DIGITALIZED MANUFACTURING: TRENDS AND PERSPECTIVES

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SEE TOMORROW'S PRODUCTION IN ACTION TODAY

Digitalized production technologies are transforming business models and changing market structures. Concepts like Industrie 4.0 and the Internet of Things represent a paradigm shift in business and society, resulting from a growing number of increasingly connected and automated devices, machines and products. Forecasts indicate that by 2020, 32 billion objects will be connected to the Internet. The economic impact of digitalization is staggering: studies show that in six economically important industries alone, Industrie 4.0 will give rise to productivity increases to the tune of 78 billion euros by 2025. But from the new opportunities that accompany digitalization grow expectations. As well as being cost-efficient and sustainable, connected production and work processes must be secure, flexible and intuitive. This has implications for individualized production with batch sizes as small as one to the same extent it does for connected large-scale-production, logistics and communication. State-of-the-art sensor technology offers a single solution to cover all these bases. It is, in fact, cognitive systems and machine learning that make it possible to have an industrial Internet of Things in the first place.

As an established partner to industry, Fraunhofer is perfectly positioned to support highly customized mass production, developing solutions that are always tailored to customers' practical requirements. In Fraunhofer's recently opened High Performance Center for Networked, Adaptive Production, experts from several Fraunhofer Institutes are working to realize the complete connectivity of machines and sensors. With this project along with many others, Fraunhofer is playing an active role in strengthening the long-term global competitiveness of the companies that make up Germany's and Europe's industrial base.

Prof. Dr. Reimund Neugebauer
President of the Fraunhofer-Gesellschaft

Prof. Dr.-Ing. Thomas Bauernhansl

"MANY COMPANIES ALREADY WORKING WITH INDUSTRIE 4.0 CONFIRM IT CAN BOOST PRODUCTIVITY BY UP TO 50 PERCENT DEPENDING ON THE COMPLEXITY OF THE PRODUCTION OPERATION."

An interview with Prof. Dr.-Ing. Thomas Bauernhansl, director of Fraunhofer Institute for Manufacturing Engineering and Automation IPA, on the advance of digitalization and the changing face of production in the context of Industrie 4.0.

There are many different interpretations of Industrie 4.0. Professor Bauernhansl, what's your view?

Industrie 4.0 is about complete digital connectivity: between the means of production; their virtual representations, or digital twins; and the employees involved in that process. This facilitates revolutionary developments in production operations by allowing highly qualified, flexible workers to collaborate with intelligent cyber-physical systems in smart processes. While Industrie 4.0 has not yet found its way into all companies, it is a trend that's being talked about throughout Germany, and we expect this to trigger a revolutionary shift in the way we approach value creation – a fourth industrial revolution.

So far, Industrie 4.0 has been more of a big-company concern. How do SMEs keep up?

I view it a bit differently. The big companies tend to regard Industrie 4.0 as a means of risk mitigation at a time when their traditional business models are under threat, and their established competitive advantages are being undermined. The rise of the Internet, for instance, has completely transformed access to the marketplace. On top of that, there needs to be a rethink of investment in expertise in the light of open source developments. For innovative, fast-moving SMEs in particular, Industrie 4.0 presents a multitude of opportunities. Sadly, not all of them have realized it yet – but the numbers pursuing it seriously are growing with each new day.

How do SMEs and their customers benefit from Industrie 4.0?

Industrie 4.0 puts customers firmly at the center of interest and integrates them into their own value creation process as "prosumers." This presents the opportunity to reorganize or even shift the responsibility for complex tasks. Put another way, the customer takes on part of the work. Thanks to these developments, SMEs will also be able to integrate peer production communities and related services into their value creation system. This translates into a high level of productivity since the transaction costs associated with the complexity of the operation are drastically reduced. At the same time, consumers benefit from huge improvements in quality of service. If SMEs put their minds to pursuing this approach, they can significantly improve their global competitiveness.

Fraunhofer IPA's Application Center for Industrie 4.0 develops innovative Industrie 4.0 solutions in direct collaboration with industry. How do companies benefit from the collaboration?

Our application center's motto is: Think in terms of business models – act in collaboration. If you look at any successful SME project, you quickly notice that they were possible only because of the networks created. In a connected world, individual companies can no longer hope to craft solutions that cater 100 percent to customer requirements – that requires collaboration. We at Fraunhofer IPA established the Application Center for Industrie 4.0 as a platform to facilitate collaboration among science, research and industry –

and among industrial companies themselves. In so doing, we have laid the foundations for economies of communication – that is to say, the synergies required to achieve profitability while delivering real customer value.

