#65

ROI EFESO
MANAGEMENT CONSULTANTS

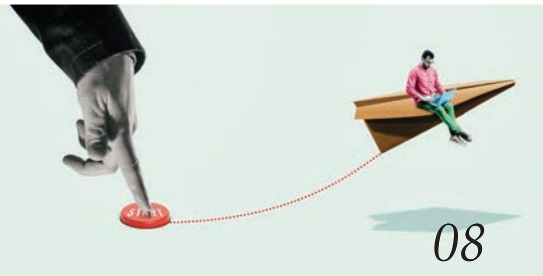
DIALOG

THE MAGAZINE OF ROI-EFESO
ENGLISH EDITION

The Industrial Next

Successful Projects by Industry 4.0 Thought Leaders

CONTENT



The goal: "Screentime Zero" - no worker should have to log on to a computer anymore.

"Our strategy is to replace calendar-based with condition-based maintenance."

Five elements to transform the whole production process to an agile on-demand manufacturing.

Issue #65

IMPRINT
V. i. S. d. P.: Hans-Georg Scheibe | ROI Management Consulting AG |
Infanteriestraße 11 | D-80797 Munich Phone: +49 (0)89 121590-0 | E-mail: dialog@roi.de | Board of Directors: Michael Jung, Hans-Georg Scheibe
Graphic/image rights: Unless otherwise noted, the image rights are held by ROI Management Consulting AG and the individual authors, Shutterstock and iStock.

SUSTAINABILITY
ROI-EFESO offsets its emissions according to the "Clean Development Mechanism" and uses the certificates acquired at "FOKUS ZUKUNFT" to support projects in two African countries that focus on self-sufficiency and security of supply in rural areas.

MIX Papier aus verantwortungsvollen Quellen FSC® C117056

The DIALOG magazine was produced on FSC® certified paper

THINK WILD!

For three quarters of a century, the ethnologist Claude Lévi-Strauss researched indigenous cultures and coined the term "wild thinking" for their way of understanding the world. This thinking is based on the belief that there is a kind of magical meta-system that connects everything that exists in the world. In order to tap into this system and its workings, and to situate their own actions within it, indigenous peoples use a technique that Lévi-Strauss calls "bricolage." This technique is based on the imaginative combination of resources, ideas, narratives, and intuitions guided by intuition and improvisation. In this way, "solutions" and contexts of meaning of great depth, inaccessible to rational Western thought, emerge in the indigenous world. Actually.

Because bricolage as a technique and method is rapidly gaining importance today. This could be due to the fact that we ourselves now live within a metasystem composed of data spaces, platforms, cloud infrastructures, databases, networks, data centers, protocols, connectors, and sensors. Within this system, fascinating opportunities are emerging to combine technologies, machines, concepts, and processes in novel ways, resulting in unexpected solutions.

Thought leaders and pioneers of Industrie 4.0 have succeeded in this in extremely different ways. Their projects range from increasing efficiency along the value chain to developing new partnership models and business models.

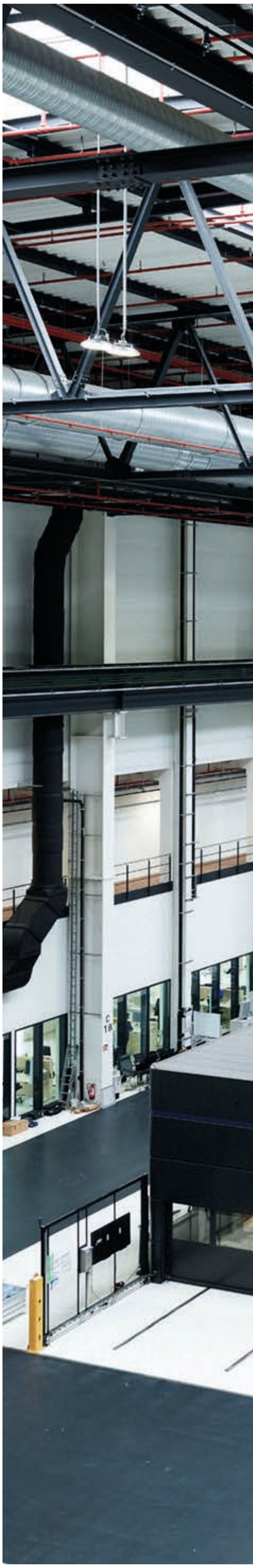
What makes them pioneers, however, is neither a particularly extravagant vision nor the development of fundamental technical innovations. Rather, it is the ability to combine resources and ideas in a creative way and to implement the resulting solutions consistently, comprehensively and sustainably. It is bricolage adapted for the digital age.

In this issue of DIALOG, we present some of these Industry 4.0 thought leaders and their solutions. Let them inspire you to think wild for once.

Hans-Georg Scheibe,
Member of the board,
ROI-EFESO

BUSINESS

INDUSTRY 4.0 PREMISES FOR THE SMART FACTORY



A factory visit to digitized heavy-duty cranes and smart parts presses.

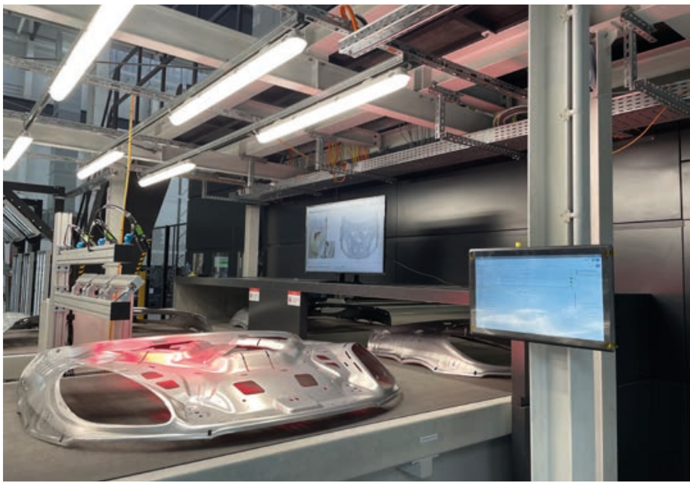
How bonnets, doors, tailgates and vehicle roofs are manufactured with future-oriented Industry 4.0 technologies can be experienced in action on the outskirts of Halle (Saale) since the summer of 2021. In about two years, a press shop for the production of car body parts was built there on a greenfield site. As a joint venture between Porsche and Schuler AG, the "Smart Press Shop" plant combines the expertise of a car manufacturer and press builder in order to jointly develop and realize new products. In doing so, Smart Press Shop acts as a neutral supplier on the market; all plant parameters are compatible with Daimler, BMW, and the VW Group.

Dr.-Ing. Timo Böhm, Project Manager, Smart Press Shop GmbH & Co. KG

A highlight of the plant is the fully autonomous set-up process for the provision of press tools, which enables competitive production of small batches. Closed cycles and operation with renewable energies also minimize CO2 emissions in the production of the outer skin components made of aluminum or steel. The number of suppliers of such components has been declining for some years, while at the same time the demands on product quality have been increasing. Against this background, the idea of implementing the smart and fully networked press shop based on Industry 4.0 technologies was born.

The highlight is a fully autonomous set-up process for the provision of the press tools.

© Schuler AG



© Smart Press Shop GmbH

> The fully autonomous setup process results in a 50-70% faster setup of the press line.

Automation increases efficiency

The plant is equipped with a forward-looking, vertically and horizontally integrated IT infrastructure to create the highest possible level of connectivity at all levels between machines and workers. But the project's objective encompasses much more than that, with seven Industry 4.0 premises:

1) **Vertically and horizontally integrated IT infrastructure:** Right from the start, data silos are to be avoided and the data flow is to be guaranteed despite the highest IT security. All machines and systems are connected via PLCs and networked in the cloud.
2) **Automated, self-optimizing processes:** This not only involves purely physical processes, but also automated order and feedback processes, (self-)optimizing straightening aids and camera-based process monitoring.
3) **100 percent paperless processes** in production and administration
4) **Digital documentation:** This includes, among other things, the topic of worker management. For the purpose of transparency and process optimization, manual processes are also reported back digitally.
5) **Real-time data available everywhere and at any time:** All information generated by the plants can be viewed and analyzed at any time and anywhere.
6) **Resource-saving production** through closed loops (Close Group Material), e.g. recycling of pure aluminium in a closed loop.
7) **Digital product and process twin:** All generated machine, operator, product and process data are stored at product level and are traceable for the customer. This is also used for big data analytics.

Already in the start-up phase of production, it became apparent that this approach works in practice and brings significant results. For example, due to a fully autonomous set-up process during press tool provision, the production team sets up the press line at least 50-70% faster than any other press shop. This enables competitive production of small batches.

Two heavy-duty cranes, each weighing 65 tons, play a central role here. These can load the press line equipment with the correct tools in parallel and fully automatically, depending on the incoming production orders. Not only is the tool store managed fully automatically, but the tools are also deposited automatically using optical safety technology. The pressing tools, which weigh several tons, are transported on and off by an autonomous tool crane, clamped automatically and media are docked automatically. In this way, the total setup time for the machine, including loading and distancing, is only three minutes. The time for production preparation, i.e. for transporting six molds to and from the line, can be halved or even tripled compared to a conventional press shop.

Increased productivity with reduced resource consumption

As a first mover, the Smart Press Shop project team had to overcome classic Industrie 4.0 challenges, such as compensating for a lack of standards in areas like IT security or digital documentation with its own solutions. In the process, major benefits have already been achieved: All workers as well as all machines and plants are networked via the cloud and all processes provide real-time data that can be viewed anytime and anywhere. This means that every part produced can be tracked from start to finish. However, positive results do not come "automatically" just from the availability of new technological tools. Ensuring the acceptance of these tools by the employees proved to be a decisive component and success factor of the project.

© Schuler AG

The key performance indicators of the Smart Factory speak for themselves: With an acceleration of the machining processes, the lead times can be reduced by a quarter. Set-up times alone are reduced by around 60 % thanks to fully autonomous set-up. This means that batch sizes that can be 60 % smaller are also possible, as well as 30 to 60 % lower inventories.

But of course, even a highly digitized smart factory is never completely mature. In the future, production planning will be supported to a large extent by AI. Currently, planning is mainly done manually in order to train staff on the processes. In addition, employees will increasingly use mobile devices such as smartwatches in the coming years.

