PRACTICAL AND USEFUL RESULTS

Process simulation in a brewery

The results of a simulation can be used to improve company-internal processes, both in plant design and in production planning, without requiring laborious empirical tests to be carried out. This means designers and users can cut development and commissioning time, save on material and energy, and lower costs – and, last but not least, reduce the burden on the environment.

Actual users are of the opinion that simulations are sophisticated and complex mathematical models that only specialists can create and which might even give results that lack practical application or are difficult for non-experts to understand.

In recent years, however, the improved performance in the computer world has meant that even office PCs have sufficient power reserves to provide practical and useful results.

An example of a simulation that can also be projected by non-experts is the Plant Simulation software package from Siemens (which was formerly developed by Tecnomatix/UGS). It provides a block library (toolbox) that today is used not only in the automotive industry but also by various manufacturers of bottling and packaging machinery.

While a simulation runs it can be monitored graphically in 2D or 3D. This allows the operator to discover weak points during operation without previously having to analyse various data evaluations.

The software package includes multiple options to evaluate the simulation results (Gantt charts, Excel evaluations of mass balance, unit assignments, resource consumption, etc.).

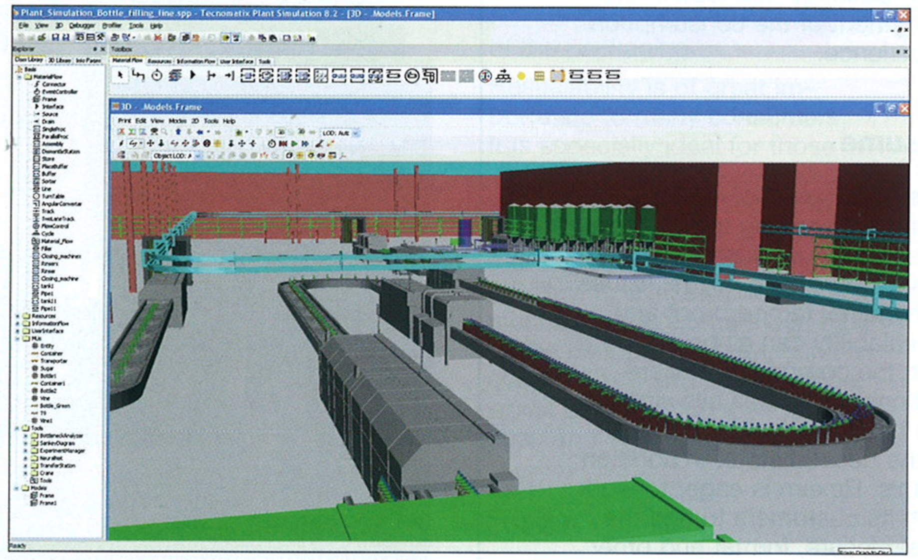

Fig. 1: Using simulations (here a 3D visualisation of a bottling and labelling plant), low-maintenance plants can be designed or existing plants can be operationally optimised, thus saving time, materials, energy, and costs. Using the 3D representation, spatial conditions can also be displayed understandably.

Advantages of a simulation compared with operating experience in production

What are the advantages of a simulation as opposed to the process know-how of an experienced employee? In many cases, the experience of longtime employees suffices to counteract adverse production events in advance. However, if the relationships exceed a certain complexity or timeframe, we quickly encounter the limitations of human predictive ability.

In general, those responsible are able to manage their specific area (e.g. boiler house or storage cellar) and the expected peak loads (electricity, steam, cold, etc.) very well, but sometimes there is insufficient coordination with the other areas or parts of the plant.

In breweries, for example, the simultaneous occurrence of recipe-based production steps (wort cooling demands on the refrigeration compressor, separator, etc.) and the resulting cumulative demands on the power supply are not always easy to foresee, which can lead to peak rate electrical tariffs if there is inadequate supervision. By using an ongoing cyclical simulation synchronised with the current plant (plant occupancy, task list, etc.) here, these critical cases can already be recognised in advance, allowing production planning to respond appropriately.

Simulations in bottling and packaging save time, material, energy, and costs

If we look at classical simulation models, we can see that the simulation of discrete processes has been around for quite some time. Such discrete processes are found in a brewery's bottling area.

