Article

Smart Factory 2025

Tomorrow’s production

DETECON
CONSULTING

Smart Factory, the production of tomorrow and many other keywords revolve around the representation of modern factories. How must or should a factory look like in 2025? This question is addressed in the following article. Let's start by saying that individual technologies will not shape the factory of tomorrow.

The motivation and supposed potential of a Smart Factory (or whatever you want to call your new factory) has already been adequately informed by various analysts and even more by corresponding product manufacturers and consulting firms. To what extent such statements - especially those of the analysts - apply, may everyone decide and judge for himself. The current examples, e.g. from SEW Eurodrive, are evidence of double-digit productivity increases. Overall, the aim is to increase flexibility, speed, efficiency, sustainability and, in the face of demographic change and a shortage of skilled workers (at least among skilled workers), to position the company as an attractive employer.

In general, a Smart Factory is the optimization of the customer order process. Analogous to Smart Products, where the optimization of the product development process and its products is in the foreground. Smart Services, on the other hand, is ultimately about new business models (see Fig. 1).

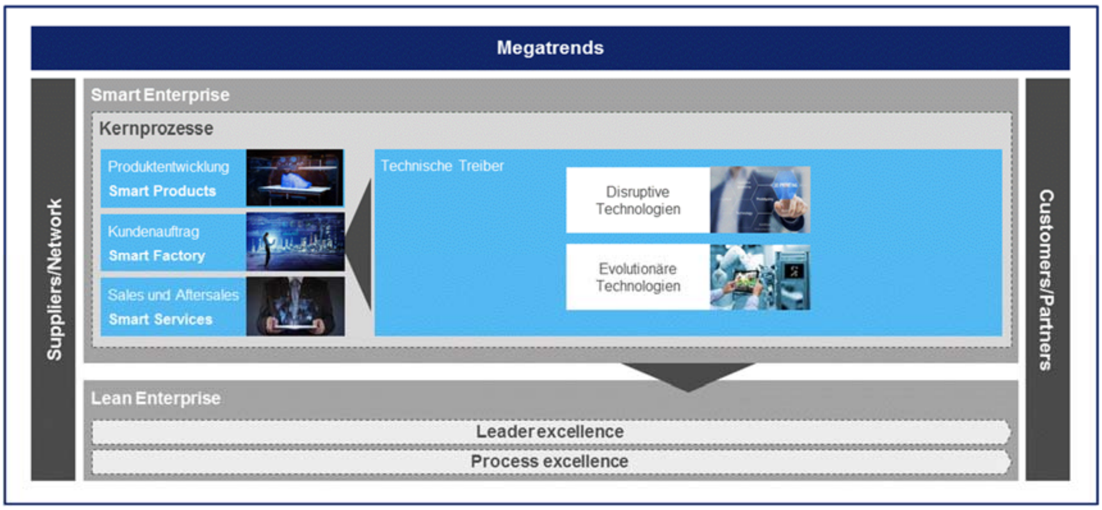

Fig. 1: Classification of terms: Smart Factory, Smart Products, Smart Services
Source: Own image

Challenges

It may sound surprising, but the factory of tomorrow has little to do with specific technologies. This is even more surprising since people are constantly talking and even more arguing about new technologies around a Smart Factory. In order to be fit for the future, technology must be planned and used in such a way that it is simply interchangeable. This results from the ever-faster changes and the rapid development of technologies and, above all, their combination. Furthermore, technology is primarily an enabler for optimizing the customer order process, i.e. all activities from receipt of an order to delivery of the product(s) to the customer and thus ultimately to increasing customer benefit. The focus on customer benefit comes, among other things, from the world of Lean. We will occur such considerations more often. But technology is also a driver of change. In order to achieve the interchangeability of a single technology, OPC-UA is often used as a solution for this requirement. However, this standard alone won´t solve the problem. In principle, machines, systems and tools can be integrated here in a standardized manner. However, a concrete description of how this standard is to be applied is required. This is illustrated by a profane example. RFID is one of the basic technologies for a Smart Factory. In order to be able to identify parts, a uniform definition of the marketing of these parts is required. Here, both, the suppliers and the own production (keyword: house parts) must be taken on board. In conclusion: Technology alone won´t solve the problem – even if RFID tags can be embedded wonderfully in the rest of the structure via RFID. In addition, the efficient use of RFID also requires a change in processes and the associated processes. Thus, the whole thing is much more than “just” technology. The same applies to machines, systems and tools. Here, appropriate specifications are required as well.