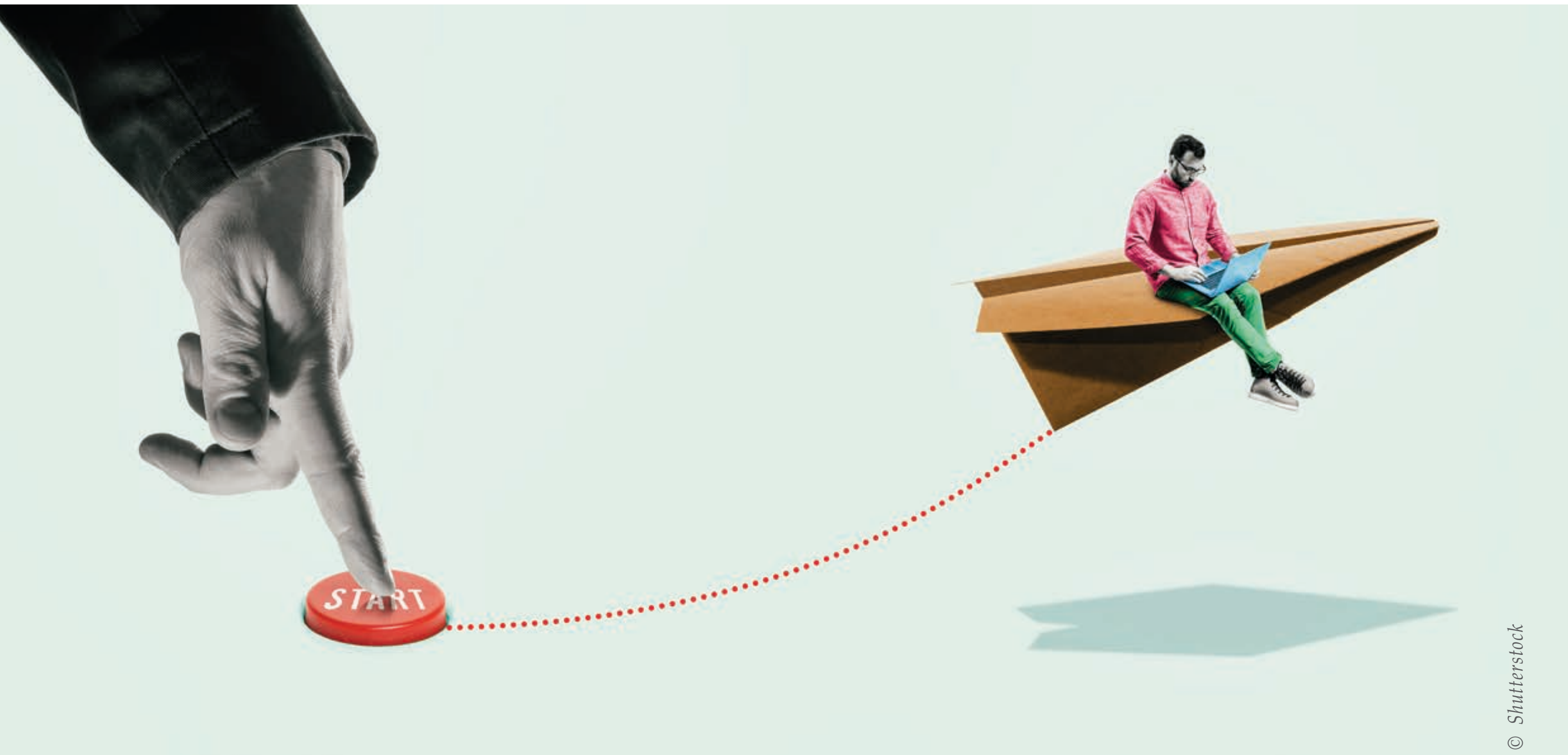
Another further development concerns quality management. Here, an optical quality control is planned that will enable fully automated defect detection and component-related defect analysis of finished parts based on cameras and with AI support. This makes deviations from the specified degree of perfection visible quickly and reliably and allows a closed quality control loop for the smart factory.

> In the future, AI will also support production planning and quality management.

Field of application: Automotive industry

Challenge: New construction of a smart factory with state-of-the-art IT infrastructure; high level of networking of machines and workers at all levels, 100 percent paperless production and high productivity with low consumption of resources as the most important objectives for the operation of the plant

Solution: Implementation of seven Industry 4.0 premises with a vertically and horizontally integrated IT infrastructure as the central element; all machines and plants connected via Programmable Logic Controller (PLC); processing of time-sensitive information and commands via Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA); all systems from MES level hosted in the cloud



BUSINESS

ON THE WAY TO "SCREENTIME ZERO"

Designing intralogistics lean: Digitalization of Kanban-based value chains.

As a subsidiary of Pepperl +Fuchs, a manufacturer of automation technologies, we develop Industry 4.0 solutions for the intralogistics of medium-sized companies. In this case, an automotive supplier commissioned us to make the delivery or provision of parts to its production lines as "lean" as possible. The goal: "Screentime Zero" - no worker should have to log on to a computer to book parts.

The company decided to digitalize its inventories and shelves in intermediate warehouses, which were already organized using Kanban. For this purpose, the processes were to be analyzed and optimized, and a complete solution was to be created that could also be integrated into other, already existing production or intralogistics environments.

Smart shelves: Detect material movements and process them intelligently

To solve this task, we combined three technologies to create a customized IIoT solution: In addition to RFID systems for identifying containers and material, this solution uses sensor strips specially developed for Kanban shelves to precisely locate and detect material movements in shelves. The data obtained in this way is processed using process-oriented cloud software.

> RFID systems are combined with sensor strips for Kanban shelves and cloud software.

All in all, we were able to fully digitalize the company's kanban-based value chain. This not only ensures more transparent, more efficient processes in the intermediate warehouses, but also enables the digital registration and "smart" processing of all material movements. In addition, a synchronous, digital image of the shelf stock can be created at any time in the cloud-side backend. The following functions and application examples illustrate how the solution works in detail:

Material staging with order-specific entry

In production, four forms of staging are common: The classic method is Kanban, i.e. , the material is always on the line and as soon as demand

© Shutterstock

arises, a signal is sent to the source in the warehouse. Other options are just-in-time production, the tightened variant just-in-time sequence and finally order-based picking. Our solution can support all four forms.

If there is a very large number of variants, it does not make sense to always have all materials on the line. In this case, we offer a hybrid solution and combine Kanban with order-specific provisioning. When the worker scans his Manufacturing Order, Kanban materials are in stock, but also a container with the order-specific components. For the logistician, this is exactly the same workflow, but it is controlled differently by the logic in the system. Since the manufacturing orders for the next few days are stored in the system, order-specific materials can also be staged on the line that would normally only be staged at the start of the order.

Material supply with automated picking orders

In every production line, material supply at the interface between warehouse/intralogistics and production is an important starting point for process improvements. For smooth workflows in the line, the right material should be available at all times in the (kanban) intermediate storage. Otherwise, missing components have to be removed manually from the warehouse, which can take up to 30 minutes and costs valuable productive time for the worker. Manual picks that are necessary several times a day reduce overall efficiency enormously.

We solve such situations by registering every pick from the Kanban shelf and, if necessary, the IIoT solution triggers a picking order in the warehouse, without any intervention from the worker. This works via optical sensor strips that are installed in the shelves and track every material movement.

Material flow control with anonymous containers

Another aspect is material flow control. Many of our customers work with Kanban containers that receive a fixed allocation to the material. When the material is used up, the exact container is returned to the warehouse and filled again with the same material. Our approach is to anonymize the containers instead, i.e., the picked material is newly paired with an anonymous, empty container of the same size, to which the corresponding virtual Kanban ID is assigned. Thus, processes can be parallelized and replenishment times can be reduced enormously. Depending on how far the warehouse is from the line, this can range from half an hour to half a day. Faster replenishment also reduces buffer sizes, saving valuable space in production. In various application scenarios, our customers have thus been able to extend their production by up to 10%.

Dr. Jörg Nagel, Managing Director, Neoception GmbH

Parallel supply processes reduce costs

In addition to the aspects mentioned, the solution also positively influences process stability and product quality. This was demonstrated in the case of another customer who manufactures highly individual control cabinets whose components are very similar: In order to avoid mix-ups during assembly, the worker is shown how many elements of which type he has to pick when scanning his Manufacturing Order at the shelf compartments via "Pick by Light". To avoid errors on the put side, where the materials are loaded, the logistician scans the bin. The correct aisle is then displayed and he inserts the parts there. The system then books the container in exactly the right position.

Concrete results from the application of the IIoT solution are, for example, a reduction in working capital along the entire process in the plant of up to approx. 20%. This is achieved primarily through the continuous material availability and a dynamizable material provisioning. But also the manual effort for the material search is reduced by several minutes per production order. The lead time for logistical material supply processes can be reduced by up to half, depending on the distance between the warehouse and production. This is made possible primarily by supply processes that now run in parallel, as these can be initiated automatically. In addition, the space required for shelves near the assembly area can also be reduced by up to approx. 20%, as the material is provided on a consumption-oriented basis.

In the future, further modules such as an "RFID to Cloud" service are to be combined with the material flow control described to form a comprehensive Intralogistic Solution Suite. RFID reading heads could be positioned at any point within production and trigger business processes. For example, a transport order could be acknowledged fully automatically in SAP as soon as a forklift passes through an RFID gate. There is therefore still further potential for implementing "Screentime Zero".

Field of application: Automation/Intralogistics

Challenge: Digitization of the kanban-based value chain of an automotive supplier with the goal of increasing process efficiency in intermediate storage and achieving "screentime zero" in the work steps of employees.

Solution: Recording of all material movements with a specially developed combination of optical sensors and identification systems with cloud software; better management of intralogistics processes in the plant through digital visualization of shelf stock in real time and direct integration into the ERP system.