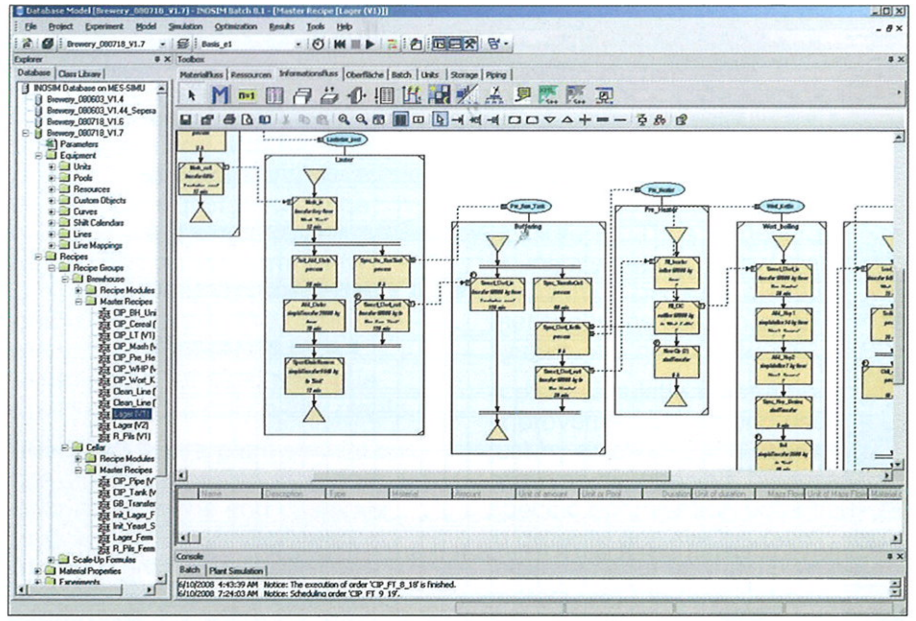

Fig. 2: The clear recipe and plant modelling (here, a brew house recipe) visualises possibilities for action for both production changes and for production problems.

The advantage of a bottling line simulation is that in designing the entire plant, it is possible to enter not only the performance of the machinery but also the transport routes and the location of the sensors into the system and thus monitor the entire system. Before making planned changes to plant or machinery parameters, such as conveyor speed, distance between bottles in filling, or sensor position, a simulation quickly provides an overview of possible bottlenecks and optimising opportunities, doing away with time-consuming and costly optimisation work on the equipment itself in the middle of production. It is also possible to determine whether

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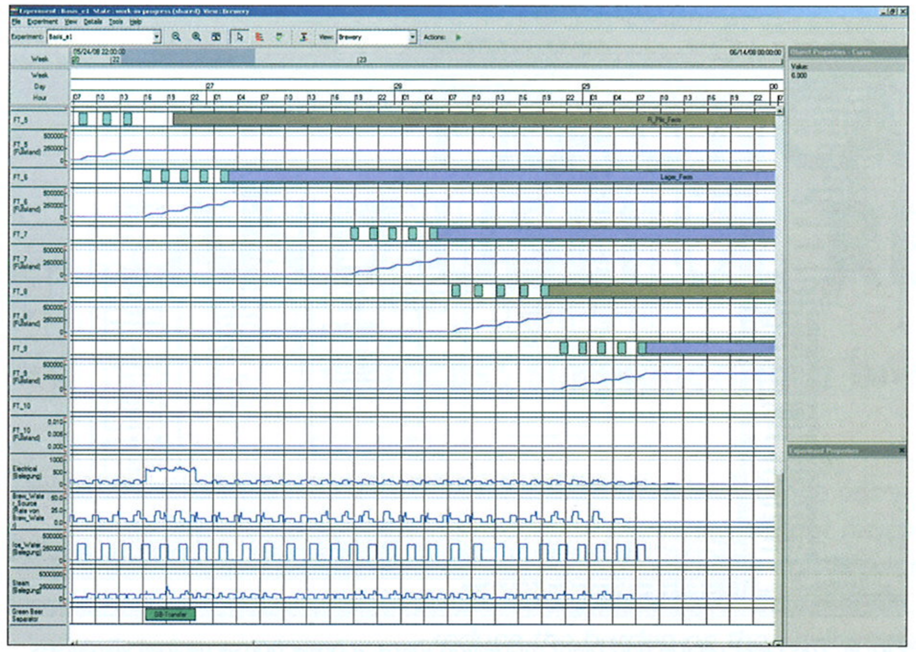

Fig. 3: The superimposition of different events (here, tank assignments) in resource consumption (lower part of the diagram) makes it possible to identify operational bottlenecks and possibly to conserve resources.

sufficient buffer space exists between the individual machines to overcome brief disruptions of the individual machines. Besides machinery performance, the settings include, for example, conveyor length and speed and thus also the distance between bottles on the machine outlet.

For the machine manufacturer it thus becomes possible to convince the end customer in advance of the performance of his planned plant and circumvent any bottlenecks by means of plant-specific modification of the machines or conveyor belts (see Fig. 1). Besides the pure simulation for plant design, the end user can also optimise plant utilisation by setting different filling sequences (and associated setup and cleaning times). The various simulation results (e.g. alternative job sequences) can be compared against each other in an interactive Gantt chart and thus an optimal filling sequence can be developed.

In the latest version of the software, the simulation of various PLC CPUs can also be tested so that the PLC programs and the monitoring and control logic based on the recorded plant states can be introduced into an optimised control system. Program tests regarding

- the user interface
- higher-level sequences (e.g. the interplay of multiple machines)
- non-time-critical processes
- complex processes (such as dependencies on different environmental conditions such as operating inputs and machine parameters)
- can be carried out, and the entire PLC logic or the optimal positioning of sensors on the conveyor belts can be tested by means of simulation – without material, process-related, or energy costs.