Can we expect additive manufacturing to play a key role in terms of personalized manufacturing?
There are a wide range of additive manufacturing techniques out there, and I'm sure they will play a key role in the future. That being said, I don't expect them to replace conventional techniques as much as supplement them and open up a whole new segment of production technologies. We also have the field of hybrid processes in which additive manufacturing is combined with conventional techniques. A component might be machined by milling, for instance, and then customized using selective laser melting to apply additional structures. At the moment, it makes sense to use additive manufacturing in any scenario in which you work in close consultation with customers to manufacture items in small batch sizes with a great deal of flexibility. But its application is spreading wider and wider. The automotive industry is already using additive manufacturing to produce components for series-production vehicles. Admittedly, the quantities are still small, but as soon as material prices drop and further improvements are made to process quality and system durability, we can expect to see a leap in the use of additive manufacturing techniques in many established areas of production.

Over the coming years, Fraunhofer IPA intends to establish eight centers focusing on mass personalization. The topics addressed range from additive manufacturing, digital battery cell production and smart materials, through frugal and cyber-physical production systems, all the way to cyber-cognitive intelligence and lightweight engineering.

Industrie 4.0 promises to deliver cost benefits. What specific savings might be possible thanks to digitalization technology?
There's great savings potential almost

across the board. For instance, you can reduce inventory maintenance costs by 30 to 40 percent thanks to real-time information that minimizes the need for buffer inventory and optimizes order quantities throughout the supply chain. This has a corresponding effect on warehousing costs. Productivity is also increased, especially with respect to planning and management tasks. Error rates are lower, too, because the ability to access quality data in real time and share it company-wide makes it possible to get to the root of the problem faster using augmented reality technology. This also makes it simpler and faster to repair systems. The potential benefit is huge. Indeed, many companies already working with Industrie 4.0 confirm it can boost productivity by up to 50 percent depending on the complexity of the production operation.

You often hear Industrie 4.0 and unmanned factories mentioned in the same breath. Does this mean human labor has no future?
That's not going to happen, people will remain at the heart of the value creation process. The only change is that people will become the conductors of the production process, focusing on making strategic decisions and monitoring factory operations. As automated as cyber-physical systems become, there will always be a need for human intelligence. It will be people who continue to design and shape products – that's not something robots will be capable of anytime soon. These days, though, machine operators are also programmers and, if need be, repairmen. The sphere of production is merging with the spheres of planning, control and optimization.

That elite of skilled workers that has the wealth of experience and really understands their work is becoming harder and harder to find on the labor market. As a result, industrial companies need to redouble their training efforts, through learning factories and the recruitment of more instructors, for instance, in order to improve retention rates.

www.ipa.fraunhofer.de/en

EXPLOITING THE FULL POTENTIAL OF INDUSTRIE 4.0

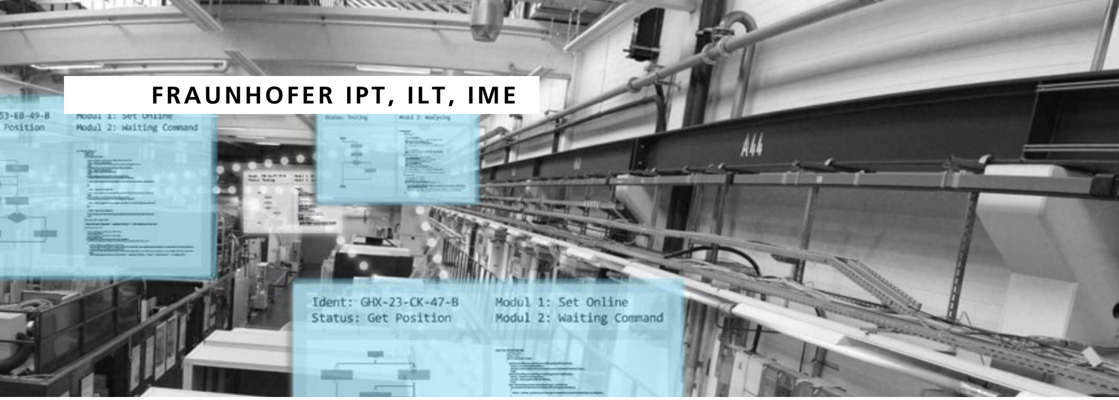
Three Aachen-based Fraunhofer Institutes are working together in the Fraunhofer High Performance Center "Networked, Adaptive Production" to realize the complete connectivity of machines and sensors with the goal of evaluating all recorded production data with intelligent algorithms in real time and flexibly adapting processes accordingly. This will yield numerous diagnostic and forecasting possibilities for the manufacturing of highly complex products in various sectors.