BUSINESS

SILENT GUARDIAN FOR THE ENERGY SUPPLY

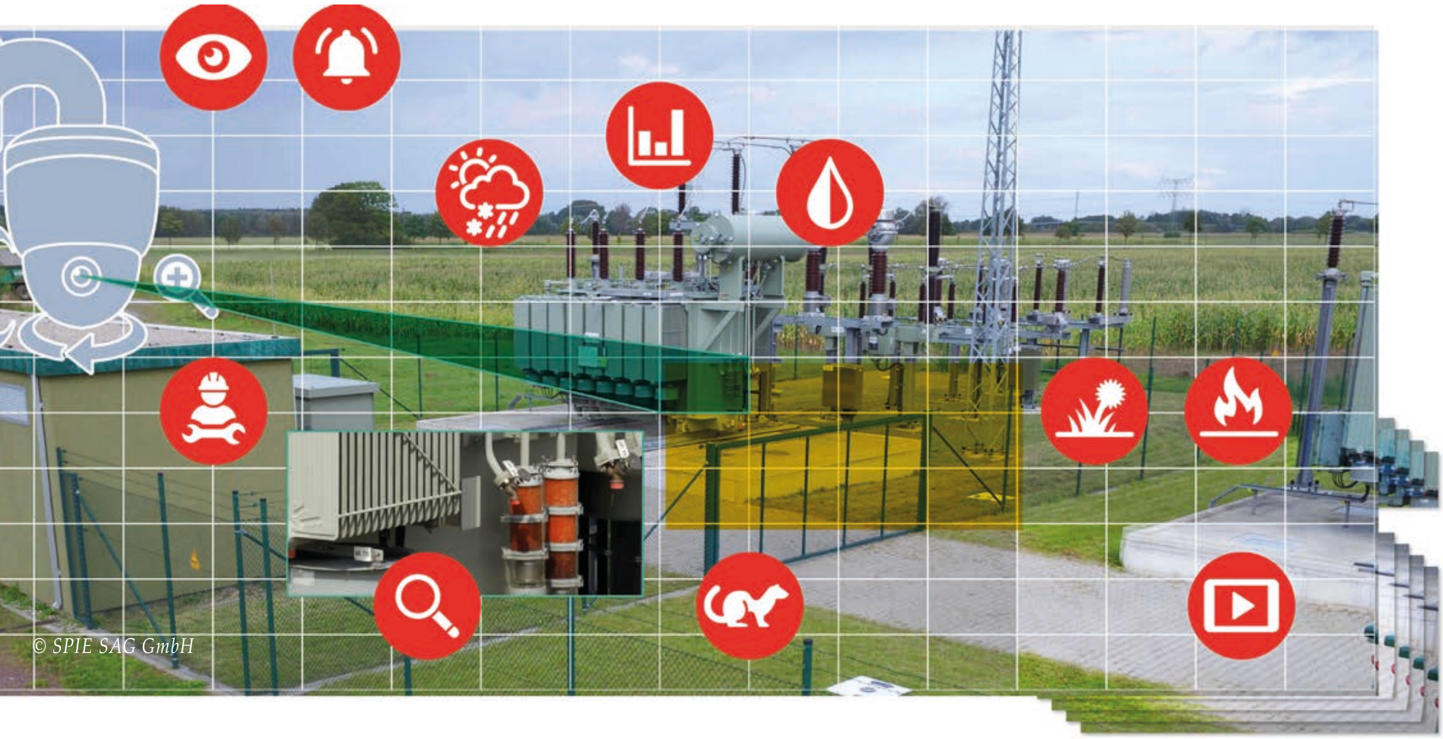
A high-tech camera system enables predictive maintenance

© SPIE SAG GmbH

When martens explore substations, contact with several hundred thousand volts sometimes ends the flying visit quite drastically. However, the risk does not only lie with the marten. Wild animal damage at such a neuralgic point of the energy supply can lead to power failures or material damage and have costly consequences. Our remote maintenance solution prevents this by simplifying the management of maintenance activities in substations. In addition to uninvited guests, a specially developed camera system keeps an eye on weather conditions, plant growth, component wear and many other points to ensure the continuous operation of the plant.

Efficient use of scarce resources

This task is extremely demanding for several reasons. Through our control center in Berlin alone, our company is responsible for the operation of 65 substations whose maintenance conditions are very heterogeneous: The plants vary in age and more than two-thirds have been in operation for more than 30 years. The older plants in particular have little or no sensor technology for measuring machine or environmental data. Retrofitting individual IoT solutions here would be very complex, cost-intensive and difficult to integrate into a control system. In addition, the substations are usually located in remote, rural regions and must be maintained by highly specialized, i.e. rarely available, skilled workers. In this respect, too, limited resources must therefore be used as efficiently as possible, i.e. , as many measures as possible, such as lawn and plant pruning, should be carried out with other activities at a maintenance appointment. This in turn requires forward planning based on precise site information.



Risk zones at a glance - live and data protection compliant

To solve this and other challenges, we developed a system together with our partner Hesotech that monitors the plants 24/7 with a camera, documents all the necessary information and processes the images and videos into measurement data using computer vision. Depending on the event at the site, the maintenance technicians are immediately alerted or informed in good time about upcoming work.

> In the digital twin, the optimal position for the cameras to be installed is calculated.

Optimal configuration with digital system twin

The central highlight of the solution are the camera systems and the associated software algorithms. All information is merged in a digital twin (2D or 3D). The algorithms developed first enable us to calculate the optimal position for the cameras to be installed in the digital twin. After the system is set up, algorithms from image processing are used to implement various use cases for optimizing maintenance. The objects and parameters (limit values, confidence intervals, etc.) that the system is to monitor or evaluate are defined, e.g. counters, critical components, lawns, plants or access points to the site.

Precise control through high-end cameras

The camera periodically records the set monitoring points - in the pilot plant these are more than 3,000 physical points . It can cover distances of +150 meters and work not only in daylight, but also with thermal and night vision images. Another special feature is that the camera system only records the predefined points and hides everything else. If maintenance personnel are on site, the cameras are automatically deactivated.

Direct alerting in case of emergency

In surveillance mode, the system detects intruders such as wild animals and thieves as well as smoke. In these cases, it automatically triggers an alarm and sends push notifications to the responsible personnel. In the event of significant faults such as a fire, the alarm-triggering event is also transmitted directly with a live view.

In "normal operation", the system controls many other functions. For example, the permanent temperature monitoring of relevant components via the thermal imaging mode ensures that critical temperature developments are detected at an early stage and countermeasures can be initiated. Networked sensors collect further real-time data via a weather station and microphones, so that detailed information from fault messages or damage is available over time and maintenance cycles can be adjusted accordingly.

Failure analysis for predictive maintenance

The bundling of these functionalities is extremely advantageous for two reasons: On the one hand, a wide variety of systems can be "informed" about all essential control factors (temperature, humidity, vibrations, damage/wear) in one step, without having to install, network and operate individual IoT solutions for these requirements.

On the other hand, the operational use and the "needs" of the plant can be visualized with the collected data. The maintenance team can access this information via a dashboard.

By the way, not only the condition of the plant and the events there can be assessed via the live view in real time. A "look into the future" is also possible. This is because the operating data from the control system can be linked with image recognition data in the digital twin to support error analysis and thus, for example, provide early warning of wear or increased plant growth in the plant.

> The operating and maintenance costs of the plant were reduced by 15% p.a. in the pilot project.

Falling costs already in the pilot project

The system is currently in operation at a pilot site and at another substation and is also to be used at the other plants in the future. Already in the pilot project we were able to reduce the operating and maintenance costs of the plant by about 15% p.a.. Thanks to the shorter response times in the event of alarms or damage as well as improved maintenance planning, downtimes have also been significantly reduced.

The approach of covering as many measurement and monitoring scenarios as possible with the camera as the one central sensor and "node" is proving to be very productive. However, future add-ons such as the installation and networking with vibration sensors in the plant are of course not excluded. They provide very good additional indicators that something is wrong, for example before smoke develops. And finally, anything that further reduces risks - for the plant operation and also for the marten - makes sense.

Nico Schultze,
Head of Innovation &
Digitalisation,
SPIE SAG GmbH

Field of application:
Energy supply

Challenge: Improving substation operational management through predictive maintenance and repair

Solution: visual monitoring, documentation and analysis of the entire plant via an intelligent camera system that monitors the plant 24/7 and processes the images into measurement data

© Drago Prvulovic/Øresundsbron

INTERVIEW

HOW TO MAKE STEEL TRUSSES TALK

Can 30,000 assets be connected for condition-based maintenance? A conversation with Bengt Hergart, Property Director of Øresund Bridge, about smart devices that link two states.

Yes, there is a kind of magic in concrete. For example, at this moment when the sunlight falls from an overcast sky onto the pylons of the Øresund Bridge and is reflected in the sea below. Or when heavy rain clouds envelop the gigantic structure, unique natural spectacles are guaranteed for travellers between Denmark and Sweden.

However, for the maintenance and safety management of the world's longest cable-stayed bridge for combined road and rail traffic, all weather conditions, the salt water and the traffic primarily represent potential risks. A special IoT solution ensures efficient and fast maintenance.

> "Our strategy is to transform from a calendar-based to condition-based maintenance."

DIALOG: Mr Hergart, Øresund Bridge is more than just a bridge – the entire facility includes roads, rails, a tunnel, toll stations and even an artificial island. That probably requires logistical masterpieces from your maintenance team?

BH: In general, we want to avoid the situation where employees are constantly on the road and have to react spontaneously to damage reports. Intelligent planning is much more important to us because it creates more efficient maintenance processes, not only in terms of logistics. The key to this is a data-based maintenance strategy, but this is much more difficult to design and to transfer to operational use as in other public facilities or industrial buildings.

We come from a position where most of the maintenance activities are based on calendar. You check, repair or do something else once a month, once a quarter, once a year

© Johan Nilsson/Øresundsbron

– but you can't be sure that the maintenance activity does follow that frequency. So, it's better to understand the actual condition on the bridge and the components of the bridge.

Therefore, our strategy is to transform from a calendar-based to a condition-based maintenance. Of course, we have a lot of condition-based maintenance already today. But most of the conditions are still stated by a human: someone goes side by side with a railroad track, inspecting and maybe starting maintenance activity.

Our target for the whole piece of property is to change such processes step by step to condition-based maintenance. In this context, deploying resources at the right time is as crucial as a constant uptime of the assets.

DIALOG: Since there is no reference project anywhere in the world, this seems to be a particularly demanding task. What are the main challenges and what is your technological approach to solving them?

BH: Essentially, it is about getting a grip on spatial distances and hurdles when using measuring tools. Consider the dimensions we are talking about: along the 16 kilometres of the entire plant there are numerous maintenance facilities, measuring stations and sensors, which are operated and provided by different suppliers. Out of, in total 30,000 assets, we are talking about over 20,000 connected assets that provide over 220,000 signals with information twice a second.