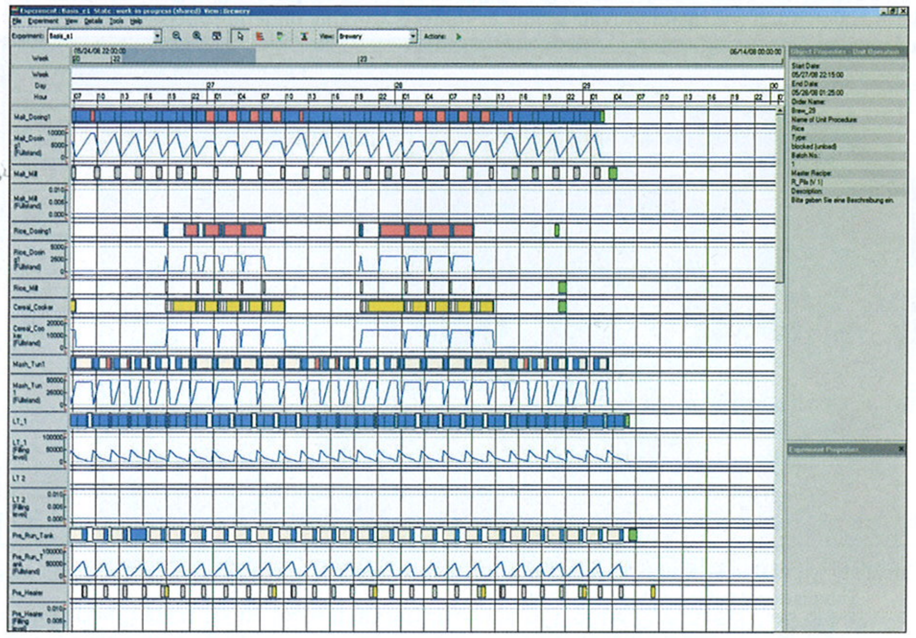

Fig: 4: The detection of buffer times in the tank assignment based on the phase durations allows the material flows to be optimised.

Practical simulation in production

For recipe-based production, it is much harder to depict the process technology. There is a supplementary program by Inosim for "Plant Simulation", with which recipes and their synchronisations and transitions can be mapped.

After the modeling of recipes according to S88[1]) nomenclature, the assignment to subsystems and configuration of process times of the individual phases can provide knowledge for production optimisation, just as in the case of bottling simulation (see Fig. 2).

In contrast to the bottling simulation, the focus here is not on the dimensioning of the container or apparatus but on recognising different technological relationships. The procedural optimisation of a boiling apparatus thus cannot be depicted because the thermodynamic relationships are very complex and the efforts required would not be proportionate to the results (see Fig. 3).

However, in addition to the settings for quantity and time, each recipe operation can also be assigned a resource consumption such as electrical energy, refrigeration, or steam, and due to the simultaneity of events (in the boiler house, storage cellar, etc.) the capacity utilisation in the ancillary can be displayed.

This by itself cannot help to recognize possible shortages or peak consumption of resources (see figure 3). Here it is important that the simulation model is connected with the production plant so that before the calculation begins, the simulation takes over the current vessel and tank assignments or the order status as start conditions.

Only then, using a current job list, can it be recognised whether, for example, after a few hours of operation, steam consumption will increase or whether the boiler house can be informed of the increased requirements. Process events can, in turn, be postponed so that the resource shortage does not occur or so that overcapacity can be used productively. This energy consumption optimisation is an essential component in planning precisely due to rising energy costs (see Fig. 4).

Another possible result to improve the quality of planning is the discovery of when yeast propagation must be restarted so that there will always be sufficient yeast available for production.

Of course, with a simulation, only ideal processes are modeled, i.e. an ideal fermentation time is assumed. In practice this is applicable only over a longer operating time and as mean value, and many of these parameters also change in the course of continuous production because of the use of different raw materials or other plant conditions. Therefore, besides an online connection, it is important that the process-defining recipe and plant parameters such as phase duration and pump flow capacity can be changed by users without programming knowledge. Only then can the operator determine the optimisation himself on-site.

Which goals can be achieved with a simulation?

The objectives that can be achieved with a plant simulation can be divided into two parts. Firstly, of course, there is the optimisation of the bottling machinery and the tuning of plant parameters before setting up a bottling line. This helps the plant equipper both to attain planning reliability as well as to convince his customers in advance of his plant design.

The percentage gain for a single plant in planning with the help of a simulation is a few percent, but a double-digit percentage gain can also be also achieved (depending on the complexity of the installation or the depth of the simulation). The basic design effort in a simulation usually pays for itself after it is implemented in only a few plants.

Secondly, with a plant simulation, not only the machine manufacturer but also the end customer (e.g. brewery) can verify and optimize production planning and test his own optimization criteria to then implement the results in his production planning system (PPS).

However, a plant simulation cannot serve as a job or production planning tool, as important boundary conditions are not considered. Thus, in general an infinite supply of raw materials is assumed because dispatch messages, as used in an ERP system, are not considered.

A plant simulation offers no improvement to the end user just by existing. Each user must examine his possible business-specific optimisation potentials in order to achieve his own improvements from his own parameters and their evaluation. □

[1]) S88 is an abbreviation for ANSI/ISA-88 Batch Control