Today, the individual processing of components or the optimization of manufacturing steps during the production process are often not feasible or only in part at best. But this is precisely what researchers from three Fraunhofer Institutes in Aachen want to achieve. They are developing a fully connected production environment which is suitable for different industrial sectors – from biomedicine to mechanical engineering. In the High Performance Center "Networked, Adaptive Production", they aim to exploit the full potential of Industrie 4.0 for particularly challenging production tasks. "With our approach, we are bringing digitalization and connectivity into a real-life manufacturing environment," says Dr.-Ing. Thomas Bergs, Managing Chief Engineer of the Fraunhofer Institute for Production Technology IPT in Aachen. "We equip the production systems with sensors which continuously transmit measurement data from the machines to a central database. What's more, they send the data wire-lessly, via 5th generation mobile networks (5G)." The collected data is stored in a specially developed cloud called Virtual Fort Knox, where it is processed and analyzed with algorithms and technology apps designed specifically for that purpose. This analysis helps to reveal new and surprising correlations, such as vibration patterns which indicate that the tool in a milling machine is worn.

Six models for pilot applications

To illustrate the many ways in which digitalization and connectivity can be integrated into production facilities, experts at the Fraunhofer Institute for Production Technology IPT have teamed up with colleagues at the Fraunhofer Institutes for Laser Technology ILT and for Molecular Biology and Applied Ecology IME to build six different models for pilot applications, including process chains for manufacturing turbine blades, for extracting active ingredients from plants, and for manufacturing battery modules for electric cars. When manufacturing turbine components for aircraft engines, precision and safety are of paramount importance. Currently, the blades are mostly milled from a solid block of titanium using machine tools. This can cause vibrations that lead to inaccuracies during machining. To solve this problem, sensors capable of precisely recording vibrations down to hundredths of a millimeter and a few milliseconds were installed in the pilot plant. In the future, the resulting huge volumes of data will be transmitted via the 5G network into the secure cloud.

A special feature of the new High Performance Center is that all production and sensor data is stored individually for each product – in a "digital twin" containing the entire production history. If damage arises later, it is possible to rewind to an earlier stage in the process and use the data to pinpoint where the fault originated in order to optimize the process. Equally, data analysis and the tracing of product history are just as valuable for the extraction of active ingredients from plants as they are for milling tasks. Under controlled conditions at Fraunhofer IME, plants are being sown, grown, biochemically altered to produce



medical drugs and then harvested. As a final step, the active ingredients are extracted and isolated.

Comprehensive big data analyses

Because different plants grow in different ways and supply different amounts of active ingredients, it is useful to trace the plants' history, so the growth conditions and the production of active ingredients can be analyzed precisely. "We can then determine under which conditions the plants are particularly productive and continuously adapt the process accordingly," says Dr. Johannes Buyel from Fraunhofer IME. "We're carrying out extensive big data analyses to find and to monitor the right parameters that affect the production of active ingredients in plants."

At Fraunhofer ILT, researchers have tailored the concept to the manufacture of battery modules. These modules are made up of thousands of individual cells, which have to be welded and bonded to each other using a laser. This is a laborious process that requires high levels of reliability, because even if a single weld is compromised during battery operation, then the whole module can fail. To solve this problem, the experts in Aachen decided to use sensors to monitor the welding. "As a result, we're able to control the quality of the laser welding in real time or trace it in the product history," says ILT engineer Dr.-Ing. Alexander Olowinsky. Thanks to the complete connectivity of the system and the continuous flow of data, it will be possible to make the manufacturing of batteries more flexible in future. "At present, the manufacturers usually specify the installation space and the cell type. By contrast, for each application, we're able to select the ideal battery type with the ideal performance data and the right size to fit perfectly into a vehicle."

http://s.fhg.de/adaptive-produktion

COGNITIVE SENSORS IN PRODUCTION PROCESSES

In industrial practice, digitalization still frequently means individual solutions that are only partially connected or not connected at all. To facilitate the linking up of production processes, the exchange of application-specific data and the optimization of workflows, Fraunhofer researchers are working on developing identification, localization and communication technologies for cognitive sensors and systems. They are also researching the exploitation of data as part of data-driven services and their accompanying business models.

Currently, department stores still mostly stock mass-produced goods. But in the future, products will become increasingly customized. In the long term, certain branches of industry will be producing goods in batch sizes of one. The automotive industry is already close to achieving this goal with cars today already being assembled according to customer specifications. The challenges encountered in the production process as a result of this can be addressed with cognitive sensor technologies. These must be able to identify and locate components, they must also allow machines and systems to communicate with one another and with their human "colleagues." To manage decisions and processes, application-specific logistics are also necessary.

Industrie 4.0 solutions demonstrated in engine assembly

The Fraunhofer Institute for Integrated Circuits IIS in Nürnberg has been successful in developing technologies that address these challenges – for instance in engine assembly. Solutions range from

industrial truck and conveyer tracking systems to improve logistics processes and ensure the right engine is delivered to the correct station, intelligent tool tracking systems to support the assembly process, and intelligent containers and innovative order-picking systems, through to machine status monitoring systems. The data-based optimization of work processes forms the basis for improving the efficiency of the entire factory. Data collected by cognitive sensor systems can also be used to automatically manage and monitor the supply chain by means of predictive analytics. Furthermore, all these technologies have reached a high maturity level in that they are already being tested and optimized in industrial pilot projects. Currently pilot projects are underway at BMW, as well as research and development projects with Siemens AG and other partner companies who intend to equip part of their production processes and logistics with digital technologies that serve as assistance systems to actively support workers in their interaction with machines.