Requirements

Back to the beginning: A central requirement of a Smart Factory is its versatility. Unfortunately, however, this is only one requirement – admittedly an important one, but still only one. A Smart Factory must also meet other requirements. These can be divided into those for:

- People
- Machines
- Facility
- Digitization
- Products
- Logistics
- Production and value creation system

See also Fig. 2.

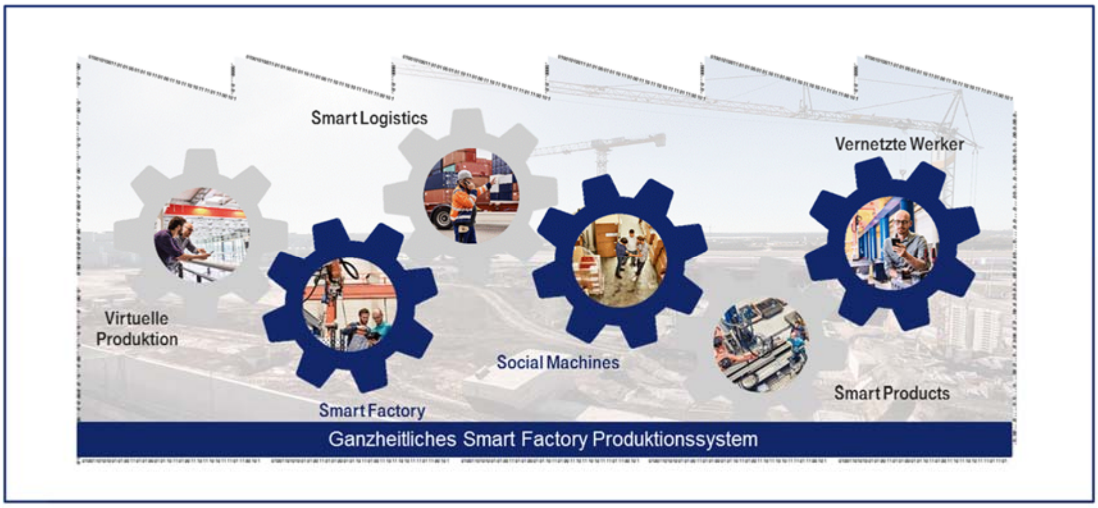

Fig. 2: The Vision of a Smart Factory
Source: Own image

The widely propagated lot size 1 does not necessarily apply to all industries. In 2025, too, there will be “off-the-shelf” products and thus lot sizes significantly higher than 1 in their production. Nevertheless, it is a maximum requirement.

Now we go in media res. Due to the complexity and multidimensional nature of this topic, the individual points can only be hinted at. The vision of a Smart Factory should be made clear irrespective of this. The specific form depends on the industry and the situation. For example, a Smart Factory will have different characteristics for each individual automobile manufacturer, such as Audi, BMW, Daimler or VW, as it does for their suppliers. The specific characteristics also depend on the respective production system (more on this later). The same statement applies to other industries as to the automotive industry. For space reasons only a general consideration is made here.

The Digital Twin as important element of digitization

Now we´re slowly getting to a central topic – the penetration of the new factory with data and thus also its digitization. Here we do not consider their specific technical implementation. Currently, the digital twin is being propagated as a central solution. Unfortunately, there is often no clear definition of its functional scope. Rather, it is considered a “panacea”. Hence a short description. All physical objects should be represented in the Smart Factory. (at least in 2025) by corresponding digital images. This also determines the granularity of the digital image. In concrete terms, it means that every machine, every tool, every part and every product to be produced has a digital image.