Those equipment data are delivered via a PLC interface, which are part of a SCADA system. The exciting question from our point of view was: could the system be trained to 'learn' the normal behaviour of each asset so that it is enabled to predict need of maintenance or suggest corrections in control parameters for the equipment by itself?

That is exactly what we have achieved with a machine learning solution. We evaluate detailed real-time data right where it is collected, and even more. After learning the normal behaviour, deviations, e.g. drift or anomalies in the railway network or other infrastructural parts, can be detected by a algorithm that informs the SCADA system, which in turn generates appropriate work orders.

DIALOG: How should one imagine this networking and which starting points were crucial for condition-based maintenance?

BH: We have many devices on the bridge that are already connected to the network. They give us a lot of information about weather conditions, signal errors etc. But this is not the whole picture of the bridge. There are still parts that could but doesn't "talk" to us now: concrete, steel, bridge bearings, expansion joints, cable system and so on. So, we had to decide, where to start this kind of conversation. One option was to start with concrete and bridge bearings. In this case, we first would have to equip them with sensors. The sensors must talk to us – that requires that we have to have some kind of fiber or wireless connection to them. By planning that it was important to map the connected devices that are already existing.

One crucial point was to understand that from the condition-based perspective. For example, if we measure in some areas, that the temperature and pressure are above or below the normal level – could that be a trigger for maintenance activities as well? In general, this was a very import breakthrough in our project: to recognize, that measuring and comparing the parameters in the surrounding of a component could be more effective than upgrading the component with a new IoT-device.

DIALOG: Please give us an example.

BH: We use dehumidifiers to lower the percentage of humidity in the steel truss. That's the reason why it's there, to keep the humidity below 40 percent. If it goes above 60, you'll get corrosion. If the humidity level of a devices suddenly goes up, it could be okay because it's raining outside. So, it goes up momentarily and then goes down. But imagine we might have seven different dehumidifiers, six of them shows one level of humidification and the seventh shows the higher level. Now, without measuring internal parameters in the dehumidifier, you can see the performance of this equipment is poorer than the six colleagues of it. And that's bad news, now we have to look at this piece of equipment, and maybe it's an indicator for corrosion in the steel truss.

“Measuring parameters in the surrounding of a component could be more effective than connecting the component with a new device.”

DIALOG: What are the next steps? Could you make the system even more precisely?

BH: It's not beneficial for us to have a more precisely algorithm, that is expensive to scale to the whole property. By the way, this is the big difference to other Industry 4.0 use cases in predictive maintenance. Mostly every downtime for minutes or hours in the industry is a disaster. This scenario is not on our agenda, we have extremely few errors. The passage was closed ten hours last year and most out of those ten hours, this was wind and accidents on the road. And there might have been 30 minutes technical error. So, we have not a very good business case to reduce down-time. Could we improve its availability? Of course, we could. But going here from 30 to 15 minutes is not valuable. Instead, our business case is to reach more cost-effective maintenance.

And yes, there's still one unsolved question: how could we state the condition of an area or component if the equipment there it's not running? Many important parts of our equipment like the jet fans in the tunnel are only running in course of emergency, so it's not possible to integrate them in a condition-based, real-time monitoring. Unfortunately, this is a huge difference to other maintenance scenarios like power plants, where things are always up and running and its condition can be monitored. But I am optimistic that this can also be solved.

“Downtime is not a worst-case scenario for us.”

Bengt Hergart, Property Director of Øresund Bridge

Field of Application: Construction

Challenge: Maintenance on the world's longest cable-stayed bridge for combined road and rail traffic causes very high efforts, as personnel is usually not on site and access to equipment requires much time and interferes with operations of the infrastructure

Solution: Delivering of sensor and actuator data via a PLC interface to IoT-gateways, which are part of a SCADA system that enables the operator to a condition-based maintenance

BUSINESS

WITH MAGIC AND LOGIC TO PACKAGING 4.0

Synchronized cooperation of design, procurement and assembly.

Intelligent machines, integrated processes, intuitive operation - these are the premises with which Windmöller & Hölscher has been implementing numerous digitalization projects for several years now. As a specialist for machines in the growth market of flexible packaging, innovations are important to us; with our products, we set new technological standards again and again.

There is also plenty of scope for ideas: Our gravure printing presses easily fill halls; cast film lines can reach the size of a multi-story single-family house and consist of at least 100,000 individual parts.

Due to this complexity and dimensions, no two identical machines leave the assembly line, especially since our customers also operate in different industries and require individually manufactured systems.

Despite low vertical integration and small quantities, we saw potential for digitization here. In order to meet individual customer requirements as precisely as possible when configuring the machine or system, every configure-to-order process includes an additional engineering-to-order component.

In order to improve these processes, among other things, we are currently introducing Product Lifecycle Management (PLM) in a new digitalization project. The focus is on resolving the gaps between the existing individual system solutions such as the ERP system, CAD systems and technical editing systems, significantly improving the flow of information between design, procurement and assembly and increasing data consistency. Above all, a central "smart" bill of materials should make this possible.

> The change from uni- to multi-directional thinking was difficult, but proved to be decisive for the success of the project.

From Master to Multi-BOM Management

Until now, a single bill of materials has been used in the company. This master BOM (Bill of Materials) primarily satisfies the needs of procurement and assembly. The list was only partially integrated into the technical systems - for products with tens or hundreds of thousands of material items and dynamic changes during the life cycle, this could hardly be handled any other way. The time required to maintain the master BOM alone was very high, as this required constant coordination between development, procurement and assembly.

Combining disciplines

The goal of the PLM project was therefore to use digitization tools to establish multi-BOM management, in which each area maintains its own bill of materials. These lists are synchronized with each other using the logic and "magic" of software algorithms. The special feature: We connect the very heterogeneous structures and visualizations of the working environments. A machine designer, for example, works in CAD with his own spatial structure and parts list in order to recombine plant

> All bills of material must represent the same product.

parts and improve installation spaces. An electrical designer, on the other hand, keeps a parts list in which the logical link between motor, converter and sensor is grouped. The assembly department, on the other hand, orients itself to pre-assembly processes, for example, from which another separate structure - and parts list - emerges. Ultimately, of course, all these lists must always represent the same product.

Rapid exchange of information

Here, the desire for a "red thread" that connects all these perspectives is obvious. But what is the best starting point for this? With a parts list in the design department, which is then passed on to the next station or department, rebuilt there, passed on and returned? This kind of unidirectional thinking and approach is classic. However, in this case it does not lead to a clear, but in the end very abstract chaotic "weaving pattern". This is not helpful when versioning customer-specific plans, e.g. if they were copied in the previous system and saved under a new assembly number. As a result, the plans were adjusted in assembly and procurement had to check these changes.

> A smart algorithm reduces the complexity for the user to a minimum.

Our idea is to pursue a multi-directional path, i.e., mechanics and electronics work in parallel and always synchronize with a common BOM model. Assembly and service are also connected to this central bill of materials and also exchange information via it. If, for example, an electrical designer decides to use a different motor, his colleague in the mechanical department finds out directly and can ask questions or modify his planning directly.

Automated data reconciliation

We are completely rebuilding this multidirectional synchronization with the PLM system. Thus, for example, the team in assembly should be able to access the information from the authoring systems in development very comprehensively and simultaneous work in the development disciplines should be possible. The central element is a function-oriented structured bill of materials (eBOM), with which every other bill of materials is synchronized.

In order to reduce the complexity for the user to a minimum, a "smart" algorithm allows the user to work only in "his" own BOM. This opens up further improvement options: For example, assembly can now access data from mechanical design, model-based definition, and electrical design (e.g., electrical component identifiers) directly and without manual data preparation. Assembly, in turn, can use an assembly-optimized BOM to manage digital work instructions.

The roll-out of the solution has already started, and in test and training phases we are training over 600 users to operate the system. A positive experience here is already that the employees, who mainly move in three-dimensional, imaginable space, also gain a good understanding of connections between the data of the specialist disciplines.


© Fabian Distel

Dr. Fabian Distel, VO-PLM, Windmöller & Hölscher KG

Field of application:
Mechanical and plant engineering

Challenge: very high effort for the maintenance of a master BOM (Bill of Materials); constant reconciliation between design, purchasing and assembly necessary

Solution: Synchronization of several bill of material views that enable simultaneous work in the development disciplines; function-oriented structured bill of material (Engineering Bill of Materials, eBOM) as central element

INTERVIEW

"IT'S ABOUT THE CORE OF CREATING YOUR OWN VALUE"

Prof. Dr. Holger Bonin, Research Director of the IZA (Institute for the Study of Labor), on the consequences of automation, superstars of digital structural change and the limits of virtuality.

© Shutterstock

DIALOG: Professor Bonin, a few years ago you analyzed the well-known study by Oxford economists Carl Benedikt Frey and Michael Osborne on the substitution of jobs by automation for Germany on behalf of the Federal Ministry of Labor and Social Affairs. How serious will the structural change that is coming our way be?

HB: It has relatively little to do with reality if you only look at the technological substitution potentials and derive spectacular scenarios for the labour markets of the future from them. After all, these undoubtedly existing potentials are also matched by positive economic adjustments. This is the reason why we have so far not observed that work is becoming less. On the one hand, machines - whether physical or virtual - have to be developed, manufactured and integrated into higher-level systems and processes. That doesn't happen by itself. For another, if productivity actually increases through digitization and automation, the goods and services produced will become cheaper, which will lead to an expansion of markets. Another factor is that new business models also emerge, which in turn lead to additional employment.

In addition, higher productivity also leads to increases in wages and entrepreneurial income, which also have a positive impact. Among other things, this is due to the fact that new jobs are created in areas that cannot be efficiently automated, especially in the service sector or in the skilled trades. These effects massively counteract the substitution process.

In general, this structural change is not disruptive, even compared to previous technological upheavals. That gives us some time to adjust to these changes. In Western Europe, unlike in the US, for example, we also have the advantage of a productive and well-qualified workforce. Most companies are therefore asking themselves how they can make their employees more productive and train them, rather than how they can get rid of

"The structural change in automation is not disruptive. That gives us time to adapt to these changes."

There may be polarization. The low-wage sector may remain relatively stable, with workers at the upper end of the income scale even benefiting disproportionately, while the middle class comes under pressure to adjust. The clerical jobs and skilled manual jobs with a high routine content that used to be so secure are becoming fewer.

DIALOG: What does this pressure to adapt mean in concrete terms?