Nerve cells of the Industrial Internet of Things

"Cognitive sensors enable digital transformation to be realized," explains Prof. Dr.-Ing. Albert Heuberger, executive director of Fraunhofer IIS. "Cognitive systems are the nerve cells of the Industrial Internet of Things (IIoT). They not only measure and record data, they also evaluate them, make decisions by reaching intelligent conclusions and forward this information as and when needed. Fraunhofer IIS supplies concrete solutions for wireless localization and communication in the entire IIoT and IoT environment. Cognitive sensors also use and integrate machine learning to provide the right data at the right time and place for the right application."

Intelligent containers

On the one hand, it is important that workers always have the parts they need ready to hand and that the production line does not grind to a halt due to lack of supplies. On the other hand, a surplus of assembly parts not immediately needed would push up warehouse costs. Researchers have developed a customized solution for this in the shape of intelligent containers that know their exact location, monitor their status and detect when supplies are running low and automatically order parts. These containers communicate via s-net® technology developed at Fraunhofer IIS. They send messages by radio to one another and the infrastructure, creating a communication network. Assembly workers receive relevant information on a dynamic display when, for example, the full container on order should arrive. The data recorded by the containers is collected in a cloud where it is available for big data analysis. Also, inductive near-field positioning technology detects whether the worker has taken a part from the right place and indicates where they can find the next component they require.

Workers not only need small parts like nuts and screws which are kept in such containers, they also need larger parts which are stored on warehouse shelves. To keep storage space to the absolute minimum, spaces are allotted flexibly as they are needed. This means that parts are never put in the same place. Instead, the assembly worker is guided by a light signal to the shelf where the required part is waiting. Conventional pick-by-light systems, however, either require a cable connection, which makes them difficult to install, or they have a short battery life. In the Pick-by-Local-Light (PbLL) project, researchers are developing a new kind of picking system based on wireless sensor networks.

www.iis.fraunhofer.de/en

BLOCKCHAIN AND ITS IMPLICATIONS FOR INDUSTRIE 4.0

Blockchain could be one of the key technologies of the future – and harbors a great deal of potential for application in Industrie 4.0. Prof. Wolfgang Prinz, PhD, deputy director of Fraunhofer Institute for Applied Information Technology FIT, talks to us about the opportunities and risks presented by the technology.

Professor Prinz, there's a lot of talk about blockchain at the moment, but not many people actually know what it is. The term is a bit abstract – what's behind the buzzword?
Blockchain is an open, distributed ledger that is immune to data manipulation. It is used to record transactions – not just financial transactions and transfers of assets and rights, but also audit-proof storage of quality-relevant production data. This puts blockchain in a position to usher in a new age of Internet usage: an Internet of trust and value to follow up the Internet of Things.

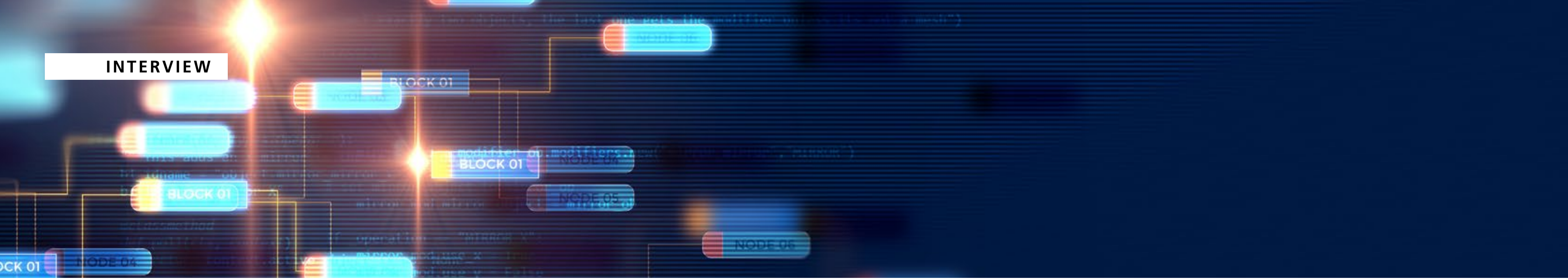
Proponents say that blockchain has the potential to revolutionize our lives – from production supply chains and trade to machine connectivity, provision of power and electro-mobility. Which industries and sectors will be most affected?
We're still in the exploration phase, so I can't give you a definitive answer to that question at the moment. What we can say is that it will potentially affect any sector in which business models revolve around online transactions. Since production processes are becoming more and more connected, this applies to almost every industry.

