Facilities of the Future | Factory Planning

The Factory that Comes to You

The planning of a factory by no means ends when the keys are handed over to the client — after all, new product generation or machinery has to be upgraded or replaced at some point. As time goes by, factory halls often take on a different appearance, as new cables are laid and machines are repositioned. It is therefore difficult for planners to gain an overview as a means of comparing the real situation with a virtual model, especially when facilities are located far away from research centers. The Virtual Service Support system (VSS) developed by Siemens Corporate Technology (CT) in Munich can greatly simplify factory modernization processes. VSS is a mobile remote data transmission system (see Pictures of the Future, Spring 2005, p. 54) that sends live pictures and sound to service centers via mobile radio. To this end, a worker at a factory wears a headset equipped with a camera and microphone. VSS is currently being used as the first commercial application of its kind for maintenance activities at a Finnish steel plant. The service center for the factory is able to view the factory live via a mobile phone, and specially trained service technicians can then guide a worker wearing the headset to the best location for viewing the machine. It’s like being there yourself — and the technician can even take a photo of the machine, mark areas where the worker should move to next, and then send the photo to the worker’s portable PC. Among other things, the system can be used to quickly evaluate the situation at a factory from afar before rebuilding work commences. “Our experience has shown that after several years, you can hardly depend on a factory’s original plans anymore,” says Joachim Häberlein, who is responsible for the development of customer support at Siemens Corporate Technology. Meanwhile, VSS is being used for the first time in practice in a robot that grabs bottles as they pass by, takes them to a quality control station, examines them, and returns them to exactly the right spot on the production line.

All of this was planned and tested in the virtual world. To do so, A&D developers inserted the virtual robot into its future real position in an image of the existing factory. All bolts, measurements, electrical connections, data communication and pressure systems were verified before actual implementation. The researchers even ran a realtime simulation of the robot’s operating parameters. On the other hand, the initial data entered into the system for simulating the bottle-picking robot came from the physical bottling unit. “The fascinating thing about SmartAutomation is that you can directly link reality and a simulation,” says project manager Bernd Opgenoorth. Despite the excellent performance of the simulation system, there is still room for improvement, especially with regard to the comprehensiveness of the planning process. That’s because data from the entire production chain does not pass seamlessly from the first draft design to the finished factory model. In many cases, data has to be transferred manually from one program to the next — for example, from a 3D drawing to the visualization software, or from a virtual model to the language used by a computer controller or machine tool.

“What we need to do now is eliminate the discontinuities and automate the transfer of data from the beginning to the end of the process,” says Opgenoorth. Researchers from his team are working with A&D PL to solve this.

Lego for Factories.

A similar approach is employed by the “SmartFactoryKC” project managed by the German Research Center for Artificial Intelligence (DFKI) in Saarbrücken. The center is a consortium of companies and research institutes that is also working on a miniaturized version of a real production facility. A founding member of the consortium, Siemens A&D also provides funding for the SmartFactory, which, like SmartAutomation, simulates production in the virtual world. One of the factory’s purposes is to demonstrate how components from different manufacturers can be combined. It’s a visionary idea that foresees new factories based on standard modules much like giant Lego blocks. This would require that each producer’s modules be equipped with standard interfaces.

In addition, all SmartFactory plant components for the miniaturized production facility are to be equipped with radio frequency identification tags (see p. 52), thereby making it possible to automate inventory registration and precisely pinpoint machine locations. This, in turn, will make it easier to expand or convert existing factories. Machine locations could be fed into virtual models to enable planners to determine exactly where new equipment should be installed. “A lot of work — and information — goes into virtual factory models,” says DFKI project coordinator Eric Palmgreen. “So it makes sense to use this great variety of data over and over again.”

Prototype for Perfection

Planning and designing technically sophisticated products was, until recently, a long, drawn-out process. Today, however, Siemens relies on digital product development, which involves planning all steps — from the first model sketches to prototypes — in virtual reality. This makes it much easier for experts to coordinate their activities and often shortens the product development process by months.

Mail sorting machines have an insatiable appetite. In just one hour, they can process up to 40,000 items, which fly through their sorting gates at lightning speed, whereby soft pressure is applied at each gate to send envelopes along on their proper track. A rigid envelope, for instance, one with a CD inside, can do great damage in such a high-speed system, as it can get stuck in one of the gates, causing a huge backup of hundreds of letters in just a few seconds. The machine then has to be shut off, resulting in costly downtime.