HB: The engineer whose job it has been to design and produce the car may find it difficult to think of the car as a hub of data streams, to understand the business value of that data, and to design the car for data use. That brings us to the issue of continuing education and development. The key thing is not that the engineer needs to get more involved in customer service or sales, which can certainly be the case. Rather, it is about the core of his own value creation. From the individual's perspective, this is indeed disruptive. After all, you can't just say, "Now change your mindset! “

The debate on how to achieve this further development is, on the one hand, not being conducted intensively and bindingly enough. And on the other hand, it is too one-sidedly focused on "digital literacy", on coding skills and the like. But it is primarily about a broad range of non-technological skills that are very difficult to learn in adulthood, about communication skills, about the ability to think in terms of business models and processes. So far, we don't have any particularly good concepts for how to develop these skills.

Other countries, such as Singapore, have recognised this at least conceptually and anchored it in higher-level qualification strategies. An influencer, to use a new job description, does not need digital literacy, he does not have to code. But they must be able to recognize that money can be made in social media and develop a business model.

them. And let's not forget one thing: If we look at photos of workplaces from 30 years ago today - it was a different world. But that world and today's world have a place within a working life. Some of the people in these photos still have ten working years ahead of them. I am optimistic: we are quite adaptable, also with regard to the ongoing changes through digitalization.

DIALOG: But this structural change also has problematic aspects?

HB: Yes, of course. Basically, change is perhaps more of an opportunity than a risk. But it requires agility and a willingness to shape things in order to adapt to it. On the one hand, we have distribution issues: what share of the profits from automation ends up with the entrepreneurs, what share with the employees? And where do the profits accrue? If, for example, the robots in European factories belong to Japanese or Chinese companies, then additional jobs may be created primarily there and not in Europe. How the profits from automation are distributed also depends on the structure of the labour markets - the legal framework, the role of trade unions, whether there is a minimum wage.

On the other hand, a net effect of zero also means: millions of jobs disappear, millions of new jobs are created. But the new service jobs are probably not as well paid as the old well-paid industrial jobs. And even where they are: It's unlikely that you can easily integrate into the growing market for higher-paying health services if you're an industrial worker.

© Holger Bonin

Prof. Dr. Holger Bonin, Research Director of the Institute for the Study of Labor (IZA)

DIALOG: You mentioned the top earners who benefit disproportionately from the digital structural change. What are the reasons for this and how can this segment be described?

HB: This development can be explained by two intertwined figures, the figure of the superstar and the figure of the crowdworker. Crowdworking can be described as a development in which work is increasingly advertised and delivered across borders on the Internet.

This is good for you if you can do something that is sought after worldwide, if you are a superstar; an industrial designer with special skills; a high-end programmer; a doctor who can make outstanding complex diagnoses.

Then your market - and your market value - suddenly increases. As a European, you can make diagnoses in the USA, design a factory in Japan or hold seminars in Abu Dhabi without moving. But if you are a mediocre doctor, you will not profit - on the contrary. Because the hospital company

"Formerly secure clerical and skilled labor jobs are coming under pressure to adapt. "

might get the idea of having the standard diagnoses made in India.

Crowdworking thus opens up opportunities for average experts in low-cost locations, who can take on many standard tasks, on the one hand, and for superstars, who can choose their locations and their markets, on the other. And it threatens the position of average experts in the high-cost locations with their high wages and cost of living.

DIALOG: What does this dissolution of labour boundaries mean for the individual regions, especially for the expensive western locations?

HB: Highly automated factories need very few people. But the people who are still needed are highly productive and critical to success. And they want an attractive environment. Elon Musk is also recruiting employees in Poland - but the Tesla factory is being built in the immediate vicinity of Berlin and not in Poland, where costs would presumably be lower. As long as today's low-cost locations provide the global market with neither sufficiently competent employees nor attractive framework conditions, they will not win the race, but rather lose their superstars. Other factors also play a role: legal certainty and IP protection, proximity to top universities, industrial and knowledge clusters. Some countries have recognised this and are working hard to improve their attractiveness as locations for global superstars. This is very clear in the Gulf states, for example.

"Digital literacy' is not enough as a future competence. Communication skills and business model and process thinking are critical."

The other aspect is that we will not see a world of solo self-employed people in the future. There are good reasons why companies exist. Digitalization does reduce transaction costs - but nowhere near as effectively as companies do. Certain things are hardly feasible in a crowd model. Leadership, personnel development, qualification, evaluation of offered services, enforcement of demands, relationships of trust and social bonds in well-rehearsed teams - all of this sets limits to virtuality. In addition, there will also be political pressure that will result in regulatory structures.

DIALOG: Is there a counterpart to this upper segment of superstars in the structural change of the working world?

HB: Yes, take the phenomenon of the gig economy. Typical of this is a platform that mediates small jobs globally, but which are carried out locally. These tend to be low-paid jobs without security and social protection: delivery services, manual work, cleaning, passenger transport. The physical value creation takes place locally, the coordination work globally. In a certain sense, the person working in the gig economy is the antipode of the superstar. Their sometimes precarious existence is a warning: structural change is not an apocalyptic scenario per se. But it does require active and responsible social management.

BUSINESS

PROGNOSTIC RELIABILITY WITH HUMAN AI

How Artificial Intelligence and Gamification empower a global, agile Industry 4.0 supply chain.

There are not many comparable industrial products whose smallest components are measured in the order of nanometers. On a semiconductor component, for example, a single "cube" that provides on and off switching is placed a million times. Each cube is lithographically structured and etched from layers of copper, aluminum and silicon oxide. In addition to other logic units, this creates a microcontroller that performs control functions in electronic products.

Components that can easily be hidden behind a human hair are thus in a league of their own in a global value chain. In addition, semiconductor solutions from Infineon are now essential in many products around the world, especially in the automotive and consumer goods industries. Responsive supply chain management is necessary to meet the following challenges: In addition to high capital requirements for equipment and fabs, intrinsically long manufacturing lead times, and high demand volatility, there is also the short life cycle of products with semiconductors, as the next semiconductor already enables better products. Our global team of a thousand employees with a smart Industry 4.0 supply chain solution that is continuously being developed masters this.

Our supply chain business ecosystem is based on physical make flexibility and its daily optimization in a highly automated planning process. To further increase the performance of our Industry 4.0 supply chain solution in these areas, we have launched digitalization projects that guarantee better forecasting and higher flexibility.

Digitization in two directions

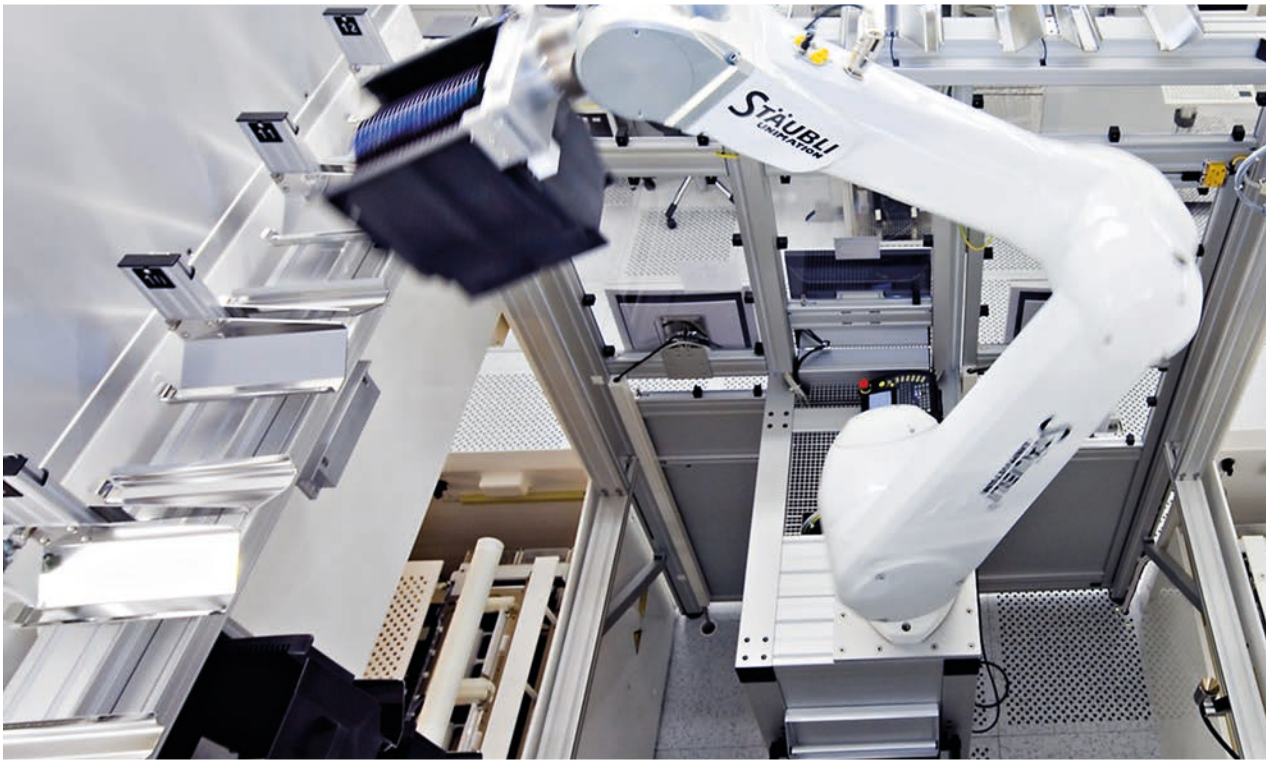
The projects pursued two digitization initiatives: "Digitization for Input" focused on demand-oriented aspects. In addition to the optimal use of available data, the focus here was on employee competence and change management for the implementation of measures, as well as a gamification approach for the integration of AI-supported planning.

At the same time, "Digitalization for Execution" should create the infrastructure for a global, flexible, virtual factory, further establish automation in the company and improve responsiveness to a changing order situation on a daily basis in the global production network.

This approach enabled us to further expand our supply chain as a competitive advantage and, at the same time, to bundle the empirical values from our sites, for example on Big Data analyses in manufacturing or in the traceability of errors in quality management. The following elements proved to be particularly important for the success of our Industry 4.0 solution:

COB (Customer Order Behavior)

Our project team visualizes the ordering behavior of customers in heat maps on a weekly basis



over a period of 26 weeks. The two-dimensional representation generates images that experts can use to assign predefined categories (e.g., over- or under-scheduling) to customers. Once a sufficient number of such images have been assigned (labeled), this assignment can be passed to a deep learning (DL) machine. This enables a reliable and fast analysis of the customer's ordering behavior, which in turn allows a better understanding of the customer's needs and allows changes in ordering behavior to be identified.