Prof. Wolfgang Prinz, PhD

What are the implications of blockchain for Industrie 4.0?
Connected production has a major role to play since it involves exchanging orders, processing them and facilitating payment. Here, smart contracts have the potential to handle small-scale CPS (cost-per-sale) transactions automatically and cost-effectively. Just as important will be blockchain's capacity to register quality- and audit-relevant production data easily, securely and transparently. As a trusted network infrastructure, blockchain technology can pave the way for Industrie 4.0.

What specific applications does blockchain offer for Industrie 4.0?
Industrie 4.0 stands for progressive connectivity and automation of production processes. But before you can implement it, you need trust in the system – trust that it is secured against manipulation and trust that it can process supplier, production and finance transactions transparently. Specific applications include supply chain management, automated order processing between machines, and the recording of data and intellectual property rights. While these examples serve to optimize existing processes, there is also the possibility of whole new forms of organization.
Smart contracts can be used to create a decentralized autonomous organization (DAO), the purpose of which is to organize and manage production networks. Production machines are assigned their own identity and sell their services via smart contracts, which they also use to order the materials they need, and to pay suppliers and reimburse loans.

How much will blockchain technology impact the Internet of Things (IoT)?
Smart contracts allow IoT components to automatically execute business processes themselves, all the way from the agreement of conditions to the final settlement. A simple example is a sensor that offers data of varying frequency according to different conditions. Using a smart contract, the data delivered by the sensor can be linked directly to a financial transaction. We can extrapolate this case



and apply it to machines that allocate tasks to one another and use smart contracts to process the payments as well as to guarantee the proper protection of any intellectual property rights.

What's the benefit of Bitcoin and other cryptocurrencies in the era of PayPal and co?

They offer an alternative form of payment and, most importantly, an alternative way to process that payment. With Bitcoin, the payment process no longer relies on a company and its payment platform, but is processed cooperatively via a network. The central platform, that's to say the intermediary, is replaced by the network.

What are the drawbacks of blockchain technology?

Blockchain is still a very recent technology, and has room for improvement in terms of performance, energy efficiency, transaction frequency and the complexity of the application development process. Nevertheless, we already have access to powerful infrastructures that are capable of implementing applications today. You could compare the current situation with the first HTML version of the web. If you continue the parallel with web technology, you can just imagine how many possibilities and development opportunities will arise over the coming years.

What are the risks of blockchain technology? How do you think it might be manipulated?

Although transactions recorded in the blockchain are resistant to manipulation, we must be careful to regulate access. Almost all manipulation to date has resulted from misappropriation of access data. One of the risks of blockchain is its resistance to manipulation itself. Once smart contracts have been recorded in the blockchain, they are immune to manipulation and guaranteed to be executed in line with the specified terms.
However, if a mistake has been made, you can't simply correct it by rolling out an update. As a result, we have to be very careful in the development of smart contracts. We should also be giving some thought to verification and certification solutions that would allow SMEs to verify and use the technology.

Fraunhofer FIT has already set up a blockchain laboratory to design blockchain solutions. What solutions have you been able to implement?

We've already implemented solutions in supply chain, financial transaction and document management. At the moment, we're working with the Fraunhofer Academy on a solution for recording training certificates and reports in the blockchain. In the industry sphere, our projects have included pay-per-use solutions for new plant engineering business models, an energy trading platform for smart grids, transparent storage of production data, and an associated production chain traceability system. These have been supplemented by projects focusing on e-mobility, automated driving, collaborative media production and the corresponding safeguarding of intellectual property rights.

www.fit.fraunhofer.de/en

DIGITALIZED MANUFACTURING: A FORMING PRESS GOES INDUSTRIE 4.0

What might Industrie 4.0 look like in the day-to-day manufacturing environment? What are the advantages of increasing connectivity? What specific benefits will it bring? Many manufacturers are still uncertain about what to expect. Using of a forming press and its digital twin, Fraunhofer researchers demonstrate the leverage that digitalization can bring to manufacturing.

Life without a smartphone? Today this is barely conceivable for many people. How would you hook up with friends when you're out and about? How would you find out when the next bus is coming? Or how heavy the traffic is on the highway right now? In the world of industry, digitalization is also set to usher in some major changes. It is a process that is already well under way in certain business sectors as well as in society as a whole. Yet in the realm of manufacturing, many companies are still uncertain what it will mean for their everyday operations.

Increasing machine availability, extending service life

Researchers at the Fraunhofer Institute for Machine Tools and Forming Technology IWU show how manufacturing can become highly successful with digitalization by demonstrating their concept of Machine 4.0, featuring a fully operational forming press and its digital twin. Standing two meters tall and weighing in at 1.5 metric tons, the forming press operates at a force of 15 metric tons to punch, deep draw and cut components to size. Digitalization brings considerable advantages to this type of machining. "It provides seamless monitoring of the process, the machine and the tool itself," explains Dr.-Ing. Tino Langer, division director at Fraunhofer IWU. "This, in turn, can deliver substantial increases in machine availability and service life, as well as a significant reduction in tool setup times."