As a result, the digital image of the real factory contains a large number of twins including the factory building, see Fig. 3.

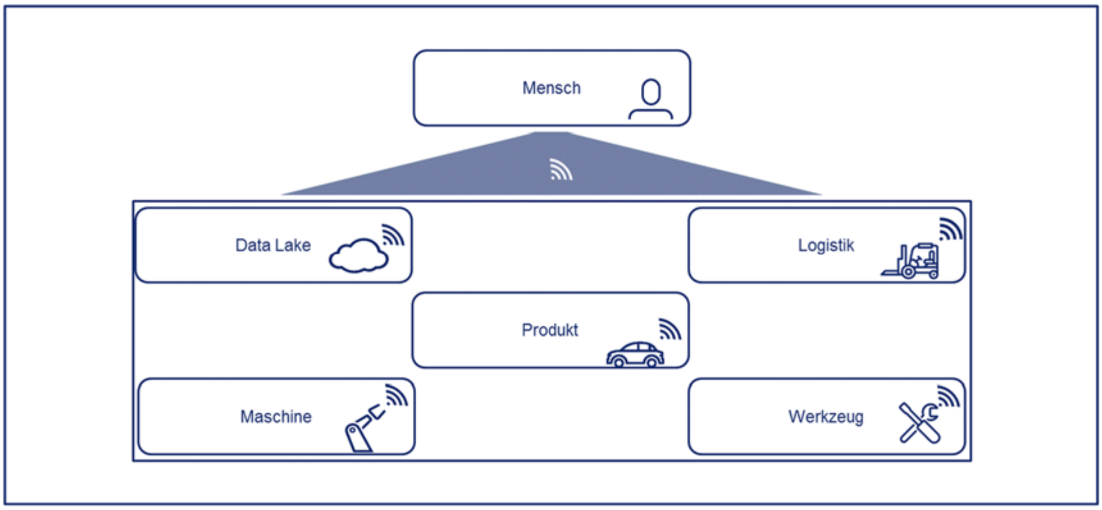

Fig. 3: The interaction between Digital Twins
Source: Own image

Even each container, autonomous transport unit, (sensitive) robot has its own digital twin. The twin describes the functionality of the real image, but also stores the state and other important data. Therefore, a distinction is often be made between different versions of a digital twin, i.e. the respective product in the form of design drawings and its implementation (cycle time, production errors, reworking), see also Fig. 4 and Fig. 5. This also includes the use of the product by the customer. The digital twin has already been explained in the detail in the article ("Digital Twin"). The Digital Twin, for example the factory´s, can thus be understood as a composition of individual digital twins. This also applies to machines and products. All in all not really easy.

