BOSCH Research Info

Issue 1/2002

Virtually Perfect Production

When a future Bosch product is released for production, it will already have passed its virtual acid test. Whether it's a starter, a generator or a power drill, each item will already have been intensively tested with state-of-the-art software tools, while production planning is concurrently optimized.

Today, a variety of software tools are already being used for simulation in product development and production planning – for instance, for factory, production line or machine simulations. Project Cope (Cooperative Engineering) is an initiative by Bosch Research to consolidate and integrate these methods and tools and, consequently, company-wide know-how.

The intent behind Cope is to release for production only those future products that have already been thoroughly simulated, tested and extensively operated virtually on the computer. Simulation can achieve early detection of problem areas in the planning and design of production systems, and that's just as true for the plant as a whole as for the individual details of a machine tool or the assembly station of a shop floor worker. The results are converted into the real "nuts and bolts" of a plant only after planning, simulation and optimization have been completed. This approach has already been successfully demonstrated in several pilot projects. Engineers can view production steps in time-lapse mode and observe the attained production quantity, throughput time, and how the system reacts to faults.

The planning of production systems is analyzed and optimized on a virtual model by using simulations. Shown here is a simulation of the ergonomics of assembly workstations.

Since Cope is designed to support the entire development and production process of a product, it is more than simply a simulation tool for a digital factory. Feedback loops with product development can ensure that starters, power drills or windshield wipers are designed right from the start to ensure the optimum production and assembly process. This close coordination of development and production planning provides new opportunities for cost reduction and ultimately ensures that customer demand for volume products from Bosch is met more swiftly than ever.

Editorial

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On the Road to the Digital Factory

The products of the future – whether in the auto industry, in power tools or in automation technology – are becoming ever more complex and must succeed in a dynamic market environment. This presents a challenge to product planning and development. "First come, first served" is a maxim that's taken seriously in the competitive world of manufacturing. Digital planning and simulation tools are consequently playing an ever more important role in all phases of the product generation process at Bosch. They help shorten product development times and speed up the transition to mass production.

Bosch is therefore working intensively on the further development and integration of simulation and planning software. As a result, it is already possible to ramp up and run machines virtually on the PC to substantially reduce ramp-up times and costs.

The vision of the digital factory, however, can not only solve technical problems on the computer but also support the development of new planning methods for manufacturing. At Bosch, these activities have been consolidated in the Cope (Cooperative Engineering) project initiative. Through the integration of methods and software tools, and by their flexible application in the product generation process, Cope is making a substantial contribution to shortening the time to market for Bosch products.

Planning the Works with the Computer

Planning manufacturing plants on the computer has a clear advantage over conventional engineering drawings: Engineers can use the digital model of the plant to simulate the dynamic processes in a production setup and to optimize the entire production process to meet the requirements of the market – even before the plant is built.

The simulation of production and assembly systems has become increasingly important in recent years. The dynamic observation of the 'behavior' of entire factories or individual assembly lines provides previously undreamed-of insights into manufacturing processes. And this information can be used to fine-tune production to the needs of the market and above all to reduce costs, even before the foundations of the plant are poured.

Bosch researchers and development engineers observe the processes in a factory on different levels with a progressively decreasing degree of detail. Machine simulation strives to optimize the operational processes and machining cycle of a machine tool or a machining center (see back page of this issue). Bosch manufacturing engineers also find line simulation very useful. This method facilitates the design and layout of production lines or assembly lines with respect to machining times, the number of stations and intervening buffers.

But as we advance toward the 'digital factory' – the complete modeling and simulation of a production system on the computer – the ultimate goal is not to examine the individual elements, such as machine tools or assembly lines, but to view the plant as a whole. Subordinate units such as individual lines are represented as black boxes in the simulation model, and only the interactions and relationships between these units are examined. This approach makes it possible to map the behavior of a total production environment – from receiving to shipping.

As part of Project Cope (Cooperative Engineering), Bosch Corporate Research and Development harmonizes the various planning and simulation software tools with one another, creates interfaces and readies them for their application in the business units and plants.