Real and virtual sensors

Sensors mounted on various parts of the forming press measure variables such as forces, machining paths and expansion rates, enabling the machine to monitor itself. But rather than being analyzed separately, this data is fed into a software module known as Smart Stamp. This generates a digital duplicate of the forming press – a virtual twin – where the data is fused and analyzed. Is the press operating smoothly? Or is the ram, where the upper tool is mounted, slightly tilted, resulting in workpieces not being formed properly or the tool wearing out more quickly? "Sensor data from discrete sources is often not particularly meaningful," Langer says. "But data fusion gives us precise answers to these questions."

However, it is impracticable to mount sensors to some areas of the press. This may mean critical gaps in the data regarding process or production machinery. But here, too, Fraunhofer researchers have come up with a solution: virtual sensors, which exploit the readings provided by real sensors mounted at various places on the machine. Based on this data, an algorithm calculates the reading that a real sensor would have delivered were it installed in a relevant but inaccessible location. This kind of virtual sensor is very good at depicting the degree of bending in the press frame, for example. "In the EU project iMain, we showed that the readings calculated with our virtual sensor correspond very closely to those of a real sensor," Langer says.

www.iwu.fraunhofer.de/en

SMART, SECURE EXCHANGE OF DATA

Data absolutely has to be protected against unauthorized access, there's no question about it. But until now, when it comes to digital security in data transfer – between doctors and hospitals, for instance – we have had to make do with isolated solutions. Smart algorithms are now available to link these solutions together, reducing data traffic and thus making data transfer even more secure.

Most people don't know it yet, but from 2019 onward patients in Germany will be getting new rights enshrined in German social security law. Patients will be able to take control of their patient file and decide for themselves who gets access to what personal information. Say you want to give your family doctor access to all of your information, including hospital stays and diagnoses from specialist doctors such as orthopedic surgeons; then it will simply be a case of checking the relevant box in your patient file. Patients will also be able to prevent specific people from viewing their information – your gynecologist, for instance. Until now, these and similar sorts of data transfer arrangements have been forced to rely on isolated solutions – making it next to impossible to verify that stipulations are being met. What is more, it hasn't always been possible to ensure the security of the data transfer.

Automated access rights and secure connectivity

Now, researchers from the Fraunhofer Institute for Applied Information Technology FIT have stepped in to remedy these shortcomings. "We've developed smart algorithms that can link up the plethora of isolated solutions using connectors," says Prof. Dr. Harald Mathis of Fraunhofer FIT. These connectors serve multiple purposes. Their first job is to assign access rights and ensure that these are being respected. That is to say, they automate the compliance process and notify the patient of who has accessed their data. Second, the connectors also ensure that data is linked and transferred safely and securely. The safety aspect is about ensuring that the data remains unmanipulated throughout the transfer process, while security focuses on ensuring that no unauthorized person can gain access to the data from the outside. One way to guarantee this security is to intelligently sift the data. What data is relevant and needs to be transferred? And what is surplus to requirement? "It's a bit like a game of soccer. If I keep on shooting at goal over and over again, at some point the ball will go in. In the same way, when I transmit large volumes of data, the risk is that much greater that something will go wrong," says Mathis. The less data transmitted, the more secure the process becomes. Fraunhofer's smart connectors are also able to fulfill this function, sifting out any data that is irrelevant to the case at hand. The connector software can be added on to existing network and software architectures.

Smart connectors for industrial production

The application of these connectors is by no means restricted to the health sector – in fact, they can be usefully applied in any scenario in which there are large quantities of data to be securely transmitted. Industrial production is a case in point, where machines, robots and infrastructure are becoming increasingly connected with the advent of Industrie 4.0 and the Internet of Things. Sometimes, the data also needs to be transferred from one production location to another – which is where the connectors can provide the necessary security. Fraunhofer has already received initial inquiries from interested companies.

www.fit.fraunhofer.de/en

MASTERING DIGITALIZATION

Digitalization calls for highly dynamic infrastructures and service platforms, as this is the only way to ensure that data can be securely transported, processed and analyzed in real time. However, this often poses difficulties for companies. The Berlin Center for Digital Transformation helps companies overcome these challenges.

The digital transformation creates numerous opportunities for manufacturing companies, but it also involves new challenges. How can companies integrate cyber-physical systems into production processes? How can novel technologies such as gesture-based robot programming, digital assistance systems, augmented reality or the Internet of Things support production? The Berlin Center for Digital Transformation helps companies of all sizes – from start-ups to major corporations – deal with these challenges.

