SIEMENS

Digitalization – Special feature on the future of manufacturing

Modeling new perspectives

Simulating processes makes it possible to manufacture products that are innovative, customized and nearly error-free. A high level of connectivity delivers benefits in areas extending far beyond the manufacturing industry.

The path of higher productivity

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More than a pipe dream

The German term *Industrie 4.0* refers to a tremendous force of change through which digitalization is putting manufacturing processes on a new track. The principle of complete interconnection is already being partially applied today.

"The most profound technologies are those that disapear... They weave themselves into the fabric of everyday life until they are indistinguishable from it," wrote computer scientist and visionary Mark Weiser nearly 25 years ago in his essay "The Computer for the 21st Century." It turns out he was right. First, computers became networked. Now, more and more pieces of everyday life are following suit: smartphones, household appliances, vehicles. The consulting firm Gartner estimates that about 25 billion objects will be interconnected on the "Internet of Things" by 2020. Today, there are 3.8 billion such objects.

Lean, fast, stabile

Using an app to control systems such as the lighting, heating and air conditioning in your home; buying electricity when it's cheap; participating in the design of your new car in real time – as digitalization progresses, it's unveiling incredible possibilities for those who keep pace with these developments. That's true for individuals, and it's true for companies, which must act with ever-increasing speed, efficiency and flexibility in the face of global competition. The Internet enables firms to collaborate more closely with partners, address customer requirements systematically, establish new business processes and, above all, manufacture products more efficiently. How? Through virtual 3D development, digital planning and monitoring, and nearly error-free production.

This transformation has been labeled *Industrie 4.0* – a German term that's still relatively unfamiliar in Germany, with only 21 percent of the country's population being aware of it, according to the survey conducted by Bitkom, a German association for the ITC industry. The fact that there are over 100 different definitions of this term available doesn't make it easier to grasp its meaning. Yet this trendy buzzword simply refers to the complete digital representation of a company's entire value chain. Embedded software is enabling equipment, machines and materials to communicate via the Internet, optimizing each other and thus keeping processes smooth right up to the sale of the finished goods.

Key elements of this vision are already available. For a long time now, engineers have been using software to simulate robots, production plants and communications systems and optimize their interaction. An approach of this kind is an element of product lifecycle management (PLM). For example: The new Maserati Ghibli is manufactured in Grugliasco near Turin, Italy, in a state-of-the-art manufacturing process on a production line created specifically for this sedan. Here, components of this exemplary Italian car are drafted digitally and tested virtually before they are manufactured.

Industrie 4.0...

... is being described as the fourth industrial revolution. The three prior stages of industrialization were shaped by mechanical production (at the end of the 18th century), electrification (at the end of the 19th century) and automation (50 years ago).

Along the way, industrial software and solutions from Siemens ensure that the digital and physical worlds merge.

The transition to a digital enterprise

Partial solutions as a step towards fully digitalized, custom production – that's taking the industry sector light-years beyond the manufacturing processes used at the beginning of the 20th century. After all, back then, the challenge was to mass-produce goods in the highest possible quantities in order to standardize processes. The challenge of the future is for companies to digitalize their entire value chain. Siemens' declared aim is to support its customers in this process. With its Digital Factory Division, this engineering company is helping drive the transformation towards the digital enterprise at high speed.

Tremendous opportunities emerge when the virtual and real worlds unite. And these opportunities are paving the way for tremendous growth, as a study by PricewaterhouseCoopers forecasts: half the companies surveyed anticipate double-digit growth over the next five years due to the increased digitalization of their portfolio of services and products. One out of five companies expects growth to exceed 20 percent. There's talk of over €30 billion annually in Germany's five core industries. Germany intends to tap into that potential. "Compared to international competitors, we're in a particularly strong position, because we were the first to deal intensively with this topic," said Professor Thomas Bauernhansl, who heads the Institute for Industrial Production and Factory Operation at the University of Stuttgart and the Fraunhofer Institute for Manufacturing Engineering and Automation (IPA) in Stuttgart.

Becoming the global market leader

"Germany is one of the world's specialists for mechatronics systems and for highly variable mass production. In addition, its industrial sector, research institutes and political leaders work hand in hand," said Bauernhansl in describing the country's advantages. The German government, for instance, has included *Industrie 4.0* – as one of its ten future-oriented projects – in the action plan for its high-tech strategy. The goal here is nothing short of being the worldwide innovation and market leader.

