

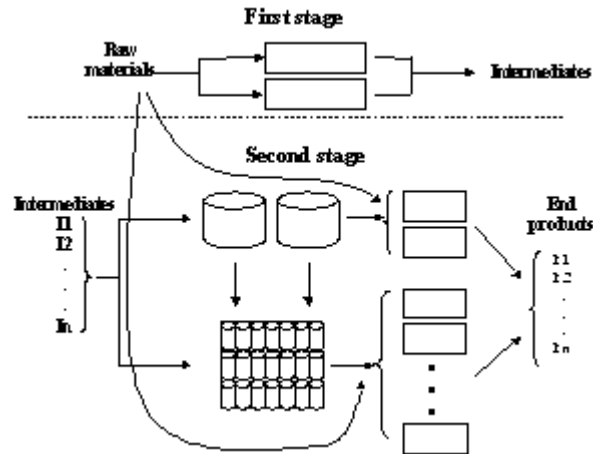


BASF

Solving BASF's plastics production planning and lot-sizing problem using combined CP/MIP

BASF is the worlds leading chemical company. It has production establishments in 39 countries in Europe, North and South America and Asia. BASF's segments are chemicals, plastics and fibre, performance products, agricultural products, and oil and gas. In total, the company produces more than 8000 products, which are sold in 170 countries all over the world. Customers are found in construction, health care, the textile and leather industry, the automotive industry, nutrition, the electro and energy sector, sports and leisure and the packing industry.

The case study we are presenting comes from the area of plastics production. Basically, this is a two-step production process. In the first (chemical) step, one or several monomers are polymerised. In the second (physical) step, some additives (colour, stabilizer, etc.) are added. Both processes are continuous, with the machines running all 24*7 hours per week. One of the properties of plastics is that the value to volume ratio is rather small, that makes storage and transport very expensive. Therefore, storage of intermediates should be as small as possible.



While the number of different polymers that come out of a polymerisation unit is comparatively small (usually, less than a dozen), the number of end products may be quite big: Both exceed the number of production units by far. Therefore, production is in campaigns. The process of changing from one production campaign to another is called a changeover, which is usually ex-pensive both in time (lost production) and money (lost product, cleaning). The amount of time and money depends strongly on the sequence of products.

The production planning process consists of three tasks:

- The quantity ordered by the customers has to be divided into campaigns. For the products with a higher volume it is advantageous to produce several campaigns, otherwise the quantity that has to be stored is too big. Campaigns may be very different in size.
- The next task is to assign the campaigns to machines. Machines are different: some perform better on one set of products, some on another set of products.
- The final task is to sequence the campaigns on the machines. The sequence has to be chosen carefully to avoid excessive changeover expenses. At the same time, the coordination between the different process steps has to be considered.

Why was this problem/opportunity selected?

The usual approach for solving such problems is to decompose the different planning tasks into different steps, which are treated sequentially. While this approach is adequate in many cases, an analysis of the complex interdependencies showed clearly that such a decomposition was not suitable in this case. Instead, the three tasks have to be treated simultaneously. On the other hand, no single technology is able to do this. The hybrid MIP/CP approach developed in LISCOS is the perfect solution, because it combines the strength of MIP technology for solving lot-sizing and the assignment problems, and the strength of CP technology for solving assignment and sequencing problems.

Description of technical solution

A hybrid model has been built which can be seen as an application of a mixed logical linear programming (MLLP) framework.*

Neither of the two solvers has a full representation of the problem, instead the two solvers work in close co-operation. The MIP acts as the master process, responsible for the lot-sizing and the assignment. When it has found a promising partial solution, it calls the CP solver to do the sequencing. If the CP model is feasible, some of the variables of the MIP model are fixed; otherwise a "no good" constraint is added to the MIP model to eliminate the infeasible CP solution.

Benefits

The algorithm was installed as part of a production planning and scheduling system on the users' PC. The main user interface is an interactive Gantt chart, which is connected to an SAP R/3 system.

With the help of the optimisation tool, the company was able to increase reactivity dramatically. Without the system, manual planning took several days and was therefore performed once a month only. With the planning system, a plan can be generated in less than one hour. This enables the company to react to sudden changes, like machine breakdowns or urgent orders more efficiently, and to increase customer satisfaction.

There are a number of potential applications for this technology in BASF, because many planning problems in the process industry consist of the three aspects lot-sizing, assignment and sequencing. A similar system using the same technology is currently being developed for a second business unit.

* See Hooker JN, Kim HJ, Ottosson G: A declarative modelling framework that integrates solution methods. Annals of Operations Research 104 (2001) , pp 141-161.