IFFOCUS

1/2014

THE HUMAN IN MANUFACTURING

SMART MANUFACTURING WORKPLACES
Lessening the Impact of Demographic Change

WITHOUT PROTECTIVE BARRIERS
Enabling Humans and Robots to Work Directly with Each Other

AUTOMATIC INSPECTION AND QUALITY ASSURANCE
Optical Technologies Detect the Minutest Defects

Photo: Fraunhofer IFF

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The Fraunhofer Institute for Factory Operation and Automation IFF specializes in research in the fields of digital engineering, logistics and material handling systems and engineering, automation, and process and plant engineering. Together with our clients, our engineers develop innovative applied solutions and thus create new manufacturing concepts.

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» People will keep their place in the manufacturing of the future, guiding and controlling operations creatively and flexible. They will control manufacturing's growing interconnectedness. «

Prof. Michael Schenk, Director of the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg.

Editorial

The concept of "Industry 4.0" is being discussed everywhere. It can be seen as the fourth Industrial Revolution in a series of milestones in the history of industrialization. Yet, isn't there more behind this almost overused concept than just an evolution or a paradigm change made possible by advancing digitization?

Networked Manufacturing

The fact is, all systems will be interconnected in a self-controlled production system in the future. The prediction of deserted factories has proven to be false: People have kept their place, guiding and controlling operations creatively and flexibly. They control manufacturing's growing interconnectedness. In the factory of the future, they will add their skills and take advantage of the strength, precision and indefatigability of technical systems.

This is moving humans and machines closer together in a single work area. Their combined capabilities will make it possible to shorten manufacturing cycles and increase the range of models of products. Not least, this division of labor is also a response to demographic trends: We are already experiencing a shortage of young professionals. We will have to support the skilled labor we have with technical assistance systems that match their skills, thus enabling them to work more capably and longer in workplaces designed for an aging workforce.

Smart Work Systems

Our experts at the Fraunhofer IFF intend to help companies do this. Time and again, our partners and clients face the same questions in corporate practice: What technologies do we need so that humans and machines can work together in a common work area? What technical systems can assist humans whenever very high precision is required? How can they relieve workers of physical labor? How can a quality product be produced in a safe work environment?

In this issue of our IFFocus, we present some very exciting projects in which these ideas have already been implemented: How robots learn to "feel" so that they don't harm people in any way. How smart assistance systems help workers lower error rates and thus reduce subsequent labor for inspections, and much more. Enjoy reading.

Your Michael Schenk

Robots with Sensitive Skin

In manufacturing of the future, humans and robots will contribute their particular capabilities and in work in a shared work area. This will only be possible, however, when robots detect people reliably and evade them appropriately. The researchers at the Fraunhofer IFF in Magdeburg have made this possible with their pressure and proximity-sensitive sensor systems.
The researchers developed a prototype of this sensor skin on an ABB robot for BMW. The carmaker intends to use the prototype to study such a robot's capabilities and identify the best area of manufacturing for its use.

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Assistance Systems Are Lessening the Impact of Demographic Change

How can people be integrated in manufacturing so that stress is minimized and they can perform their jobs in keeping with their capabilities? Researchers at the Fraunhofer IFF are working on smart assistance systems.

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Sensors Are Replacing Stopwatches

Workplaces and operations have to be organized to prevent fatigue and overwork. How much time does each step of assembly require? Researchers from the Fraunhofer IFF have developed a new system that records time.

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IFFocus 1/2014 Humans in Manufacturing

Interview

When Robots with People ... Dr. Michael Zürn, Senior Manager, Materials and Processes at Daimler on the future of manufacturing at the carmaker

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Sharp Minds

Who earned a doctorate? Who is new? Find out more about the people at the Fraunhofer IFF.

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Mastering the Energy Transition with Concepts for More Energy and Resource Efficiency

In addition to discussion of current trends and prospects for German plant manufacturing, the exchange of experience among experts is a focal point of the conference.

Over 150 experts converged at the 8th Plant Engineering of the Future Conference in Magdeburg on March 6 and 7. The program included concepts and experiences that facilitate more efficient organization of factory and plant life cycles.

In light of the energy transition, every company will have to cut costs, thus making it essential to scrutinize everyday operations and processes first. Conference attendees were therefore particularly interested in dormant potentials for savings in companies and means to profit from them. "It's like a treasure hunt. Whoever goes hunting with the right strategy and the right tools can unearth real treasures," explains the host Prof. Michael Schenk, Director of the Fraunhofer IFF.

Energy Optimized Manufacturing

The researchers at the Fraunhofer IFF are working on energy and resource efficiency in their different fields of research. Their experiences benefit industry directly: In the ERWIN Innovation Cluster (Smart, Energy and Resource Efficient Regional Value Chains in Industry), for instance, the researchers are studying technologies for companies in Saxony-Anhalt, which they can use to organize their operations and infrastructures more effectively and more efficiently, as well as means to leverage synergies and, thus, their overall competitiveness.

With Digital Engineering to Industry 4.0

Efficiency can be optimized in every phase of factory and plant life cycles. This entails using digital engineering integrated throughout the entire life cycle to design and operate new plants or additions to plants. This is a prerequisite for Industry 4.0 in which all of the production systems will be interconnected for self-controlled manufacturing. The ways in which small and medium-sized companies in particular can meet these challenges were discussed at the conference.

The Fraunhofer IFF and its partners, the VDI, VDMA, VCI Nordost, Wirtschaftsinitiative Mitteldeutschland and FASA e.V., jointly host this industry gathering in Magdeburg every two years. (akw) ■

www.tagung-anlagenbau.de

17th IFF Science Days

Rising energy costs and the simultaneous depletion of resources is the most frequently cited economic, social and environmental challenge. The search for responses is no easy task for many small and medium-sized enterprises or major industries. The goal is to reduce the use of energy and raw material in manufacturing in the long term and to organize their recovery as sustainably as possible.