In addition to adding functionalities and refinements to commercially available software, Project Cope also undertakes the programming of new tools – such as a simulation tool for a factory design with embedded production control. This tool can be used to study all of the processes in advance – before the plant is built. It is equally possible to model an existing plant on the computer and to simulate its dynamic behavior. The new tool creates a production plan on the basis of a customer order, and assigns different production orders to the individual production phases. In addition, the software monitors how well the production process is meeting its targets, and in the event of deviations provides feedback to the appropriate production phase.

Improved Capacity Utilization

It takes Bosch researchers just two hours of work at the computer to simulate a two-month production period. The results are increased capacity utilization of individual production lines, a greater proportion of on-time deliveries, and inventories that approach ideal levels. The particular advantage is that the method makes it possible to continually adapt the system's characteristics to the production environment 'on the fly' – i.e. while production is in progress. And it can do this in advance, virtually – on the computer – without affecting the ongoing production process.

These planning and simulation tools pay off especially in optimizing inventories – including the entire range of resources from raw materials to consumables and intermediate products. Excess inventories tie up capital, since the materials are lying idle. On the other hand, a theoretically ideal zero inventory level – wherein every part would be used immediately – would create critical production risks, since the smallest bottleneck would propagate production delays unchecked.

Production planning must also consistently keep an eye on the future. After all, it concerns the future production of a product. But how can the necessarily unpredictable variations in the economic environment be factored in? How does one adjust the planning to accommodate varying levels of orders received?

From the very start, the researchers plan the capacity of a plant for a very broad range of production output. This enables the plant to respond flexibly to high levels of received orders – but also to fluctuations in demand due to changing economic conditions. Order books are therefore a key input for factory simulation. One of the questions that planning and simulation must answer is whether and to what extent rush orders can be inserted into the order books, and how these impact the production process.

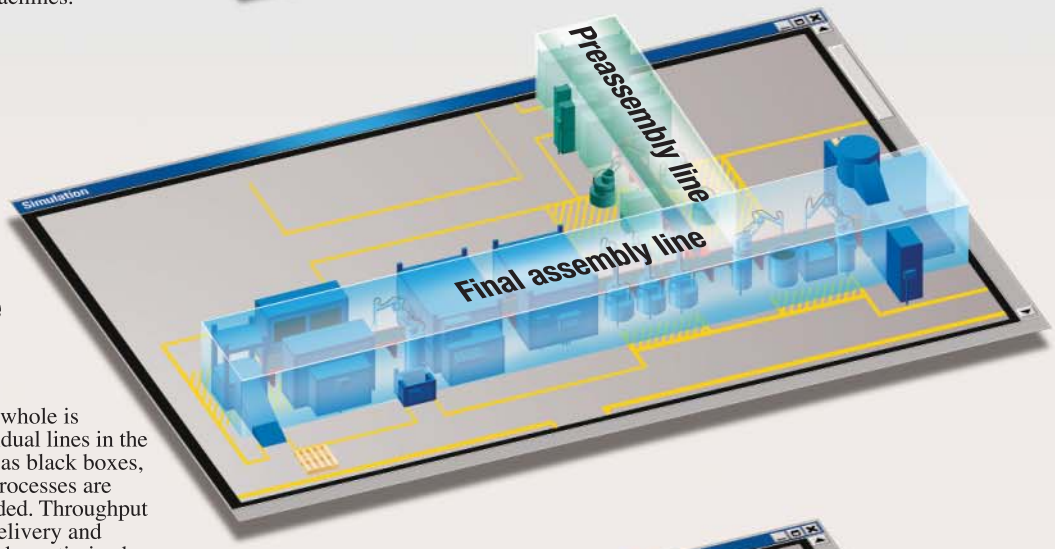
So the future of product development and production planning might look like this: A customer in the automobile industry orders an automotive subsystem from Bosch – for instance, an ABS system, a windshield wiper unit or a new engine management system. The next step is concurrent product development and production design. One of the steps, of course, is to examine whether and which components can be produced using existing systems. But irrespective of whether existing production equipment is adapted to new needs or a new system is built, Virtual Start of Production (VSOP) precedes the ordering of any new machines or the construction of any building. The go-ahead for the production process is given only after this simulation and optimization have been completed.

