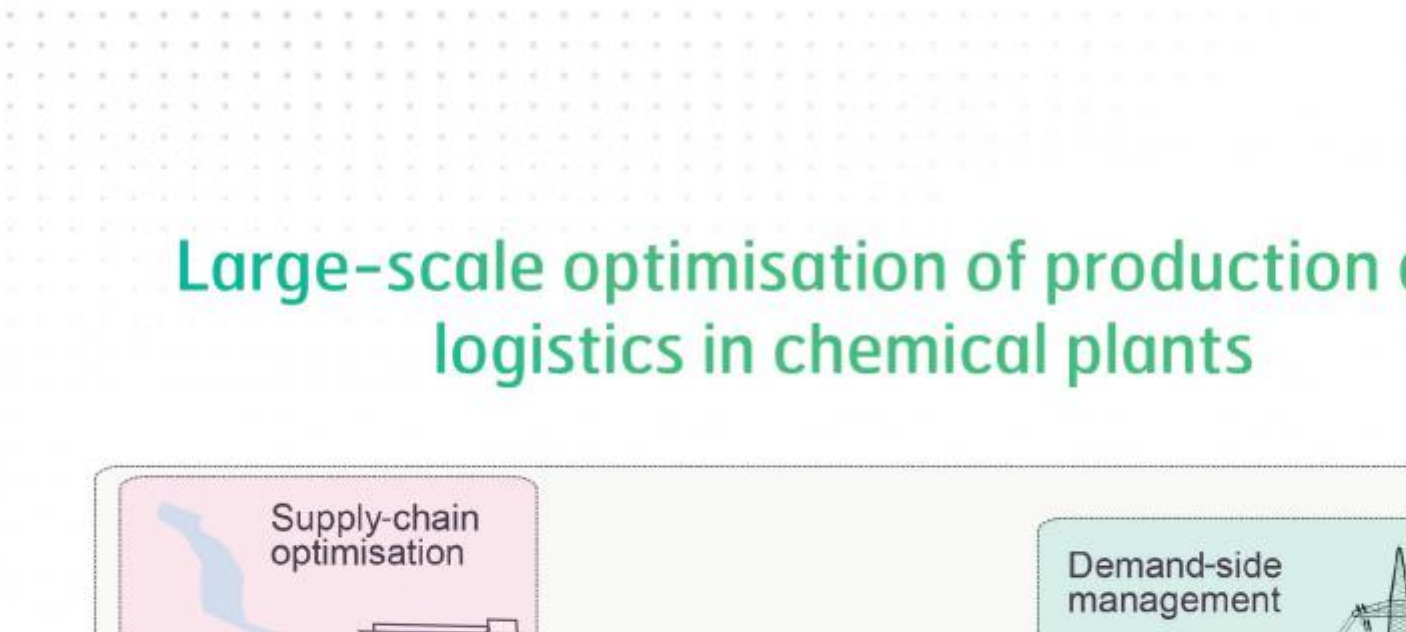
The Solution

- A site-wide optimisation model composed of modules for plants and equipment as e.g. tanks and compressors was developed.
- An economic objective is optimised which incorporates the cost of raw materials, prices of power and gas, and operating costs.
- Logistic constraints such as the arrival of ships with raw materials and the delivery of products are considered.

Theme:
Plant-wide monitoring - SPIRE02-2016
Keywords:
Site-wide optimisation, production planning, demand side management, logistics planning, inventory management, petrochemical industry
Type:
Case study
Software
Poster

Resources

Link:
Technology Short Description: Large-scale optimisation of production and logistics in chemical plant



Large-scale optimisation of production and logistics in chemical

The problem

Coupled production systems and logistics

INEOS in Köln operates a large number of production plants that are coupled by networks of shared resources. The ammonia network consists of an ammonia plant (P1), a nitric acid plant (P3) and two acrylonitrile plants (P4a, P4b). The ammonia produced in P1 can be compressed (C1, C2) and stored (Tc1, Tc2) or sent to buffer tanks (Tb1a, Tb1b, Tb3). The stored ammonia is heated before it enters the buffer tanks from which the ammonia consuming plants are fed. Additionally, ammonia can be imported from and exported to the buffer tanks via barges or train vessels.

