SIEMENS

Technical article

On the way to the factory of tomorrow

Digital connectivity as key concept for future-proof production design

How can companies create a true competitive advantage from digitalization? New production methods and production designs allow manufacturers to combine the apparent contradictions of economic efficiency, scalability, and flexibility into one concept. But the foundation is formed by data from the field – for which high-performance communication technologies and network architectures are required.

Flow – a small word describes one of the most important principles for the design of a modern production. It's about keeping the production process going. Materials and semi-finished products must be kept in a continuous process of value creation without hindrance – to prevent wasting resources or time. Stoppages at certain production steps due to defective machines, missing materials or bottlenecks must be avoided at all costs.

However, the flow as a value stream is not a new invention, but ultimately based on the invention of the assembly line production. In contrast to a manufactory production in which a craftsman carries out all production steps by him- or herself, the flow production is characterized by a high level of division of labor and minimized setup or adjustment work. Producing as many common parts as possible is the basis for efficient economies of scale in the classic assembly line production.

Production structures must become dynamic and flexible

But the markets have changed. For one thing, many industries are highly competitive with companies having to constantly adapt to the requirements of the customers. On the other hand, this means that the production program is continuously being expanded: If customers have a choice, and there is any doubt, they will choose the product that best suits their needs. In the auto motive industry, this effect has led to the fact that there are no two vehicles

At the Siemens plant in Karlsruhe, automated guided vehicles (AGVs) are replacing the rigid linking with materials handling technology.

alike in the luxury class. And third, the volatility is increasing: Markets and demand are becoming less predictable – so that investing in rigid production structures represents a growing risk.

This not only affects producers of consumer goods, where the demand for specific products can change from one season to another. In the business-to-business (B2B) sector, too, similar market structures are increasingly being observed. The demand is becoming ever more specialized, and a large number of manufacturers are ready to implement even special requirements with optimum efficiency. New technologies like adaptive manufacturing do the rest to realize a “lot size of 1.”

However, the classic flow technology linked to permanently installed conveyor technology is reaching its limits. If more and more variants are produced, special machines are increasingly needed, but they are really only used for comparatively few variants. However, the more or less tight linking makes it difficult to respond quickly to demand fluctuations. A production either builds its own “special line”, which then though only holds a fixed capacity. Or special machines are integrated into several lines, with a resulting low utilization.

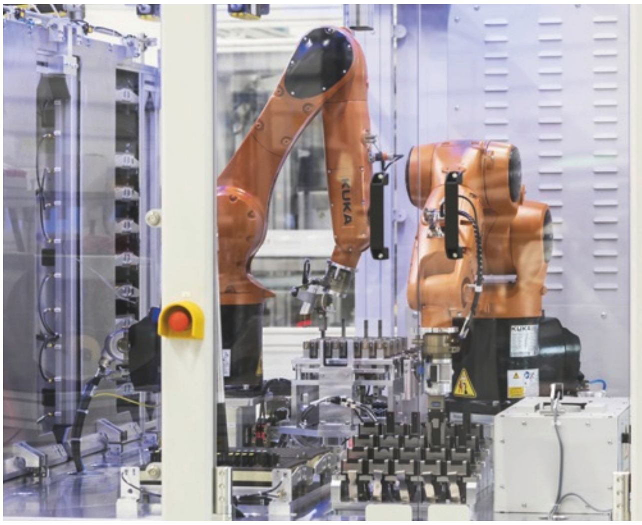
The Siemens plant in Karlsruhe (Manufacturing Karlsruhe, MFK) answers this challenge by replacing the fixed linking with a dynamic system called “matrix flow production”. Here, automated guided vehicles (AGVs) provide the material flow between different stations and production lines.

The advantage: This highly flexible method makes it possible to optimally utilize the expensive special machines without affecting the capacity of the overall line.

Digital connectivity as key concept

The basis for this methodology is the concept of digital connectivity, which means that all relevant manufacturing objects possess digital communication capabilities. This is done either via an integrated interface, if the corresponding equipment features its own control unit, such as with AGVs or mobile machines. A second possibility is the use of wire less technologies such as radio frequency identification (RFID) or real-time locating system (RTLS). This allows objects such as bins, containers, tools or materials to be enhanced with a certain degree of communication ability. The third option lastly is to use existing sensor data, which is normally evaluated in the local controller. For instance, a temperature sensor that actually only controls overloads could also be permanently analyzed for predictive maintenance. Since field sensors usually do not provide an Ethernet-enabled interface, the data can usually be tapped via the programmable logic controller (PLC). For example, Siemens offers two corresponding modules for the SIMATIC S7: CP 1545-1 for a TIA-integrated configuration, and SIMATIC CloudConnect 7 for the communication with existing machines.