The success of this approach is already evident in several factory projects. The capacity utilization of the plants has been improved, delivery dates have been met, and the products are getting to the market sooner.

Virtual Analysis down to the Smallest Detail

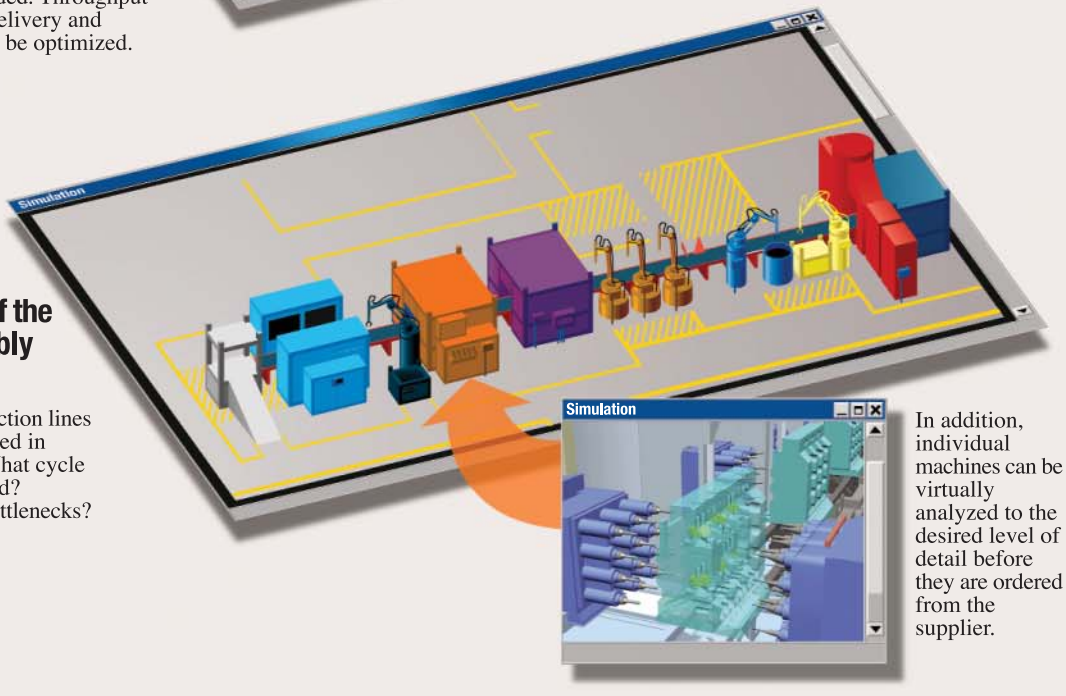
The factory in a 3D computer model

Modeling and simulation precede the construction of the factory. The planners can use a building-block principle for combining all of the production processes and machines.



Simulation of the entire production process

The factory as a whole is simulated. Individual lines in the plant are treated as black boxes, whose internal processes are initially disregarded. Throughput times, on-time delivery and inventories must be optimized.