DFC 4.0 (Demand Forecaster 4.0)

A forecast accuracy that is better by machine than by human is implemented in the DFC 4.0. The DFC 4.0 uses historical time series data and "future data" and works with a mix of statistical and DL/KI tools optimized for the best forecast accuracy for the individual product.

HAI Game trains interactions between humans and software

In order to support change management during the introduction of DFC 4.0, we use two tools: in regular so-called espresso mails, a member of the management team introduces certain functions of DFC 4.0 and their advantages, and offers employees the opportunity to obtain further information on the subject via videos, articles, etc.

In addition, we developed a game with HAI (Human & Artificial Intelligence) to improve the collaboration with our "digital colleagues" in a playful way. Although an AI usually delivers better forecasts very quickly than humans, it cannot explain them and is occasionally grossly wrong if information is missing. In a half-hour game of 20 rounds, you learn to trust the machine quickly - without intervening - because the AI simply usually "forecasts" better than the player, who also sees the time series and could predict for himself. But why bother if the AI is better? This applies both in the case when you are in your "comfort zone", but also when you have more information as an employee and can therefore make your own forecast. An “aha moment” comes at the end: Here you learn how many savings you could have made for the company if you had relied on the information provided by AI on the one hand, on the other hand it is also important to do the calculation yourself (and then accurately) in certain situations.

Global supply chain as a virtual factory with GPN (Global Production Network)

Global supply chain planning generates a daily ATP (available-to-promise) from tens of thousands of demand elements and thousands of global bottlenecks. It considers on a product-by-product basis what is available in the distribution center or will arrive there on a daily basis. This ATP is then in turn used daily by around one million order elements to either confirm or improve on the previous day's commitment. Improve here

© Infineon Technologies AG

means to commit closer to the customer's desired date than the day before. This "best of breed" IT tool of a supply chain planning and execution system, which has been in place for years, was complemented by the GPN in our digitalization project. The GPN provides a holistic view of production, quality control and material allocation across the entire supply chain. The delivery or use of faulty lots can now be stopped globally within minutes, for example.

The fact that the combination of these technologies and measures

> Global supply chain planning takes into account tens of thousands of demand elements and thousands of bottlenecks.

is bearing fruit can be seen in all the areas mentioned: The complete traceability of goods or products from the front end to the back end in the GPN also reduces errors due to manual handling and achieves significant savings. In addition, supply chain planning with the GPN improves physical flexibility and thus overall capacity utilization by several percentage points.

To solve the global chip shortage, however, it is not enough for only the semiconductor supply chain to work; the semiconductor supply chain must also work seamlessly. Just-in-time methods that operate with minimal inventory and control replenishment by range will not work in pandemic situations when there are partners like the semiconductor industry that cannot further reduce its intrinsically long lead time of up to six months for a component despite 365/24. With range of coverage control, replenishment is only initiated when the stock falls below a certain range. Example: If stock is 1,000 and requirements are 500, the range of coverage is 1,000/500 = 2 (for example, two weeks). If the demand then drops to 250, the range of coverage is four weeks and nothing is ordered for two weeks - and the bullwhip effect (i.e. the amplification of fluctuations along the supply chain) is already created. In the SCM working group of the ZVEI, which is headed by Infineon, there are already good approaches on how to get a sustainable grip on this problem and the bullwhip effect.

© Hans Ehm

Hans Ehm,
Senior Principal Engineer Supply Chain,
Infineon Technologies AG

Field of application:
High-tech/electronics industry

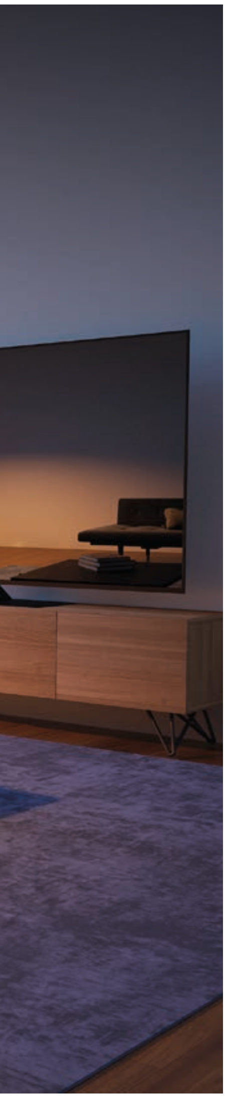
Challenge: Further develop an Industry 4.0 supply chain solution via digitalization initiatives to strengthen the company's resilience to volatility and order fluctuations

Solution: Combination of smart technologies that address improvements in several areas of action in the global supply chain, especially in customer-oriented demand planning and through physical flexibility that is optimally utilized on a daily basis through planning tools; improvement of customer order commitments

BUSINESS

LIVE CHAT WITH THE INJECTION MOULDING MACHINE

The application "socialProduction" turns machines into team members.



© KraussMaffei Technologies GmbH

What emoticons would a production machine use - 0/1 for a shoulder shrug? A ticking dollar clock when a line stoppage is imminent? For graphic designers and engineers, the topic offers potential to develop creative ideas together. After all, we are communicating with software assistants and "smart" machines in more and more areas of life. And at some point, they will no longer respond with bulky text modules and selection menu logic in the work environment, but rather fluidly and helpfully like their colleagues.

Chat rooms in which humans and machines exchange information about unit numbers, performance information or shift changes with each other like in a WhatsApp group are already available: "socialProduction", a mobile app and web application for injection molding machines from KraussMaffei, combines the advantages of social media with production monitoring technologies. In secure chat rooms, the machines report live events and problems that they detect independently in the production process. Since users can exchange texts and images in the chat, the machine is quickly perceived as an "active team member" in production.

As a digital production tool, "socialProduction" thus addresses several needs in the industry: The application improves the flow of information about machine availability and scrap rates, reduces the number of paper-based work steps and thus the error rate in the demanding injection molding process - and does so worldwide and around the clock on common devices.

Algorithm with plastics know-how

With two performance modules - production monitoring and process support - "socialProduction" is precisely tailored to the needs of users in plastics production:

Process support

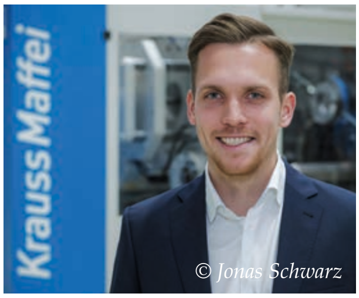
Using a self-learning process based on AI/machine learning technologies, all available process parameters of the machine are continuously monitored. Here, KraussMaffei's plastics process knowledge has been incorporated into the programming of a patented algorithm that forms the core of the software.

An anomaly detection identifies abnormalities in the manufacturing process at an early stage and proactively reports them to the user in the chat room. This prevents excessive stress and unnecessary wear of components or line downtime in good time - completely autonomously, without the need for configuration. With a simple click on the machine notification, production managers receive all essential information on process parameters and key figures such as productivity, stability and order progress of all connected machines - if required, also of third-party machines. The time window selected for monitoring can be set to three cycles (1h, 8h, 24h).

> AI/machine learning technologies monitor production around the clock.

Production monitoring

Messages about important events such as alarms or parameter changes during ongoing production are automatically sent by the machine in the form of a chronicle (machine messenger). Employees receive live push notifications on their desktop PC or smartphone and can subscribe to these as required for each machine. The intuitive structure of the "socialProduction" pages also allows quick access to important machine parameters. A complete log of all events, alarms and setpoint changes that have occurred on the machine control are additionally displayed in chronological order in a detailed view.



© Jonas Schwarz

Jonas Schwarz, Global Digital Product Manager, KraussMaffei Technologies GmbH

INTERVIEW

"OUR MACHINES LEARN WITH EVERY LIKE"

What makes machines "smart"? Dr. Christian Bartsch, Global Vice President Digital Solutions, KraussMaffei Technologies GmbH, gives examples from the application of "socialProduction".

DIALOG: Dr. Bartsch, at what point do people accept an injection molding machine as a teammate?