This high performance center, which was established in Berlin on July 1, 2016, is a collaborative venture involving the Fraunhofer Institutes for Open Communication Systems FOKUS, for Production Systems and Design Technology IPK, for Reliability and Microintegration IZM and the Fraunhofer Heinrich Hertz Institute HHI. Its chief aim is to design and deliver practical solutions for the digital transformation. In addition to their work on enabling and crosscutting technologies, the researchers here also develop solutions for four specific areas of application: telemedicine; mobility and the city of the future; industry and production; and critical infrastructures.

http://s.fhg.de/digitale-vernetzung

GREEN ENERGY IN MANUFACTURING

Times are changing, both in the energy sector and in manufacturing, and we can expect more use of "green" energy in the future. DYNAFLEX® is a high performance center established and coordinated by Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, and it is here that researchers are laying the foundations for these developments, building up a network linking research and industry, and transferring findings into teaching. Wind and solar energy are highly popular at the moment, and the energy and chemicals industry want to harness more green energy in its production operations in the future. The problem is that both solar and wind energy are extremely variable, and consequently so is the amount of power delivered. Whereas in the past, production was best served by large-scale-facilities, production systems of the future will have to be flexible and modular to accommodate these developments. There is also a need for dynamic models and digital platforms to optimize the whole system and accurately predict how fluctuations will impact energy supply and production.

In establishing the DYNAFLEX® high performance center, Fraunhofer UMSICHT has joined forces with the three universities of Bochum, Duisburg-Essen and Dortmund to provide the scientific foundation required to meet these challenges. DYNAFLEX® is the Ruhr metropolitan area's leading platform for processing dynamics and adaptivity in light of the energy transition and raw materials shift. Internationally visible research, joint R&D roadmaps, digital business models and new approaches to teaching and training form the basis of a long-term strategic partnership between research and industry.

www.dynaflex.de

AUTONOMOUS 3D SCANNER SUPPORTS INDIVIDUALIZED MANUFACTURING PROCESSES

Let's say the armrest is broken in your vintage car. As things stand, you would need a lot of luck and persistence to find the right spare part. But in the world of Industrie 4.0 and production with batch sizes of one, you can simply scan the armrest and print it out. This is made possible by a 3D scanner capable of working autonomously and in real time.

Part of the charm of vintage cars is that they stopped making them long ago, so it is special when you do see one out on the roads. If something breaks or stops working in the vehicle, however, this special status quickly becomes a problem, as spare parts are no longer manufactured either. With the advent of Industrie 4.0, this is set to change: manufacturing is turning toward batch sizes of one and individualized production. Although this is still some way off, researchers at the Fraunhofer Institute for Computer Graphics Research IGD are taking the vision of batch sizes of one a big step closer to reality, with a new type of 3D scanning system. "It is the first to scan components autonomously and in real time," says Pedro Santos, department head at Fraunhofer IGD. For the owners of vintage cars with a broken part, this means that the defective component is glued together and placed on a turntable, which is situated beneath a robot arm with the scanner. Everything else happens automatically. The robot arm moves the scanner around the component so that it can register the complete geometry with the minimum number of passes. This takes anything from a few seconds to a few minutes. Already while the scan is running, intelligent algorithms create a three-dimensional image of the object in the background. Then a material simulation of the 3D image checks whether a 3D print satisfies the relevant stability requirements. In a final step, the component is printed using a 3D printer.

No need for protracted learning process

The real achievement here is not the scanner itself but the combination of the scanner with view planning to form an autonomous system. This view planning technology was also created by Fraunhofer IGD. During an initial scan, algorithms calculate what further scans are necessary so that the object can be recorded with as few scans as possible. Thanks to this method, the system is able to quickly and independently measure objects that are entirely unknown to it. This is a unique selling point, because previous scanners either had to be taught how to do this, or else you had to have the CAD model of the component, making it possible to recognize the position of the object relative to the scanner. Conventional scanners are not suited to the task of handling batch sizes of one. "By contrast, our scan system is able to measure any component, irrespective of its position and orientation – and you don't have to teach it," explains Santos. "Also, you don't need information about CAD models or templates."

Thanks to this USP, the autonomous scanner enables completely new kinds of applications. For example, it can be used as a manufacturing assistant and improve interaction between humans and machines. This interaction is the focus of the EU-funded "Autoware" project, which involves the assembly of cylinders including the various pistons, casings and seals. The 3D scanning system enables robots – by comparing their own data with that in the database – to recognize what component it has in front of it and also to determine which component its human colleague needs next for assembly of the cylinder.

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Prof. Dr.-Ing. Randolf Hanke

THE FUTURE OF NON-DESTRUCTIVE TESTING IN THE CONTEXT OF INDUSTRIE 4.0

Cognitive sensor systems, machine learning and intelligent monitoring open up access to new markets and widen the scope of applications for non-destructive testing. In this interview, we are talking with Prof. Dr.-Ing. Randolf Hanke, director of Fraunhofer Institute for Non-destructrive Testing IZFP and deputy director of Fraunhofer Institute for Integrated Circuits IIS/EZRT, about the impact of digitalization and the opportunities it presents for non-destructive testing.