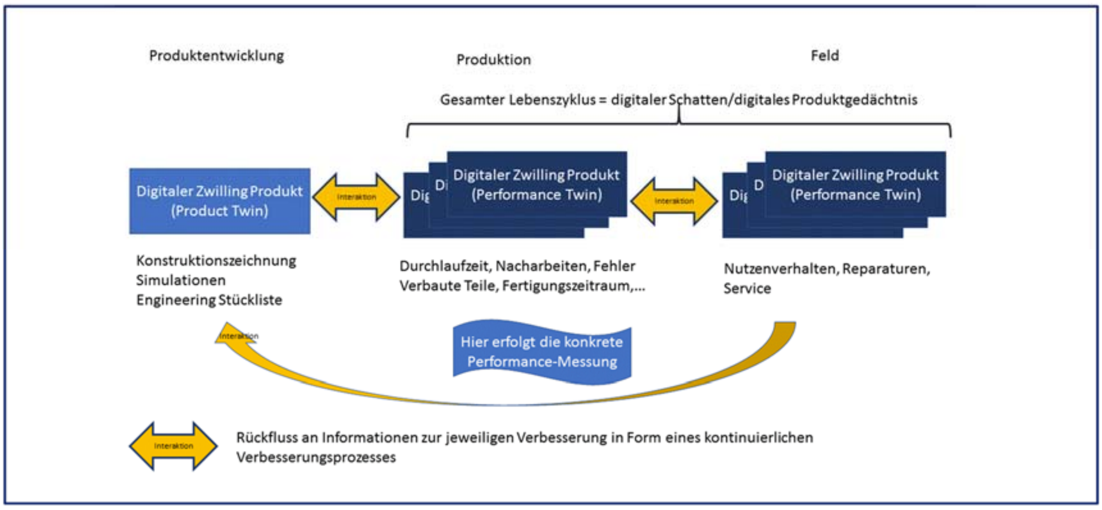

Fig. 4: Concrete forms of digital twins
Source: Own image

The individual concrete elements interact with each other. Their technical implementation will not be discussed here any further. It has already been mentioned that technologies should be designed to be interchangeable. Currently, a Data Lake and thus a Big Data system is the ideal "storage location" (whether logical or physical is rather secondary) for all the twins. This results from the very different data formats and types of data (structured, unstructured and semi-structured) and not to forget the sheer volume of data and requirements, such as real-time capability (more on this later).

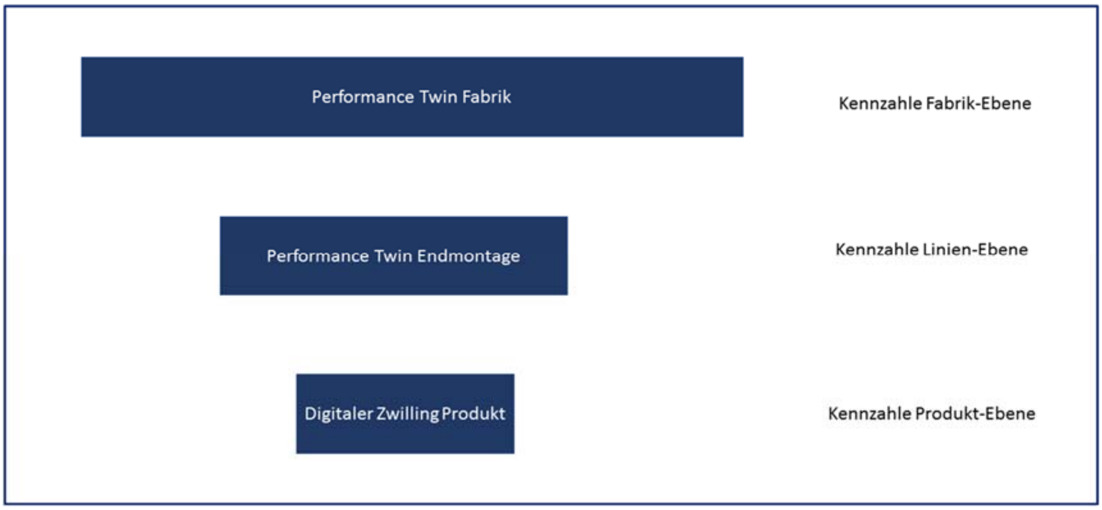

Fig. 5: Performance twin hierarchy
Source: Own image

The digital twin (or twins) can now be accessed via corresponding applications. PLM systems are the “first” users and producers of data in the overall process – at least for the product.

The connection between the two worlds is based on a clear identification of all (smart) actors in our new factory. This is done using a separate IP address for each actor (i.e. machine, part, …). This can also be used for reconfiguration or replacement. Here, the identification of a part or product (e.g. using RFID) must not be confused with reconfiguration. These are fundamentally different things in terms of both motivation and implementation.

You can see that the necessary data (from the sales order, production order, routing, inspection plan and so on) must be updated and be available in the correct form. A Smart Factory is absolutely dependent on a high degree of data quality. Nothing works without that. This may sound simple but can be extremely challenging in reality. The integration of individual IT systems alone is a non-trivial matter in large companies.