The core elements of Industrie 4.0

The transformation to Industrie 4.0 requires these four vital elements:

A common data platform ensures that all partners involved in a production process can access the latest data at any time and from anywhere. Beyond that, manufacturing requires innovative software solutions – from the initial design all the way to service.

High-performance industrial communications networks are needed to enable the exchange of information between all the elements involved in the value chain – across corporate and national boundaries.

Given the flood of data being generated, there's a growing need for greater **industrial security**. This requires solutions that safeguard all systems against unauthorized access. That includes both plant security and network security (cyber security). In addition, services for detecting and thwarting threats are essential.

As digitalization progresses, **data-based services (smart data)** are becoming increasingly important. Examples include online support or remote monitoring of a system in order to detect problems early on and prevent outages through predictive maintenance.

To fulfill this mission, German Chancellor Angela Merkel likes to be where the action is. At the end of February, she visited the prime example of a digital factory. In the Bavarian city of Amberg, the Siemens' award-winning electronics factory (EWA) demonstrates the key aspects of *Industrie 4.0*. Here, the company is already manufacturing products in the way that could one day become standard. Every year, the factory produces 12 million Simatic products, which are components for industrial control technology. Calculated on the basis of 230 work days per year, a product leaves the plant every second.

This is made possible by a high degree of automation: With the exception of the setup, repair and maintenance work, virtually nothing is done manually at this plant. Sixteen production lines work around the clock. Every hour, each of them assembles 150,000 electronic components. All along the way, sophisticated information and communications technology ensures that all processes are synchronized in ideal fashion. That makes it possible to achieve a production quality level of 99.9988 percent.

Specialists reinventing themselves

All that sounds a lot like perfection – and it doesn't sound very human. Automation has a reputation for being a job killer. Wherever machines and robots are used, there's less manual work to do. According to a study by the U.S. think tank Pew Research, 48 percent of the respondents expect robots and digital systems to lead to massive job reductions. Nevertheless, 52 percent expressed an optimistic viewpoint; they see automation as beneficial for the economy and for people.

One thing seems certain: manufacturing facilities aren't going to run completely without people. Instead, the type of tasks that skilled workers perform will gradually shift. "In the future, people will have less and less to do directly with the physical aspects of manufacturing, and they'll increasingly be taking on indirect roles and performing tasks such as controlling and monitoring," said Prof. G. Günter Voss from the Chemnitz University of Technology.

The customer has the choice

Skilled workers will take on a new role in manufacturing: "They must have the customer in mind and will no longer just be diligent laborers; they'll become service providers," says the industrial and technology sociologist. Here, Voss is addressing an important issue for the manufacturing of the future: the focus on consumers, who increasingly want customized products. Now, the challenge is to produce larger quantities at affordable prices – but in many more varieties. Things were different when mass production first began. Henry Ford famously said that customers could have their Model T painted any color they wanted, "so long as it is black."

In the meantime, car buyers choose more than the color of the exterior. They also select from numerous types of seats and upholstery and decide on the appearance of the dashboard and interior. Experts speak of mass customization and personalization. Customers should even be able to intervene in the production process via the Internet. "The step toward allowing even more variation to smaller quantities – while simultaneously enabling customers to become more deeply involved – is our forte," said Bauernhansl in summing up Germany's strengths.

Digitalization also makes it possible to achieve greater proximity to the customer in another way: companies can divide up their centralized production centers and manufacture at locations where there is high demand or a source of qualified employees. As part of a project supported by the German government, Adidas is exploring whether a global network of minifactories could replace the present global production strategy.

Developing and manufacturing products at diverse locations is nothing new. In the future, however, increasingly inexpensive automation will make it possible to produce goods efficiently wherever the customers are. Digital processes will soon make it possible to manufacture even the smallest quantities in the same quality anywhere in the world. Feeding the production facilities with the same information via the Internet will ensure uniform output.