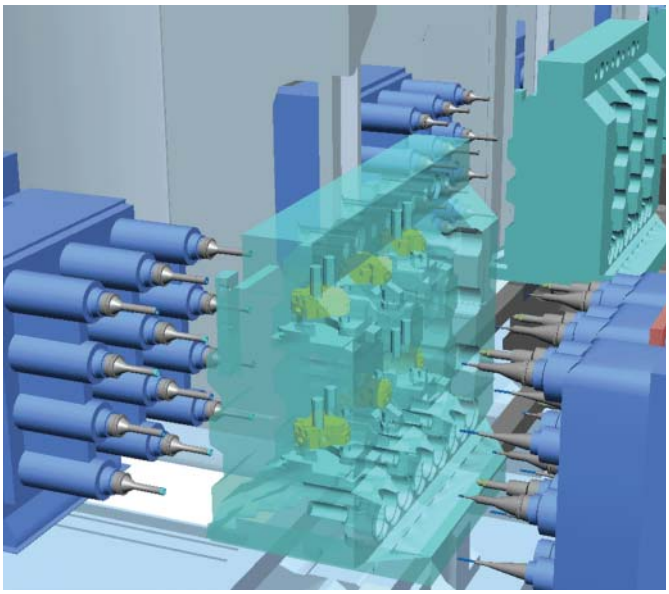
Simulation of the final assembly line

Individual production lines can also be studied in greater detail: What cycle times can be used? Where are the bottlenecks?

In addition, individual machines can be virtually analyzed to the desired level of detail before they are ordered from the supplier.

Machine Tools in Top Form

■ *Bosch researchers use computer simulations of modern machine tools to improve production processes. Three-dimensional models make it possible to observe processes that are invisible in real machines.*



This CNC machine tool is simultaneously machining six high-strength steel housings of a common-rail high-pressure pump. A mouse click is all it takes to make the green workholder transparent. 24 special tools are used in drilling, milling and tapping these components before the conveyor system transfers them to the next station. The dynamic simulation of the component, workholder and machine tool has proved useful in preventing collisions as well as for analyzing bottlenecks in the production process.

Machine tools are the workhorses of mass production. They might, for instance, perform milling, lathing or drilling steps on the aluminum housing of an ABS component, or on the high-tensile steel block for a high-pressure pump of the diesel direct injection system. The ever-increasing complexity of components and the large number of versions in which they are available pose some real challenges for modern machine tools and their control systems. Now Bosch researchers have succeeded in significantly increasing the efficiency of these powerful production systems — thanks entirely to the use of computer simulation of the machines, their production processes and their control programs.

As one example of what this approach has accomplished, the running-in period — the time it takes to get a new control program to work smoothly on the machine — has been shortened by 75 percent: Instead of having the machine offline seven hours for the changeover, it is now ready for production again in just one hour.

What's more, the production process as a whole has been streamlined: The machining time — the time it takes the machine to get the job completed — has been substantially reduced by fine-tuning many details to optimize the machining procedures. A three-dimensional model allows, for instance, engineers to shorten the routes of the tools over the surface of the workpiece, saving valuable time. And dynamic 3D simulation can prevent collisions of the machine tool with the workpiece or its holder. As a result, it's now possible to employ new control processes that were previously ruled out because of safety considerations.

The computer enables engineers to observe production processes in ways that would never have been possible on the shop floor. Real machines are enclosed, and a spray of cutting fluid obscures visibility. But on the computer, a mouse click is all it takes to remove objects that obstruct the view. And the workholder can be rendered transparent. Cross-sectional views even allow engineers to watch an angular drilling head as it is guided into an advance drill hole, where it can virtually drill "around the corner".

Simulations pay for themselves. In one Bosch manufacturing plant, production capacity was increased to such an extent that no additional equipment had to be purchased even when customer orders increased, eliminating the need for a large investment.

In Brief

■ *New Self-Locking Grease*

Working in collaboration with the Shell company, Corporate Research at Bosch has developed a new type of grease for automobile window lift drives that has substantially better self-locking characteristics than the previously used type. This self-locking grease is particularly useful because it prevents car windows from slipping out of their fully closed position. The conversion to the new grease in the assembly process for window lifters in Bosch plants throughout the world is now nearly complete.

Dates

■ *April 22 – 25, 2002*

Dr. Reinhard Neul will present a paper on "Modeling and Simulation for MEMS Design, Industrial Requirements" at the "5th International Conference on Modeling and Simulation of Microsystems, MSM 2002" in San Juan, Puerto Rico, U.S.A.

■ *May 27 – 31, 2002*

Dr. Jürgen Rapp will speak on "Laser Applications of an Automobile Supplier" at the "International Congress on Laser Advanced Material Processing (LAMP2002)" in Osaka, Japan.

Masthead

■ *Publisher:*
Robert Bosch GmbH, Stuttgart
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