Discrete events such as the arrival of empty or loaded barges need to be taken into account by driving the network to a state in which filling or unloading of ammonia via the available connections is possible. The need for energy-intensive compressing for long-term ammonia storage encourages scheduling the compressor operation such that low prices of electricity are exploited while satisfying the future demands. (Fig.1)

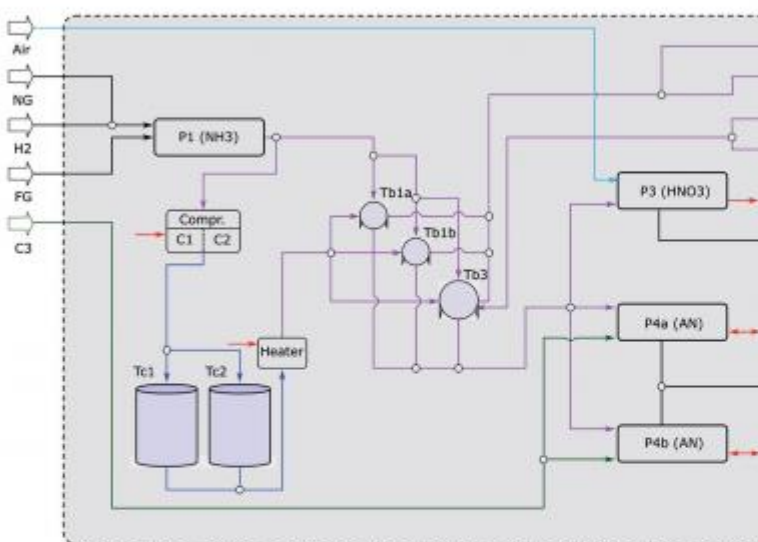


Fig. 1: The ammonia network of INEOS in Köln

The solution

A flexible planning tool for the ammonia network

The work in CoPro between TU Dortmund and INEOS in Köln resulted in a production planning tool for the ammonia network which provides optimal production plans for different possible scenarios and optimisation targets. The tool can be used for short and medium-term planning. The temporal resolution can be adjusted between hours and days. It has an intuitive user interface and data on the current and the expected situation can be retrieved from multiple sources.

The optimisation uses mixed-integer linear programming. The component models are available in a model library and can be parameterised easily. The goal of the optimisation is the economically best possible operation while meeting the logistic constraints. Constraints on the ramping up and down of plants are also included.

An optimisation of a monthly production plan based on historical reference data for the production targets and the external conditions of a full month was performed to test the power of the tool. All logistic events and the monthly production targets for the plants were fixed and the degrees of freedom were the production rates of the plants and compressors. The result showed potential savings of about 25 % of the cost for the liquefaction of ammonia. (Fig. 2)

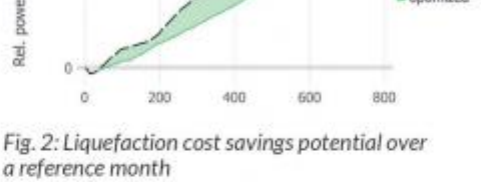


Fig. 2: Liquefaction cost savings potential over a reference month

Another use case was to predict the scheduling of train vessels for a variety of customers with individual preferences depending on the arrival dates of barges with raw materials and the constraints caused by the operation. This scenario was motivated by the low level of river Rhine in 2018. It illustrates the benefit of the tool as an aid for the planners to react quic situations.

The solution can be transfer applications with connected shared resources and logisti using the developed model li general solution strategy. Th with other software systems the use of LeiKon Intexc Suit

The summary

Optimal production for coupled plants

The new tool for the product integrated chemical product allows planners to find optim various production and logis quickly, taking into account p and constraints, storage man import and export logistics. T their visualisation support th creating feasible, cost and en production plans and in maki promises of deliveries. If the according to the experience not compatible with constrai not explicitly considered in t they provide a good starting adaptations.

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