On our way to the Internet of Energy

A growing trend toward decentralization has long been reality in the field of energy. Energy is no longer being generated at just a few power plants; more and more, it's being produced close to where it's needed – for example in mini, privately owned gas-fired power plants or in wind parks just off the coast

that generate power for entire cities. The challenge here lies in feeding this green energy into existing or new grids in a way that maximizes efficiency and minimizes the environmental footprint. Accomplishing that requires smart grids. They maintain the balance between energy supply and demand, thus preventing grid overload.

The municipality of Wildpoldsried in the Swabian region of southern Germany is a role model in this respect. This community, which has an international reputation as an “energy village,” generates six times more green power than it consumes. Here, software agents in the smart grid control the factors that endanger grid stability in other areas. This clever management is based on high-performance information, communications and sensor technology made by Siemens.

Patterned after the human brain

Smart grids transform the power grid, which was once organized in a hierarchical structure, into an “Internet of Energy” that generates valuable data. In addition to controlling complex energy systems, such grids enable remote monitoring and maintenance. They also form the basis for exciting research projects: Siemens specialists, for example, are teaching wind turbines to optimize themselves by linking together sensor data using neuronal networks, which are computational models that work much like the human brain. The wind turbines learn to adapt their operation to match weather conditions as closely as possible. That provides a basis for maintaining high electricity yields.

Ultimately, the benefits that intelligent digital solutions will be able to deliver in energy, industry and beyond primarily depend on the extent to which systematic efforts are made to continue their development. The EU Commissioner for Digital Economy and Society, Günther Oettinger, is challenging the German business community to tap into its tremendous potential. It, he says, can become the engine that drives digital progress in Europe.

“In 25 years ...

…much of humankind, perhaps more than a billion people, will be producing their own energy and sharing it via the Internet of Things, like billions of people do today with information.”

Jeremy Rifkin, economist

A smart combination

Companies can use smart data to unearth troves of valuable information – and gain a big competitive edge.

The term “big data” conjures up images of huge amounts of data, originating primarily from social media and IT but also including sensor data as well as log and measurement data from the Internet of Things. According to current estimates, the amount of data worldwide now totals one zettabyte – written as a one followed by 21 zeros. That’s one and a half times the number of sand grains found on all the beaches around the world. And in just five years, the amount of data will have increased forty-fold.

From information to knowledge

But data is still not being leveraged to full advantage. Delivery bottlenecks result in production downtime, for example, and blackouts paralyze cities – leading to avoidable losses in the millions. As Professor Gunther Reinhart, head of the Institute for Machine Tools and Industrial Management at Munich’s Technical University (Technische Universität München), notes, “We need to turn the flood of data into knowledge.” Smart data combines data analysis with a knowledge of users, devices and systems – technical expertise – and insight into the requirements of all involved parties. Reinhart cites the example of the supply chain in the auto industry: “An automobile seat undergoes a large number of integrated production steps in numerous countries before it’s installed. If there’s a delay during a single step, the entire supply chain falters and is at risk of shutting down.” But there’s no need for this to happen. Dr. Dirk Hecker, department head at the Fraunhofer Institute for Intelligent Analysis and Information Systems (IAIS), explains: “When intelligent statistical models that have been trained with historical data are used, unusual events can be detected early on. In the case of automobile seat installation, intelligent data analysis makes it possible to detect supply bottlenecks, predict possible repercussions and propose alternatives.

Predicting the future by recognizing patterns

In the energy and healthcare industries too, devices and systems are equipped with sensors that capture vast quantities of data. This makes it possible, for instance, to perform maintenance on complex systems at a distance. As an innovation leader, Siemens provides such remote service. Some 280,000 systems around the world – including gas turbines and traffic management systems in 255 cities – are connected to Siemens’ remote service platform. All the information that Siemens service technicians use to monitor operating statuses, eliminate errors and prevent failures is fed into that platform.

What’s more, smart data is driving innovation and research. Equipped with around 30 million sensors, the world’s largest particle accelerator, the Large Hadron Collider (LHC) operated by the European Organization for Nuclear Research (CERN), generates more than 300 terabytes of data a year. After receiving an alert, it used to take experts up to two weeks to pinpoint the source of a fault. Using Siemens’ new analytics software, it takes only half an hour. Beginning in 2017, this software is also to be used extensively in regular operation.

When data is turned into information, the edge that’s gained extends beyond knowledge: in Germany, revenue from big-data solutions is expected to jump to €13.6 billion in 2016 – twice the figure for 2015.