Smart Machines

Unfortunately, what has been said so far does not really help – because the approach is too individual. All the twins in their different forms must be able to build up knowledge about themselves. In concrete terms, this means that they must “know” what functionality they have. Here, too, OPC-UA comes to mind immediately. Unfortunately, jumped too short again. Machines and systems should also be “intelligent”, i.e. self-controlling and thus self-learning and self-optimizing. The functionality is therefore not a static matter, but unfortunately (from the implementation point of view) a dynamic one. This must be taken into account in the description and implemented accordingly. The machines communicate with each other and exchange data as required. Thus, they also have communication units – i.e. they are CPS (Cyber Physical Systems). Unfortunately, tool management is neglected in the discussion. Here, appropriate smart solutions are needed, too. Automated documentation is essential. It contributes to ensuring the required quality.

Smart Products

Parallel to the machines and tools, the products to be produced are of course also becoming smarter – i.e. more intelligent. Through the Digital Twin, they get “a consciousness” (this should not be taken to literally). They get knowledge about their condition, how to produce them and are able to self-control them. This is illustrated using the example of the car. The functionality of autonomous or semi-autonomous driving would enable the cars to control themselves through final assembly (from the “Wedding” for example). In conjunction with smart machines (for example in the form of autonomous transport units), decentralized control of production and manufacturing is ultimately possible. This control must be aligned with the customer´s cycle (Lean says hello). The monitoring of such new approaches by humans will be an enormous challenge for them or have you ever monitored a swarm of bees?

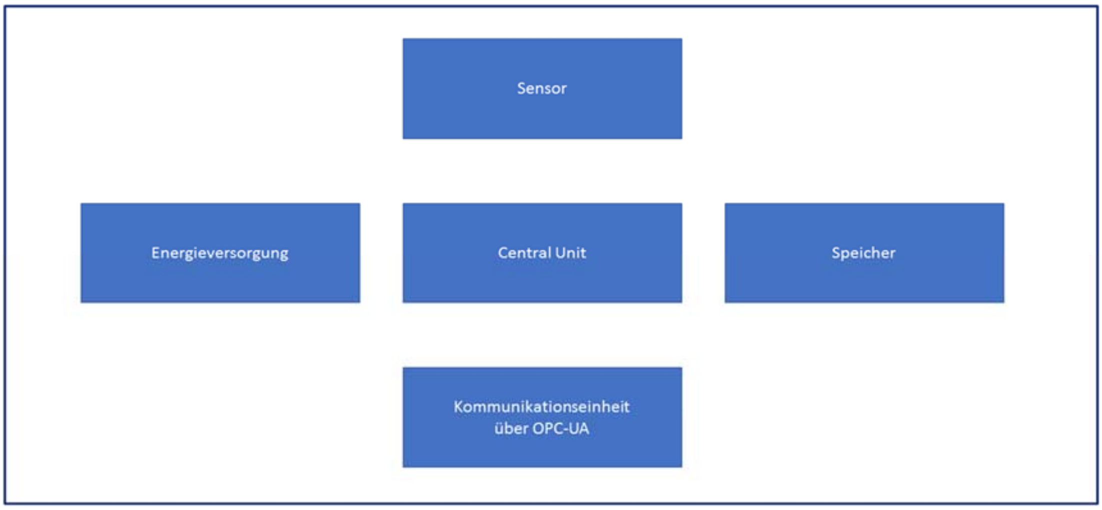

Fig. 6: Schematic representation of smart sensors
Source: Own image

Smart sensors help with both, the machines and the products, see Fig. 6. Intelligent containers are a striking example here. Smart products also require an appropriate infrastructure to exploit this potential, see Fig. 7. These are not only needed when the beautiful new products are delivered to the customer, but also for their production.