Professor Hanke, how would you define non-destructive testing?
Until a few years ago, non-destructive testing (NDT for short) was taken to mean the process of examining components and products for quality defects without having to take them apart or destroy them. That's still the case today, but the definition has become a little more complicated.

What's changed?
Our current view of NDT is restrictive and incomplete, there's no doubt about that, both in terms of the solution of NDT problems and in the range of possible application for NDT techniques. Imagine you're in Munich on business and you're invited to the Oktoberfest. You'd look completely out of place in a suit and tie; what you need are authentic German Lederhosen. So, you go ahead and order a pair on the Internet, wear them to the beerfest, and impress everyone with your dress sense. At the end of the evening, you take off the Lederhosen and hang them in the closet, where they will remain unworn for 364 days. Some might hit upon the clever idea of sending the Lederhosen back to the store where they were bought. And this brings us back to non-destructive testing: when they receive returned goods, vendors need to inspect their condition to determine whether they are still salable. Non-destructive testing methods can be easily adapted to such tasks. This is a huge market for sensor technology, but nobody would describe it as non-destructive testing in the usual sense.

So, you see new markets opening up for non-destructive testing in the future?
Absolutely! Just look at the product life-cycle: A product goes through a period before manufacturing and a period after manufacturing. It all begins with the raw material and, sooner or later, ends up with the recycling or reuse of the product. Inbetween, the product goes through a whole series of value creation phases, including trade, transport and e-commerce. What you have to consider is where there might be more customers and potential users of NDT technologies, specifically, what issues are of importance to these customers and what solutions we can offer. These are by no means restricted to production scenarios.

What do you think customers want?
The first question you have to ask yourself is what customers don't want. I think it's safe to assume that most customers don't have any great interest in test systems in the conventional sense. Customers want solutions that are smart, offer added value, and help them to optimize their processes. Such solutions might use, for example, cognitive sensors that are smart enough to determine what data needs to be collected and analyzed to deliver the information needed to make the right decisions. This principle applies to every business sector, any process, and any imaginable task. Our collaborative project with the startup company Mifitto is a good example. We were asked to find the most efficient and cost-effective way of extracting digital data on the internal dimensions of thousands upon thousands

of different pairs of shoes so that online shoppers can be sure of choosing the right size. We were able to deliver the necessary information based on precise, high-speed computed tomography data, and we also created a further significant source of added value by combining highly accurate X-ray data with intelligent software. As a result, Mifitto could advise its customers not only on size alone, but also on what shoe would provide the optimum fit.

What do you mean by smart in the context of data analysis?
Smart monitoring is the key term here. In the future, it won't just be a case of deciding whether a product is good or bad. Rather, it will be about providing customers with a monitoring system that shows them how they can optimize their processes. And by process I don't just mean the conventional production process – I'm talking about the materials development, design, maintenance and recycling processes as well. This has triggered a shift in our research focus. In the future, we won't just be testing, we'll be sorting, characterizing, monitoring and checking as well – in short, imitating the human brain that uses the body's sensory system to extract information and/or adapt its responses to sensory input. As a result, we will be developing cognitive and self-adapting sensor systems that will be able to decide for themselves what they measure when, where and how, along with monitoring and characterization processes etc.

How does non-destructive monitoring fit into Industrie 4.0?
At the moment, work in the field aims to apply self-teaching algorithms to extract information from a huge quantity of data information that allows us to better understand processes, observe and optimize them. These days, when people talk about big data, they are talking almost exclusively about factory data, logistics data, cost data, machine data and so on. What we've hardly considered so far in relation to big data is what we call smart materials data. In the future, we will monitor the evolution of materials and products across the entire value-added chain, that is to say, the complete lifecycle, from raw material through usage all the way to recycling – in fact, any stage at which people, machines or the environment change the material, component or product in any way. We won't just collect material data in bulk or at random, but pick out the relevant data. As to what data is judged relevant or smart, that will be up to the smart measuring system itself, the cognitive sensor system.

In the future, I could well imagine a scenario something like this: The customer is receiving a smart monitoring system – let's call it a Black Box. They don't need any knowledge of NDT processes. The Black Box contains all the necessary robots, which have access to various sensor systems and use these to decide themselves which sensors they use to solve a given task.

This all sounds like science fiction. Do you really believe that such visionary ideas will soon become reality?
Absolutely! After all, this mimics the way human beings work. Everyone has a body equipped with different embedded sensor systems and a brain to process the data and control the body's responses. Each new task is processed with a moderate degree of attention. As soon as an event is registered indicating that something isn't right, we become more alert. We activate more of our senses and try to focus harder on what our eyes and ears are telling us. In other words, we humans always apply a nuanced approach to sensing, using our intelligence. That is the standard we ought to be aiming for in non-destructive testing, too.

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