These field-level communications technologies are routed in a second layer through an industrial network that is specifically tailored to Operational Technology (OT) requirements. While office networks primarily focus on fulfilling



Digital connectivity delivers the data for predictive maintenance.

user expectations (ease of use of services, confidentiality, bandwidth), in factories it is important to guarantee the availability of the network with the latency required. A second difference arises from the communication: In office environment there are almost exclusively vertical communication connections between end devices such as desktop PCs, tablets, and printers to servers. In the factory network, on the other hand, horizontal communication dominates, i.e. between machines and plant sections. Third, for industrial networks, the continued functioning of segments is required even when higher-level layers have failed, e.g. to ensure a controlled shutdown of complex plants.

Of course, the differences have to be considered when selecting components and designing the network. Switches, routers, access points, and gateways must always be designed to meet the requirements of the relevant environment: Rugged plug-in or screw connections guarantee communication even in the event of shock and vibration. A high degree of protection against dust and moisture ensures the long-term availability of the devices. And a sophisticated design allows for easy installation, commissioning, and use of the devices in daily operations. For this reason, Siemens has, for example, developed the SCALANCE XP200 switch family, which offers a high degree of protection (IP65) and screw connectors.

Connections to the platforms

Finally, for digital applications, the connection to the platforms is important – whether as cloud, on-premise or edge solution. For this, suitable data aggregations and event-oriented protocols are necessary to generate actual information from continuous data noise for the realization of digital applications. Also essential for this is the appropriate formatting of the data and the transmission of the corresponding semantics. After all, real information is supposed to arrive at the data lake that can be used company-wide regardless of the manufacturer of the production equipment and regardless of the plant location. A suitable description of this data can be ensured by the OPC Unified Architecture (OPC UA). OPC UA is not only grammar for the Industrial Internet of Things, but also a complete architecture with possibilities such as cyclic or acyclic communication, method calls, and security mechanisms.

However, for OPC UA to become an actual language, the so-called companion specifications are required. On the one hand, joint working groups of manufacturers or industry associations and, on the other hand, the OPC Foundation as "master of standardization" define domain-specific agreements on how certain technical objects are modeled. As an example, a temperature sensor: The value can be transmitted in degrees Celsius or Fahrenheit, or in Kelvin, as an integer or decimal number, with an identifier of "t", "temp", "temperature" and so on. The companion specifications therefore provide a precise definition so that all manufacturers of sensors can use the identical data model. Increasingly, the harmonization of the various companion specifications is coming to the fore.

Besides the technological perspective, it is also important to bear in mind the system and the implementation. To achieve minimum engineering and operating costs, a seamless interaction of all components is paramount. Siemens, as a solution provider, demonstrates a real advantage here: all products are configured and diagnosed in the TIA Portal. For larger communication structures, the network management system SINEC NMS can be used. So that the actual architecture meets the requirements, a design consultation by the manufacturer's experts is recommended.

The transponders with ePaper display from SIMATIC RTLS enable novel interactions between man and machine.

Application scenarios for the factory of tomorrow

How can real added value be created from this architecture? Let's take another look at the Siemens plant in Karlsruhe. In addition to the control of the AGVs, which are connected to the control system via IWLAN components from the SCALANCE W family, and the monitoring of load transfers via SIMATIC RFID readers, there are many other application scenarios that support the digital transformation of the production. For instance, the maintenance work at the robots used could be planned better via a cloud connection. To this end, various parameters from the field level, such as current consumption, acceleration behavior or service life, are sent as a data stream to an application, which can then predict possible wear. The material flow – especially at the interface from man to machine – can be optimized through the use of real-time locating systems such as SIMATIC RTLS. On the one hand, every product – no matter where it is located – can be found at the push of a button. Search times are eliminated in particular by the fact that the location is continuously reconciled with the information in the merchandise management system. On the other hand, the new SIMATIC RTLS transponders with ePaper display offer the possibility for a dynamic, location- and status-dependent communication with employees – replacing printed delivery notes with manual additions. And finally, even the concept of predictive quality statements could become reality step by step. The idea here: Through the continuous comparison of measured values and test results from the line and the results of the final quality check, models for predicting product quality could be made with big data approaches – so that a complex final examination is only required on a case-by-case basis.

Contradiction resolved

The examples show that productivity through new digital methods is possible and can raise the quality of products and processes to a new level. But this not only requires new production methods and IT platforms, but above all a high-performance, flexible, and future-proof communication architecture. Digital connectivity is the deciding factor for the factory of the future.

Security information

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept. For more information about industrial security, please visit

https://www.siemens.com/industrialsecurity

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