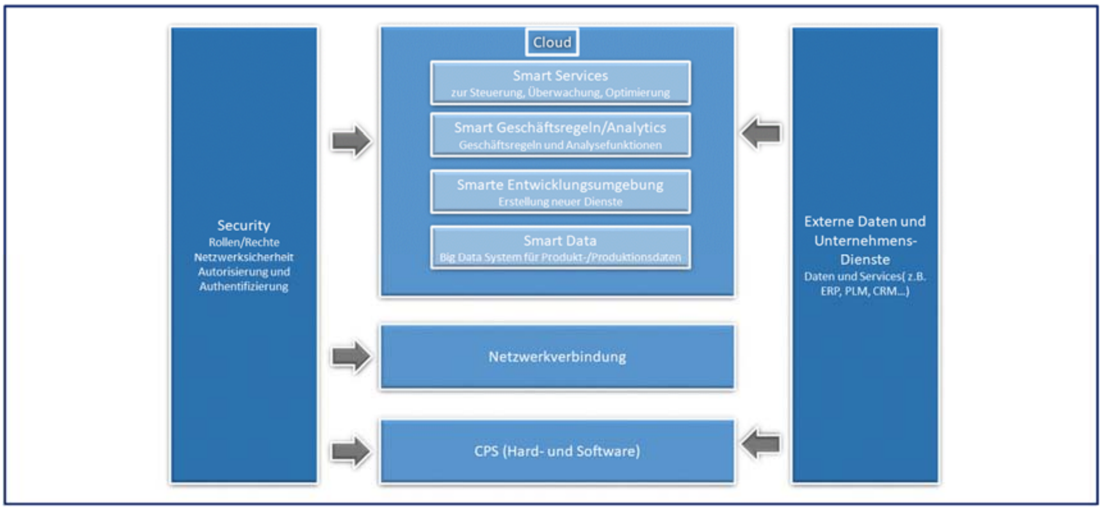

Fig. 7: The concept of a CPS infrastructure
Source: Own Image

However, the approaches outlined so far are still too short, i.e. they ignore central points. Work plans and inspection plans control the products through production - also in 2025. The individual work steps and their quality check are stored here. In order to do justice to the increased flexibility, both would not only have to be linked with the engineering and production data, but also generated as far as possible from corresponding 3D models (automatically). This is likely to drive experienced production managers to their forehead. Surprisingly, "good old Lean" helps here once again. The keyword here is standardization and modularization - which computer science has virtually internalized. This also brings a completely new dimension to vertical integration, but it is already quite demanding.

Digital Factory

As a result, the image of a digital factory has changed considerably and thus expanded its functionality, especially if the VDI 4499 is taken as a basis. Admittedly, the directive dates back to the years 2008 to 2016. A "face-lift" is certainly appropriate - especially in the context of a factory for the year 2025. Via the digital factory, the physical factory should finally not only be planned, but also monitored and continuously improved, which is already mentioned in the mentioned standard. A real-time representation of the processes in the real factory is required for control. The most different digital twins help here of course immensely. This is not only true with regard to control - much more so to master the entire complexity and also to handle a migration of an existing factory (Brown Field approach). After all, it does not always necessarily have to be a new factory. The integration of the individual twins into a digital factory will therefore still occupy the companies in the next few years. All in all, the entire physical value stream is digitized, which represents a significant efficiency lever.

In order to use the hoped-for potential of the individual twins and the digital factory, the already mentioned Data Lake or Big Data System is also required. Big Data and Advanced Analytics represent the "brain" of the digital twins. This will be used at the end of the day to control and continuously improve the Smart Factory - hopefully.

However, the digital twin is not the only "new" thing in the digital factory. The already mentioned extreme importance of data and information modelling is currently still neglected. In 2025 there will be a continuous mapping of data and information - because without it there will be no functioning Smart Factory that will meet our initial goals. There must be transparency as to which data is generated and required where. Otherwise nothing runs in the new smart world. TOGAF and a capability map help with the extensive modelling.