Giant sorting units are therefore equipped with precise mechanical instruments for measuring letter stiffness. Like a small finger, such instruments briefly tap each letter to measure its resistance. Envelopes deemed to be too rigid are removed before they can cause damage. The stiffness measuring instruments have to be both sensitive and fast in order to be able to touch each envelope as it flies past without damaging it.

Around a year ago, engineers responsible for the production of sorting machines at Siemens Industrial Solutions and Services (I&S) Postal Automation division in Konstanz, Germany, found that they needed a particularly...
Factories of the Future | Product Development

The ability to bring products to life as realistic 3D computer models is crucial for sales success.” says Friedrich. “That’s something we’ve never done before in product development.”

Global Turbine Development. Work carried out by experts at Siemens Power Generation (PG) in Berlin involves turbine blades for complete gas turbines. These machines, which are as heavy as several locomotives, consist of thousands of components, including several hundred precision blades that must be joined together exactly. Before the milling machine is used virtual planning tools for the first time on a major scale while developing the brand-new 340-megawatt turbine for a new gas and steam facility in Ischring, Bavaria (see p. 54). The most important goal here was to reduce development time through better coordination of staff working in departments housed at several locations, such as designers in Orlando, design engineers in Munich, Germany, and production specialists in Berlin.

Up until recently, design drawings were sent back and forth, with engineers writing down comments on the documents. In other cases, sketches were scanned and sent electronically. Experts also frequently had to travel to meet with people in other locations. Today, development project participants conduct videoconferences. In the case of the Berlin-based turbine project, each of the two locations was equipped with a Powerwall VR system, which was used for presenting the virtual turbine model, and which was linked via data connections. This enables participants to view and discuss the same model simultaneously. "Development engineers have proved tremendously as a result, and the entire process has been accelerated," says Michael Schröder, who heads the mechanical turbine development at PG. Unlike abstract design sketches, virtual models enable joint communication between various designers to enhance understanding of the situation at hand. Component installers, for example, recognize very quickly whether some components might collide during the assembly process. Virtual models also make the entire development process more vivid and dynamic, says Schwarzo. The product development process for a new turbine is generally a difficult undertaking that consists of many different steps. It basically begins with a draft design in 3D-CAD programs. These 3D models are created before detailed machining the blade surfaces. This cutting force calculation enabled engineers to accurately design the dimensions of the clamps that hold the blade in the milling machine while it’s being processed.

CT mathematicians are also looking at natural fluctuations — conditions in a gas turbine combustion chamber, for example, that are always the same. Changing gas compositions, temperatures, and component tolerances have a major impact on the performance of the blades. The mathematical optimization approach takes into account precisely these fluctuations and uncertainties in the calculation, thereby enabling an optimal design. Mathematicians refer to this as Robust Design Optimization — or RoDeO (see Pictures of the Future, Spring, 2006, p. 75). “This probability approach borders on pure mathematics,” says Friedrich. “That’s something we’ve never done before in product development.”

Videoconferences supported by virtual reality tools are replacing sketches sent by courier.

As computed tomography scanners provide images characterized by higher spatial and temporal resolution, they rely on ever more sensor boards — assemblies of components that detect X-rays and convert them into electrical signals that are reconstructed into anatomical images. It has therefore become impractical to manually insert sensor boards in related test facilities. Indeed, the newest Siemens computed tomography scanner family, which will be introduced by the end of 2007, will have up to 150 sensor boards. Now, however, with the help of Siemens Corporate Technology (CT), Siemens Medical Solutions (MDS) has come up with an automated sensor board testing technology that, according to Project Manager Dr. Marcus Wagner from Med’s Computer Tomography Detector Center, “achieves a placement accuracy of 0.1 mm or better.” Known as AutoSETA (Automatic Sensor Test Facility), the technology involves the use of a robot arm to place sensor boards in a section of the test facilities. Indeed, the newest Siemens computed tomography scanner family, which will be introduced by the end of 2007, will have up to 150 sensor boards. Now, however, with the help of Siemens Corporate Technology (CT), Siemens Medical Solutions (MDS) has come up with an automated sensor board testing technology that, according to Project Manager Dr. Marcus Wagner from Med’s Computer Tomography Detector Center, “achieves a placement accuracy of 0.1 mm or better.” Known as AutoSETA (Automatic Sensor Test Facility), the technology involves the use of a robot arm to place sensor boards in a section of the test facilities. Indeed, the newest Siemens computed tomography scanner family, which will be introduced by the end of 2007, will have up to 150 sensor boards. Now, however, with the help of Siemens Corporate Technology (CT), Siemens Medical Solutions (MDS) has come up with an automated sensor board testing technology that, according to Project Manager Dr. Marcus Wagner from Med’s Computer Tomography Detector Center, “achieves a placement accuracy of 0.1 mm or better.” Known as AutoSETA (Automatic Sensor Test Facility), the technology involves the use of a robot arm to place sensor boards in a section of the test facilities.