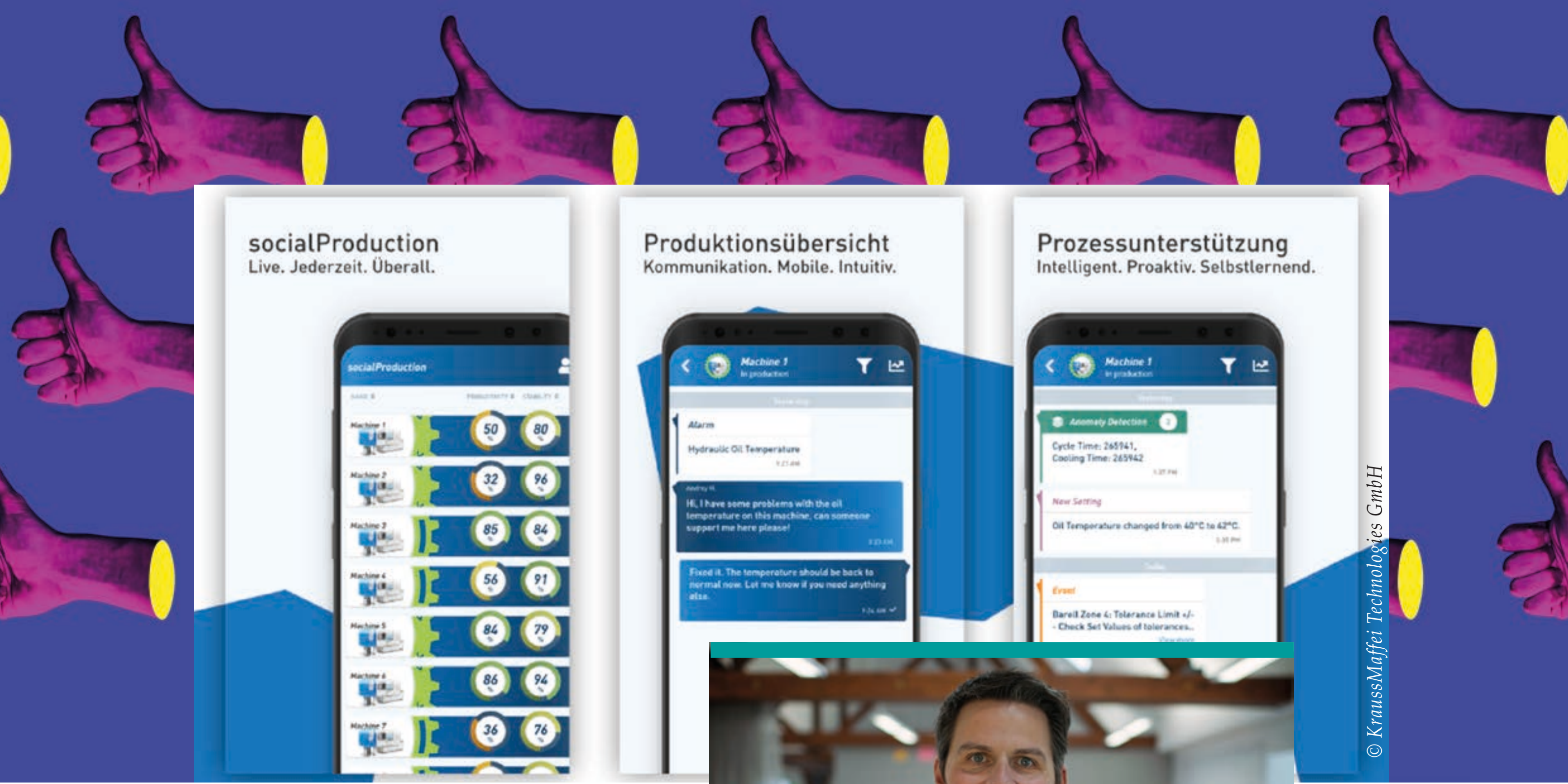
CB: As soon as support becomes noticeable. For example, shift handover: If I regulate this on paper and by Post-it, it is quite error-prone. However, the machine's tolerance rate for illegible writing or incomplete information is 0 - all information must be entered so that the next shift is optimally informed. Otherwise, the software "annoys" with inquiries or points out irregularities in the machine's chat room. If the process then quickly runs better, the human-machine interaction has become a bit more natural again.

Help with the right knowledge at the right time is also well received. No one wants to scroll through a page-long PDF or hear standard chatbot phrases when something goes wrong. Or when, as in the case of injection molding machines, 100 or more material and control parameters have to be finely tuned in the right combination to achieve top product quality. No one can keep track of all that anymore.

DIALOG: But couldn't a kind of injection molding Wikipedia be of sufficient help?

CB: No, lexical knowledge, even in digital form, is a collection of data that, depending on the quality of the search function, I sometimes have to slog through longer or shorter to find the right information. An application that proactively supports me, i.e. recognizes problems and directly suggests the appropriate solution options, is more effective.

Like our anomaly detection, which really "looks" at the process across all parameters and identifies outliers that can be insidious or erratic. However, since our plastics and process knowledge is now not only in the heads of the employees, but also in the self-learning algorithm of "socialProduction", this makes the work in production immensely easier.



© KraussMaffei Technologies GmbH

© Christian Bartsch

Dr. Christian Bartsch, Global Vice President Digital Solutions, Krauss-Maffei Technologies GmbH

DIALOG: And in the future, the machine will take care of everything itself?

CB: I don't think so, because with new customer requirements, the spectrum of what the machine has to do is always evolving. For the foreseeable future, we will need people to make these modifications: Product designers, engineers, data analysts.

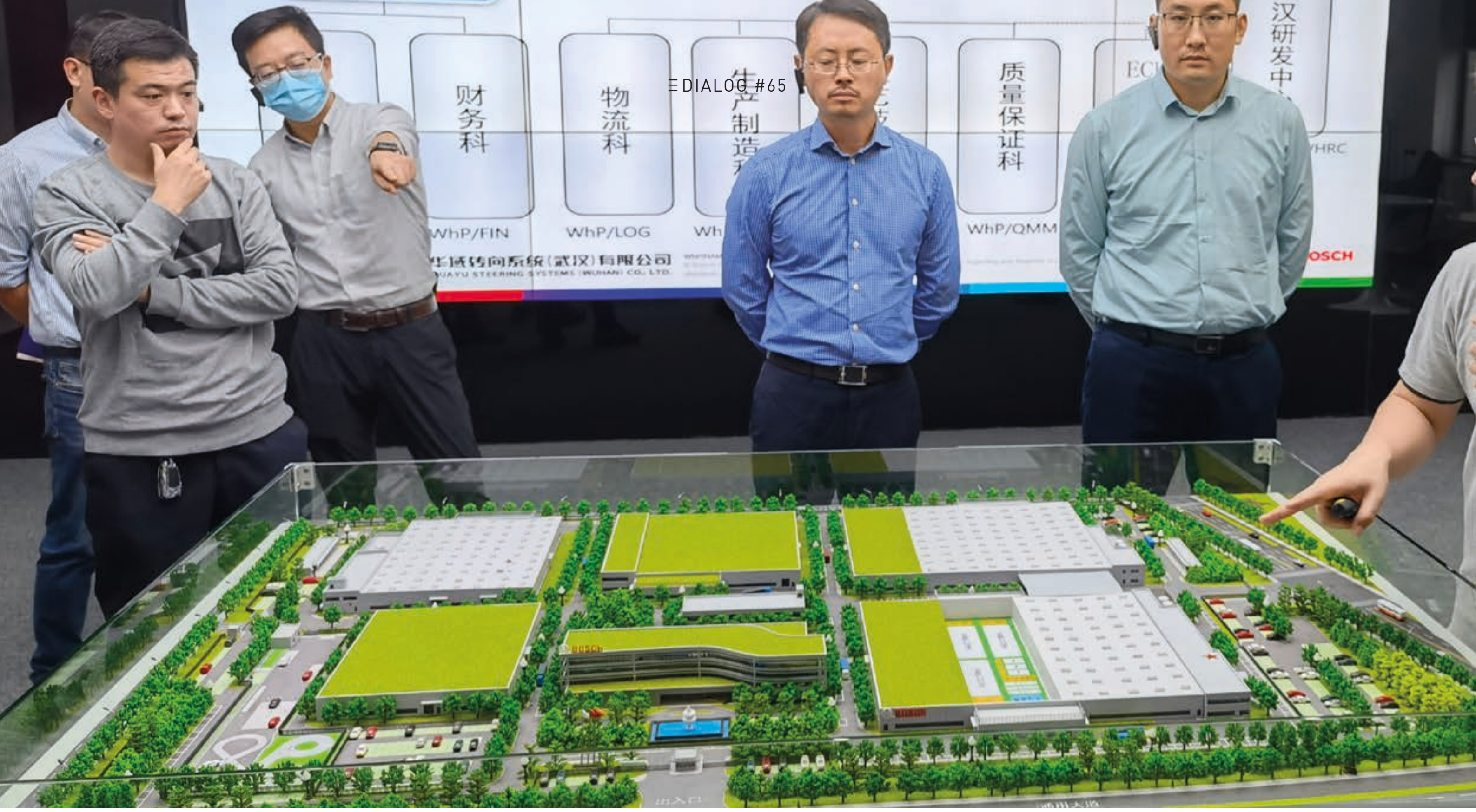
What is exciting about the further development are, for example, all the options with which we can further train the machines to analyze the enormous amounts of data and to communicate with us even more precisely and authentically despite this complexity.

Example: In the future, an employee at a customer site can simply respond to a message from the machine with a "like", in the sense of "fits, thanks". Then you know that the algorithm has done the right thing. They have already integrated another, very simple machine learning mechanism - and the machine learns with every Like.

Field of application:
Mechanical and plant engineering

Challenge: Increase attractiveness of digital manufacturing tools in human-machine communication; improve information flow on machine availability and scrap rate; reduce error rate in demanding injection molding process

Solution: "socialProduction", a mobile app and web application for injection molding machines that combines social media functions with technologies for production monitoring and process support; status information of the machines available live in secure chat rooms for employees; independent detection of deviations in the production process through AI/ML-based solution



BUSINESS

TARGET: IDEAL ONE-PIECE FLOW

An automotive supplier orchestrates the material flow of 70,000 parts with a smart transport system.

With its electric and hydraulic power steering systems, Bosch HUAYU Steering Systems ensures that car and truck drivers can move their vehicles comfortably in traffic. The high-tech enterprise has the largest business scale and highest market share in its sector in China. At its plant in Wuhan, Bosch HUAYU manufactures electrical and hydraulic power steering systems and the key component worm and pinion with around 70,000 pieces in work in progress (WIP) inventory.

Five years ago, the plant launched a project with the aim of optimizing component production and coming as close as possible to the guiding principle of one-piece flow. Among other things, throughput times and flexibility were to be improved, for example by automating the manual movement of goods between workstations or by digitizing the previously paper-based data capture.

FITS: High-flexible planning with limited resources

Already well on its way, the project team had to deal with the constraints of the pandemic. During the COVID-19 breakout in Wuhan, the majority of business were obliged to close down. That resulted in a drastic reduction of direct personnel in the factory. Since some of the targeted technologies had already been implemented by this time, it was possible to maintain production with

> Five elements to transform the whole production process to an agile on-demand manufacturing.

© Bosch HUAYU Steering Systems

a severely reduced workforce and continue to fulfill customer orders.

This was made possible by FITS, an advanced planning and scheduling solution, which stands for “Flexible Intelligent Transportation System” and was initially concepted in the process of planning the worm single frame flow. The system should be able to capture real-time status feedback from each asset, enabling precise production planning. Furthermore, it should dynamically adjust the production task of each equipment according to the production planning and equipment state. Additionally, a dynamic change of the individual workstations should also be made possible. Therefore, the system had to have these properties:

- high-flexible production route planning with limited resources;
- accurate to the dynamic scheduling of each equipment;
- material transfer automation, single box traceability;
- real-time feedback of material information and real-time monitoring of equipment status

This evolved into the FITS project: By using the core production scheduling system, based on RFID and MES structures of manufacturing systems, the whole production process was transformed from a traditional discrete planned manufacturing to an agile on-demand manufacturing. A set of five solutions has been implemented for this purpose:

Core algorithm & Advanced Planning and Scheduling system (APS)

The central element of the project is its “smart brain”, i.e. the software algorithm. The algorithm analyses customer needs and converts those with other demands into executable production tasks. It records each piece of equipment so that an optimization to the setup sequence in the material flow can be made in the shortest possible time. In combination, an overlaying APS system for real-time planning and scheduling is matching deliveries with unexpected production volatilities. In case of exceptions like machine breakdown or missing material, an automatic rescheduling is initialized: the production plan is updated automatically, the shop floor manager is automatically notified and only has to confirm.