The human factor

Of course, people will still play a central role in 2025. Even then, the factory will not be deserted and it will not control itself completely autonomously. Statements to the contrary testify rather to a certain incomprehension with regard to the complexity to be depicted. Also for economic reasons, such a scenario makes little sense. Admittedly, here we make a powerful "shot into the blue".

Analogous to Lean transformation, the tasks and contents of employees in production will be subject to very strong change. Demographic change is helping to cope with increased productivity. The proportion of producing activities will decrease in favor of monitoring tasks. As a result, the demands on employees in production increase enormously and constant further training is indispensable. To what extent a differentiation between "Blue Collar" employees and "White Collar" employees makes sense is left to the reader. The increased complexity forces to a clearly improved support of the employees in production. Augmented reality and virtual reality solutions in connection with tools from the 3D printer will have an important part here. In innovative companies, mobile solutions are already widespread today. The employees, regardless of their position and task, will therefore interact and act in a networked manner with each other and with machines. In order quickly act and react to events that occur, decisions will be very data-driven. Real-time capability is the order of the day here. All those involved in the process (not only humans, but also machines) are supported by Advanced Analytics approaches. These will continue to spread in production and contribute to the sustainable optimization of processes (not only through predictive maintenance and quality, but also with regard to the entire production system and production control). In the course of these changes, the organization must not be neglected. Due to the shorter product life cycles and the associated faster product changes, it makes little sense to optimize the organization around the products. Flat and flexible (i.e. agile) structures are called for.

Digital Logistics

Changing logistics is necessary to maintain the necessary adaptability. In a Lean sense, logistics efforts are a type of waste. This is necessary, but it must be minimized. However, in the sign of the Smart Factory, logistics is becoming very important. Autonomous transport units, organized in swarms and in conjunction with smart products and machines ensure a significant reduction in costs while maintaining or increasing flexibility at the same time. The annoying stocks can also be further reduced. RFID as a basic technology plays an important role here. Even here it should be clear, RFID is not the measure of all things. There are a multitude of technologies for tagging and identification. Here we should remember the beginning of the article - technology has to be designed interchangeably. In this context, the term "digital supply chain" is also being strained. This means that paperless and highly automated logistics (also within the company) must finally be implemented. This is particularly true of route trains. Autonomous representatives are already using BMW in Dingolfing or Spartanburg, for example.

Digitization enables complete transparency throughout the entire logistics chain, including sensor-supported monitoring of the transport route for correspondingly sensitive parts or products - the cloud and block chain makes it possible. Automatic gates, early detection of delivery delays, early warning systems in the event of supply chain disruptions (e.g. natural events) are just a few of the keywords that can be implemented in connection with Big Data systems.

Automated warehouses should further reduce logistical costs. This statement applies not only to large logistics centers, but also to "smaller representatives". Horizontal integration along the entire logistics chain is a central component of this and accordingly challenging.

Smart Facility

Of course, the factory building as such must also be transferred into the future. Smart sensors are also used here. The overall consumption of resources must be minimized - keyword: sustainability. Resources are a waste (again a reference to Lean, even if the topic is considered less intensively here). A Digital Twin of the factory building thus joins the long list of twins listed so far. As already mentioned, there is an interaction between the individual twins. Thus, the digital image of the factory building continues to be located in the digital factory, only functionally significantly expanded (interaction and control are mentioned here). As already mentioned, the digital factory will play a central role in our beautiful new Smart Factory.

The increasing networking and communication of all process participants also increases the need for a powerful, flexible but also scalable infrastructure. This must also be secure (keyword cyber security). This must be taken into account at an early stage in the overall planning. Edge Computing will replace the rigid SCADA architectures. Smart infrastructures help here. It simply does not help if new technologies are introduced, but the IT networks are not powerful enough and they have to be very powerful and flexible at the same time. Cloud-based approaches are therefore unavoidable. However, this does not mean that all production data ends up in the cloud. Here it is necessary to proceed very selectively.

