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Industrie 4.0 – from vision to reality

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Industrie 4.0 – one approach to the challenges of the process and manufacturing industries

Companies in the process and manufacturing industries are facing some enormous challenges. These include not only tougher competition, but also mounting cost pressure. At the same time, products, processes and technologies are becoming increasingly complex, innovation cycles shorter, products more individual and resources, such as energy or raw materials, more and more scarce. The vision of Industrie 4.0 points to one possible solution, featuring flexibly organized production systems, and integrated networking of all stages of the value chain.

Globalization with demanding challenges for industry

While globalization offers huge opportunities, such as bigger markets, better procurement conditions, and more favorable production conditions, it does create some demanding challenges for industry as a whole. For example, companies must constantly boost their productivity and flexibility and market new and more individual products with higher performance and efficiency levels in ever decreasing cycles to withstand the glare of global competition.

Digital processes - the technological foundation of successful companies

Successful enterprises are handling these challenges better and better. They are doing so thanks to a combination of production using fewer and fewer resources,
flexible mass manufacturing (mass customization), and the integration of process steps from the customer back into the network of suppliers. The use of innovative, fully digitalized processes and industrial hardware and software based on open standards forms the technological foundation for this. This is where the much discussed vision of “Industrie 4.0” comes in. It envisions comprehensive networking of distributed production technology and embedded controllers.

**Industrie 4.0 with three core elements: production network, product and production lifecycle and cyber-physical systems**

In our view, Industrie 4.0 comprises three core elements. In the first, the production network, manufacturing execution is playing an ever greater role. Interlinking of manufacturing execution systems (MES) with the automation level will continue to increase, not only within one location of a company but also across company boundaries. The integration of the ERP (enterprise resource planning) and MES levels will progress further to create complete transparency and a linkup to the business administration data. All the necessary information will then be available in real time across company boundaries. The second core element describes the merging of product and production lifecycles based on a uniform data model. Only then can the requirements resulting from ever shorter product lifecycles be technically and economically managed. The third core element are the cyber-physical systems (CPS), which are the basis for greater flexibility and therefore shorter times to market. These production units can be flexibly integrated into existing production processes.

**Industrie 4.0 with three fields of action: manufacturing operations management, cyber-physical systems and digital enterprise platform**

Our way of making Industrie 4.0 tangible and real consists of three main activity areas: Powerful manufacturing operations management, the digital enterprise platform for integrating product design and production engineering, and cyber-physical systems, which can be flexibly integrated into existing production processes.
Manufacturing operations management

The potential for manufacturing companies is significant: in Industrie 4.0, products, conveyors or tools intercommunicate and organize themselves with the help of sensors and RFID chips, to optimize production, even across the boundaries of individual companies. In this production world, the product itself is an active element of the production process, in which the virtual and the physical worlds intermesh seamlessly because each element exists both physically and as a virtual model. The production systems are networked both within the individual process steps as well as with the business administration processes of the producers. The result is a holistic system comprising the development of products or production plants, but also the production itself. Ordering processes, sales, logistics, services, and corporate management are likewise integrated.

Cyber-physical systems

In Industrie 4.0, products possess all the information that is necessary to manufacture them. They can be identified and located in a network of cyber-physical systems (CPS) and they know their own history, their current condition and alternative ways to achieve their target condition. This results in a network of machines, warehouse systems, and resources that exchange information in real time.

The CPS work out permissible scenarios by simulation based on the virtual modules, compare and evaluate them based on currently valid optimization criteria, and then determine the best possible combinations. For example, if a production machine is busy or defective, the workpieces will make their way to another machine that is free. If quality defects are revealed during production, a message is sent to the relevant upstream station so that the cause can be automatically remedied.

Thanks to the development of new monitoring and decision-making processes in production, value-add networks are controlled and optimized. This type of production promises significant benefits. On the one hand, vertical integration of processes and production systems permits, for example, closer connection of ERP and production systems and therefore holistic corporate management. On the other hand, horizontal integration via global value-added networks permits end-to-end
transparency, flexible responses to changes or disturbances in the market, and optimization of all stages of the value chain.

**Digital enterprise platform**

"Industrie 4.0" is not a project with a defined end. For many experts, it is no less than the fourth industrial revolution, after mechanization in the 18th century, mass production based on division of labor through the introduction of the conveyor belt in the 19th century, and the use of electronics and IT for automation in the 1960s. "Industrie 4.0" is the description of an evolutionary process that will continue for many years to come. Its major facilitators are new technologies such as big data, cloud computing, or the Internet.

Many elements of this vision are already available today, such as the communication and networking of individual components, data integration of product development and production processes, and the integration of the virtual and the real world. For example, in terms of "Industrie 4.0," Siemens now already offers a wide range of components for fully integrated automation and drive systems and the Product Lifecycle Management Software, our "digital enterprise platform."

**Industrie 4.0: a start has been made, basic technologies already exist today**

The full potential of integration can only be leveraged when smooth data integration through all stages of the production processes has been achieved, from product design, to production planning and engineering, to production itself, to services, and back again. Ideally, this bidirectional integration will extend over the entire lifecycle of a product. A start has already been made because the technologies for merging the virtual and real production worlds already exist today and are in practical use. In this system, planning, simulation, and optimization of all steps of the value chain are performed in a shared virtual world before the first machine even starts up. It is not just the product that is developed on the computer, but also its production. Information from the real world of production is fed back into the virtual world in parallel for ongoing optimization. This provides considerable productivity gains and shorter times to market.
Still many questions on the way to Industrie 4.0

There are still many questions to answer before "Industrie 4.0" fully becomes a reality. This especially applies to international standards, which are still lacking in many cases. New security concepts also need to be developed. This is because all industries have a vital interest in securing their know-how and their value-added networks. Hardware and software also have to be constantly developed. Further work has be done on partially autonomous optimization, semantic standards, and dynamic architecture concepts to enable flexible and increasingly innovative types of cooperation. But "Industrie 4.0" also needs people who understand these cyber-physical systems, who design and orchestrate their use in newer and newer forms that keep changing as technology evolves.

The importance of people with their creative abilities is increasing

Critics of Industrie 4.0 fear that it will lead to factories without human beings and depersonalization of production. But the opposite is true: the importance of people will increase. In the creative areas of production - for example, product and production design - human intelligence will remain indispensable in any case. And at the operative level, employees will play a central part, but then primarily as creative planners, controllers, and supervisors rather than operatives performing manual activities. And, finally, in many cases, business models, internal processes, and value-add networks will have to be re-thought and re-implemented, tasks in which machine can never be a substitute for human beings. The resulting challenges for training and lifelong learning call for special attention.

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