Meanwhile, the Virtual Design Center in Munich to work with them on the planning process. The Center designs complex products on computers and brings them to life in the virtual world, where they are then tested before even one prototype is built. Among other things, you can hear the sound of washing machines running at the center, even before any such machines have been built.

Concurrent Engineering. The ability to bring products to life as realistic 3D computer models is nothing new. Computer-aided design (CAD), for example, has long been a workhorse in industrial design departments, and the simulation of flows and acoustic oscillations is standard technology today. “What we’ve done here at CT is to link all these virtual modeling and simulation tools to create an integrated approach,” says Bernd Friedrich, head of the Virtual Design Center. Friedrich’s work focuses on mechatronics systems development — i.e., designing and linking mechanical components and electronic control systems in parallel. Engineers in at the very end the control system was tested with the finished hardware,” Friedrich explains. “But that approach simply takes too long.” That’s because errors such as a motor with insufficient power or a slow control unit generally aren’t discovered until all the components are operating together in a finished machine — by which time it’s too late. “It was often the case that several prototypes were built and tested before a production-ready design was ready,” says Friedrich. The new parallel — or “concurrent engineering” — approach has engineers from all disciplines working together from the beginning, which means a fully functional product model is stored on a computer before anything is built. The computer can thus be used to simulate and run through several product variations. Moreover, customer requests can be taken into account right up until shortly before the conclusion of the development process. “We’ve found that this approach cuts development costs by about one third,” says Friedrich. “It doesn’t matter whether it’s automotive components or power plants — new products can be brought to market more rapidly, and this shortening of time-to-market is crucial for sales success.”

The stiffness measuring model for postal turbine development — a high-tech device whose electric motor would be inserted shortly before the conclusion of the development process — was one pursued here only if you are capable of developing the necessary algorithms yourself. That’s why the Virtual Design Center team includes several mathematicians who developed the so-called “multi-physical approach” together with engineers. The concept takes into account many different physical properties — such as temperature distributions, material properties, oscillation characteristics, and strengths. Parameters that determine a real product’s future functionality and quality are therefore incorporated into its virtual model. The only way to determine in advance whether, for instance, a washing machine will actually spin quietly after it’s built.

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large machines and even entire factories. Schwarzlose introduced this tool at PG in 2003, at a time when the 340-MW high-performance turbine for the building power plant was still at an early development stage.

In 2005, a further element was added: a VR system for gas turbine final assembly. Since it takes weeks to assemble a giant turbine, and the process is almost as complex as building an aircraft, VR technology has accelerated the assembly process. The technology allows specialized mechanics to practice manual assembly maneuvers in advance using virtual final assembly programs — something that would have been inconceivable just a few years ago. Schwarzlose recalls how things used to work during the early stages of work on the insching turbine. Back then, in order to test assembly operations, a full-scale model of a turbine combustion chamber had to be built in Berlin. What's more, it took months from the moment an order was placed until a model could be fully assembled. And, of course, it wasn't possible to test the assembly process over time.

**Tremendous Savings.** The amount of time gained through the use of new virtual tools is tremendous. Depending on the complexity of individual turbine components, it used to sometimes take weeks or even months before researchers could determine whether it would even be possible to install or manufacture certain components. "While it's true that virtual reality can't replace a real operation in every single case, the fact remains that an actual model cannot depict or make noticeable the smallest tolerances," Schwarzlose explains. All in all, the virtual planning process can reduce development times by several months, according to Schwarzlose. The insching turbine will be operational next year after only seven years of planning and construction. Projects in the past took much longer to complete.