Manufacturing Execution System (MES)

An MES developed by Bosch was implemented to record the data generated in the production process. Among others, the MES includes functions like tool-, quality-, order-, and energy management, light system control and manufacturing data analysis.

> In case of exceptions, the systems “smart brain” does an automatic rescheduling.

Automatic Guided Vehicle (AGV)

The FITS algorithm generates transport requests based on the real-time production status and material availabilities feedback by the MES data and sends them to an AGV dispatching system. The system executes the transport orders and thus independently transports materials, components and tools between the individual stations and workplaces. The individual AGVs have the functionality to adjust the height of their wings. This ensures transport to and from production cells of different heights. For the AGV, no floor guide rail or magnetic strips need to be laid, nor is it necessary to attach a QR code to ensure that minimal floor changes can be overcome.

© Bosch HUAYU Steering Systems

Radio-frequency Identification (RFID)

Each transport rack (which holds 48 identical parts each) was equipped with RFID tags, and each production line was equipped with corresponding RFID readers. All process- and machine data is stored on parts-level via MES and synchronized with the RFID data. Of course, the (automated) setup of equipment also had to be synchronized with production program planning.

FITS results:

- From >700 to 48 pieces of lot site
- From 90h to 12h lead time
- Direct FTEs reduced by 50%

Human-machine interaction (HMI)

The electronic information visualization of intelligent manufacturing, namely the window of human-machine interaction, is the bridge of system diagnosis and monitoring.

At present, the FITS project selects a hand-held terminal that can scan electronic tags to read information of suspicious materials, and conducts isolation, scrap or return processing on the corresponding interface. Mobile tablets are used as paperless office tools for on-site inspections and equipment adjustments. They are also connected to the wireless network to obtain and monitor the production status and the quality of parts.

INTERVIEW

"TAKE A LOOK BEHIND THE BOUNDARIES OF YOUR OWN DISCIPLINE."

How do you use Industry 4.0 technologies to make manufacturing more efficient – without creating new complexity? Jun Bao, Wuhan Plant Manager at Bosch HUAYU Steering Systems, calls empirical values.

DIALOG: Mr. Bao, what smart factory vision are you pursuing with FITS?

JB: We started the project with a few objectives that nicely outlined our vision. First, to plan the different quantity of the machines for different processes. For a continuous material flow, several pre-conditions must be ready. For example, for every machine we need to know its actual status, what type of component it is producing and the manufacturing progress. In simplified terms, it is IoT of each machine equipment.

Second, since we want to have a one piece flow of the component, we needed to define a standard unit. This enabled us to adjust the components like this. So, we defined a standard lot for this component, which is 48 pieces. We put it in a standard packaging that can be accepted by every machine. For each lot, we know in real time where it is, what's the manufacturing progress and how many of the individual parts have already been processed.

Third, we had to consider where in the process it would make sense and be profitable to implement the targeted solutions. So naturally with the ideal one-point flow, we will not have any additional non-value operation, like moving components. So as a precondition, those components should move by themselves or automatically. Therefore, we need to find a way to move a single lot from one station or from one machine to another.

DIALOG: But every machine is in every time or sometimes in a different status. How did you manage this complexity?

JB: This was the fourth precondition: we needed a kind of a data analytics "brain" knowing the status of the components and the status of the machines. And it should also be able to give dynamic orders to each AGV, to each machine and dynamically telling them what to do or what you need to do now and what you will do next. Our FITS algorithm can do that – and even more. He is dynamically receiving the feedback of the machine. If suddenly one machine broke down, FITS informs us directly and makes suggestions how to react, e.g. switching to other machines in a certain time frame.

DIALOG: Besides the technologies used, what made your project successful in the end?

JB: The teamwork and the development of the competences. In the past, team members in the manufacturing industry mostly had different roles and backgrounds. These roles are evolving by the request of multi understanding.

However, new ideas are often developed behind the boundaries of your own discipline! For example, by concepting and running FITS we realized how important it is, that a process engineer needs to have IT knowhow as well. A maintenance engineer needs to know how AGV is running, how to maintain an AGV and how to market a new one. This is naturally happen and if you want to implement as much useful IoT solutions as possible, you need to intentionally notice who is growing to which of this mountain knowledge. It is important to give the chance to your teams to grow in this way. By doing that continuously, you will have not only one highly motivated team, but more and more teams who can plan, implement, and evolve an industry 4.0 solution as well.

Field of Application:
Automotive Industry

Challenge: Transforming the production process of car components from traditional discrete planned to agile on-demand manufacturing. Due to the COVID-19 lockdown, the project team also had to manage a drastic reduction of direct personnel from sixteen to two operators

Solution: Conception and implementation of "FITS", a transportation system to optimize the material flow. With the combination of five core modules (MES, APS, AGV, RFID and HMI), FITS transformed the production flow from dedicated production lines to a modular production system. Adjustments during the lockdown also led to more flexible and highly automized processes that enables the plant site to react quickly to short-term interruptions

EIGHT PRACTICAL EXAMPLES FOR THE IMPLEMENTATION OF THE SMART FACTORY.

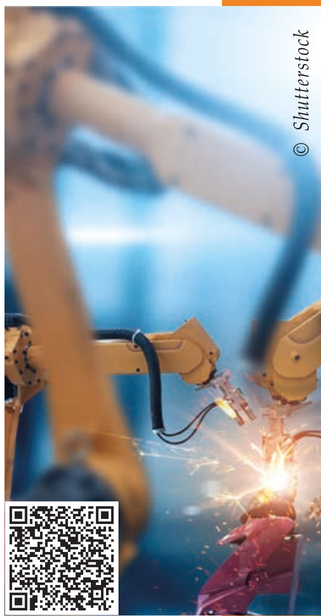
QR-CODE LEADS TO THE CASE STUDY

SMART VALUE-ADDED ASSISTANTS

Even with a high level of automation in manufacturing, there is still room for improvement - for example, with cross-departmental process automation. In this case, ROI-EFESO used tools based on Robotic Process Automation (RPA) in the Operations department to save time and reduce the workload of employees. The smart helpers already passed the practical test in the first project phase: After only three months, the RPA tools were already handling 14 processes in eight business areas such as R&D, HR, controlling and quality management.

INDUSTRY 4.0 EXCELLENCE

Smart analytics, RFID trackers or customer portals: Which investment actually pays off in which timeframe? This project was about mastering an Industry 4.0 transformation in twelve months. First, ROI-EFESO designed a target image for the overall architecture via an Industry 4.0 assessment and showed ways for the Industry 4.0 transformation to exploit existing resources. The company then put several new applications and methods into practice.



SMART FACTORY PLANNING

Will products in the ideal factory of the future control their production completely independently? Or should the focus rather be on the perfect choreography of people and machines? In this case, a company developed four of its plants in Europe into "smart factories". ROI-EFESO determined the status quo in terms of digitalization and Industry 4.0 with its Smart Factory Scan and created development scenarios and location strategies. In addition, the project team classified key topics and initiatives for each location in a portfolio for possible Industry 4.0 pilot projects.

DIGITAL SHOP FLOOR MANAGEMENT

With an automotive manufacturer, ROI-EFESO created a best-practice model for digital shop floor management in two plants with the goal of expanding this approach to approximately 50 plants globally and thus achieving optimal networking of all shop floor information. In this way, improvement initiatives were to be initialized more quickly and efficiently, and the plants were to be comparable with each other on the basis of uniform key figures. This is exactly what an IoT platform with a uniform reporting system made possible. In addition, all collected data can be aggregated at any time, from the machine up to the plant management.

END-TO-END DIGITIZATION

How do digital tools create a customer journey with a wow effect? Especially when a company with several brands is very broadly positioned, the uniform design of an end-to-end process to the customer is a critical aspect for success. ROI-EFESO used parallel front-end and back-end teams to solve this task. These ensured that product customization worked from the point of sale through manufacturing to product delivery. Thanks to the company's high affinity for digital applications, the processes were successfully restructured across all sales channels and for all brands.

DIGITAL PROCESS TWIN

With a digital twin, not only products but also processes in production can be simulated. In this case, ROI-EFESO was to reduce the reject rate of the high number of variants in production. To this end, the project team analyzed which process parameters influence performance and quality results. Based on the collected data, a "Digital Process Twin" was developed in a cloud application. This monitors the physical process in real time and thus provides a virtual cockpit for value stream management.

FUTURE FACTORY

ROI-EFESO accompanied the development of a customized factory of the future for a manufacturer of special equipment - from the drawing board to the handover of the keys. The focus was on increasing the quality of the products, reducing costs and making projects plannable. The factory was created using three strands of action: the design of the physical elements, the design of the information flow and the management of these two tasks. Using cloud technologies, the company was also able to implement an interface-free fusion of the digital and physical worlds.

SMART-PRODUCTS-DEVELOPMENT

A series developer realigned its product portfolio to smart products. ROI-EFESO supported the necessary change process by setting up three teams in the company. In this way, the different competencies and perspectives of "digital immigrants" and "digital natives" were united in the organization. A key success factor proved to be creating tangible results, e.g. with valid prototypes, in order to bring skeptics and observers along.

BUILDING INDUSTRIAL FUTURE

As one of the leading international management consultancies with an operations focus, ROI-EFESO has been helping companies since 1999 in discrete manufacturing and the process industry to optimize their product and technology portfolio, increase operational excellence, design global networks, optimize the organization according to lean principles and reduce costs throughout the entire value chain. ROI-EFESO uses Industry 4.0 and IIoT technologies to align processes in a customer-oriented way, realize efficiency potentials and enable new business models.

As part of the internationally active EFESO Group, ROI-EFESO has a strong presence in the world's most important industrial regions. ROI-EFESO's work regularly receives prestigious awards for its quality of results, efficiency and degree of innovation. Since 2013, ROI-EFESO has honored the best practice solutions in the context of industrial digitalization with the international "Industrie 4.0 Award", which is one of the most important benchmarks for digital transformation in industry.

www.roi-efeso.com