Smart Factory Production System

Although Lean does not fit into the wonderful world of a Smart Factory for many protagonists, these ideas have considerable and also useful influence and significance. Rather, it is about transforming ideas from the Lean world into the world of a Smart Factory. Even in a Smart Factory, stable, lean and efficient processes are the measure of all things. How to define "stable", "lean" and "efficient" is exactly the content of the new production system. Nevertheless, we speak of a digital transformation. The integrated production system is part of this and thus exception.

This is often referred to as Digital Lean or Lean 4.0. As with the term Smart Factory, names are sound and smoke. Content alone counts. Individual elements from the production system, such as the shop floor meeting, are simply digitized 1:1. There are already very useful solutions around today. Other elements, such as the pull control, are not quite as simple. These have to be transformed within an autonomous, swarm-based and decentralized control system. Supermarkets must also be transported into the smart age. Automated solutions are the order of the day. It should only be noted here that decentralized control was already propagated in a Lean Factory - some 30 years ago. So it's about time to digitize things. Other approaches, such as customer orientation and batch size 1, are not really new for Lean supporters either. Reference is made here, for example, to the relevant literature from the 1980s.

With the factory layout, however, the minds and spirits are divided. Classic line production versus modular and island production. If you design a Smart Factory today, the line structure is certainly the measure of all things. This is especially true for high quantities and low variance. The situation will certainly be quite different in 2025. Especially in the automotive industry with a high variance but also a high number of units, the planning efforts will continue to increase until the said date. By combining digitized Lean production with smart technology-driven approaches, the automotive industry can certainly reduce planning costs by around 40%, personnel costs and space requirements by around 20%.

Thus, in 2025 (another bold "shot in the dark") the line structure will have been broken up in favor of modular and island-based approaches. Audi postulates an increase in productivity of around 20% through these innovative approaches. However, the effort to be made for a complete new conception of a flowing production should not be underestimated. Here it is important to find the "right" granularity of the individual modules or islands, which is also the reason why it will still take one or two years until robust solutions are found and those responsible are convinced. But there are still some years until 2025.

Additive manufacturing will make another revolutionary contribution here. Until then, product development had also switched to bionic design approaches. Their influence on production will be very dramatic. They will revolutionize the factory structure in the future, but not (yet) in 2025. All these points will have a considerable influence on the Smart Factory production system - it will be digitally transformed.

Changed Added Value

Last but not least, the shift in value added should be mentioned. Not only the factory is becoming increasingly digital, the products produced here are also subject to this change, irrespective of whether they are really still produced physically in the classical sense. Zero marginal costs in the form of complete digitization have a strong appeal to decision-makers. This phenomenon can already be seen very clearly in a wide variety of industries (such as the book/music industry or the automotive industry). The trend here will continue to intensify. From this point of view, too, the company's own production system must undergo a change. Added value is simply no longer generated exclusively in the factory buildings, but increasingly in product development. Today, product development is at odds with sales and after-sales who takes the lead. A redesign of the production and thus the value-added system would bring clarity (after agreement has been reached).

Conclusion

From what has been said so far, it is clear that building a Smart Factory is by no means a trivial matter. Technologies are already available. Solutions that can be used in practice for many requirements already exist - or it is claimed that these solutions exist - especially on the part of the product manufacturers.

A discussion that has hardly been held so far will revolve around data sovereignty in the future, so who owns the data that accumulates daily in production? An analogous discussion is currently being held about the data, for example in cars. This could provide machine and plant manufacturers with information on the user behavior of their products. On the other hand, manufacturers would give considerable knowledge of their production and production system away. The "battle is still to be fought," whoever emerges as the winner in the end.

Thus, a methodical procedure is required when converting an existing factory or redesigning a Smart Factory. Vision and a corresponding strategy derived from it should be at the beginning.

The Company

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Detecon International GmbH
Sternengasse 14 - 16
50676 Cologne
Phone: +49 221 9161 0
E-Mail: info@detecon.com
Internet: www.detecon.com

www.detecon.com

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