VR is set to become a key part of product lifecycle management at PG. A roadmap for establishing a PLM process is currently being worked out. The goal here is to permanently incorporate all development processes, combine various development platforms, and simplify the exchange of data. New simulation tools, such as those made by UGS (a major PLM player recently acquired by Siemens — see p. 16), will further develop virtual reality into a key development component whose depiction of reality will become increasingly exact. Such precision has long since moved beyond individual products to include entire factories that are developing and testing manufacturing facilities, to bottling logistics and production departments, to bottling logistics system also ensures that the material logistics and production departments are not negatively affected by fluctuations in order volume. This supports efficient capacity planning and high machine-capacity utilization."

The EMP, which produces exclusively on a make-to-order basis, has an amazing delivery reliability rate of 99 percent, meaning that 99 out of 100 customers receive their exact number of ordered units within 24 hours at the required quality.

**Flawless from the Furnace.** Production processes at the EMP are synchronized and perfectly aligned with one another. Practically nothing is done by hand at the plant, with the exception of machine setups and repair and maintenance work. Men and women in blue overalls at the facility plan production, make decisions, and coordinate and monitor activities.

**Snapshot:** A worker carefully examines a module under a magnifying glass. The module has just emerged from a soldering furnace, where printed components are mounted on circuit boards at a temperature of 250 degrees Celsius. The worker is responsible for ensuring that the circuit board is stable, and that nothing is missing or incorrectly mounted.

Precise facility planning (below). 100 percent quality achievement (center), and continual process control (right) helped ensure that the Ambberg plant was named Europe's Best Factory.

Amberg's factory hall is as tall as a two-story building and covers an area the size of one-and-a-half soccer fields. A gallery offers a view of the production floor, which is as clear as a whistle. Wide aisles can easily accommodate three workers walking side by side, and with most machines no higher than 1.4 meters there’s no problem making eye contact.

**Cost Effective.** The EMP is living proof that it’s possible to make products at the same low cost as at a sister factory in Nanjing, China on a daily basis. What’s more, this facility captured first prize in Germany’s Best Factory/Industrial Excellence Award 2007. The two organizations that present the award — the INSAAD Business School in Fontainebleau, France, and the Department of Production Management at the Otto Bishheim School of Management in Vallendar, Germany, also named the plant Europe’s Best Factory.

The awards jury assessed operational strategy, product development, supply chain management, organization, human resources, service, partner management, and continual improvement and awarded the EMP top marks in nearly all categories. The plant’s success is partly due to its use of the best machines available, its low-cost procurement sources, and its mastery of the production process. Still, other downtime, and inventories. Our flexible order logistics system also ensures that the material logistics and production departments are not negatively affected by fluctuations in order volume. This supports efficient capacity planning and high machine-capacity utilization."

Tim Schröder

Siemens’ electronics plant in Amberg, Germany, demonstrates that even supposedly expensive manufacturing locations can be competitive. The facility boasts low-cost production, brings innovative products to market, and is always striving to improve. As a result, it was recently named Europe’s Best Factory.

Back-track-look-back..." — it’s practically impossible for the human eye to follow the extremely rapid movements of the machines in the Amberg Electronics Manufacturing Plant (EMP) as they stamp chips, transistors, resistors, and capacitors onto blank circuit boards that fly by on conveyor belts. Here at the EMP, Siemens Automation and Drives (A&D) produces "invisible intelligence" for industry and everyday applications. The associated devices are part of Siemens’ Simatic line of programmable logic controls — a product family used in regulating just about every kind of production machine, from welding systems and cement manufacturing facilities, to bottling equipment, automated car washes, daray products processing systems, and ski lifts. The EMP itself has 16 production lines operating around the clock, each of which processes 150,000 electronic components per hour.

Siemens is — by a wide margin — the world market leader in electronic controls for industrial automation. What’s more, its market share has been growing by one percentage point per year for some time. This achievement is in no small part due to the Amberg plant’s 870 employees, who produced 11 million Simatic modules last year. "And this year, we plan to build more than 12 million," says plant manager Hans Schneider.

Ulrich Brück, who is responsible for employee initiatives and the Siemens top™ Management Program, refers to this employee check as statistical process control. Here, a computer randomly determines which module on the screen, and the functional units she needs to check are marked in color. If she

Precise facility planning (below). 100 percent quality achievement (center), and continual process control (right) helped ensure that the Ambberg plant was named Europe’s Best Factory.