How can solutions be found, which can be implemented in everyday corporate routines by existing means? What technologies are available? Are there already good practices and possibly research partners who could assist in implementing new energy and manufacturing concepts?

The 17th IFF Science Days in Magdeburg in 2014 will be focusing on these questions. Traditionally, each of the professional conferences hosted jointly by the Fraunhofer IFF and Otto von Guericke University Magdeburg is devoted to current challenges in the manufacturing sector. Hundreds of decision makers and experts from business, industry, research and academia will meet up once again at two conferences, "Digital Engineering" "and the "19th Magdeburg Logistics Days", held simultaneously over three days from June 24 to 26. A varied program with over ninety presentations and workshops will offer an opportunity to exchange experiences, to discuss the latest research findings and to present best practices.

This year's topics range from smart and sustainable manufacturing and potentials of digital logistics to state-of-the-art energy management through means for small and medium-sized enterprises to tap the full potential of digital technologies. (mar) ■

www.wissenschaftstage.iff.fraunhofer.de

VAKOMA GmbH Receives the 2013 Foreign Trade Award

Minister of Research and Economics Hartmut Möllring (l.) and Small Business Chamber of Commerce President Hagen Mauer (r.) presenting the 2013 Foreign Trade Award. to VAKOMA sales manager Christoph Krossing.

VAKOMA GmbH, a machine manufacturer in Magdeburg with a long history and one of the Fraunhofer IFF's project partner was awarded the 2013 Foreign Trade Award on September 5, 2013. VAKOMA sales manager Christoph Krossing accepted the award. The Small Business Chamber of Commerce Magdeburg, the Saxony-Anhalt Chamber of Architects, the Saxony-Anhalt Chamber of Engineers and the Saxony-Anhalt State Chapter of the Federation of German Wholesale, Foreign Trade and Services confer the award every year at their Foreign Trade Day.

Among other things, VAKOMA GmbH designs energy efficient and easy-to-maintain drive units that are easily compatible with other manufacturers' old plants and uses virtual reality technologies to sell them. VAKOMA GmbH is working together with the Fraunhofer Institute for Factory Operation and Automation IFF on a mixed reality technology that will increase process reliability of systems installed abroad and will additionally be used for marketing.

Read more about their collaboration in the article on p. 32. (akw) ■

Minister of Agriculture Aeikens Thrilled by Fraunhofer Research

Prof. Udo Seiffert from the Fraunhofer IFF (r.) explaining to Minister of Agriculture Aeikens (l.) how he enables farmers to increase their yields with hyperspectral scanning.

Saxony-Anhalt Minister of Agriculture and the Environment Dr. Hermann Onko Aeikens's visit to the Fraunhofer IFF on April 11, 2014, reminded him of his own days as a researcher: "I appreciate intensive research, particularly the diversity of topics I encountered here today," reported the minister.

What was planned as an informal conversation is now pointing toward stepped up collaboration with the research institute.

The researchers presented their contract research for agriculture and forestry. "I find it particularly impressive that the Fraunhofer researchers have extended their conception of production to agriculture – from plant research to waste recovery. That has been thought out very sustainably," summed up Dr. Aeikens.

The researchers presented their concepts for efficient logistics in forest management and explained how energy can be recovered from agricultural and forestry waste such as chaff and digestate. Furthermore, researchers presented their work on a special measurement system that accurately determines the nutrient content of wheat: A hyperspectral camera takes pictures of the grain – not ordinary photos, though. Rather, it "looks" direct inside a plant and delivers information on its constituents to the researchers. This will enable farmers to increase their yields in the future. (akw) ■

The Fraunhofer IFF at the 2014 Hannover Messe

At the Hannover Messe in April, researchers from the Fraunhofer IFF presented new solutions for smart factories and Industry 4.0 from their research in digital engineering, automation, logistics, and process and plant engineering.

Planning and Building Products and Production Facilities Simultaneously

Fraunhofer researchers have developed and built new production facilities in record time for the specialty chemicals company LANXESS and many other companies. Digital engineering makes it possible for research and development to proceed simultaneously to plan products and manufacturing. Visitors learned how this works at the main Fraunhofer-Gesellschaft booth.

In early 2010, LANXESS decided to enter the water treatment business and needed a production facility for Lewabrane reverse osmosis membrane filter elements to be built by the fall of 2011. Collaborating with the company's experts, researchers from the Fraunhofer IFF in Magdeburg had the manufacturing technology designed and operational in just nine months. Afterward, they designed a second, fully automatic and, thus, more complex plant in just one year. Part of this plant – scaled down – was on display for the first time in Hannover.

Medium-sized companies that produce one offs and small series especially profit from the benefits of digital engineering, namely greatly reduced development times, lower costs and better engineering.

Smartly Managing Renewable Energies

More and more frequently, companies are producing part of their electricity themselves in order to cut costs. Wherever possible, they want their energy to come from renewable sources, be they biomass power plants, solar collectors or wind generators. Unfortunately, they are not always available. Researchers from the Fraunhofer IFF in Magdeburg have developed a novel dynamic management system that compensates for their volatility. The researchers from Magdeburg presented their solution for small and medium-sized enterprises at the Fraunhofer Energy Alliance's booth.

Energy Optimized Manufacturing: Leveraging Synergies

Potentials for energy savings lie not only in buildings or technical infrastructures but also in manufacturing in particular. This is also a starting point for researchers in the Fraunhofer ER-WIN Innovation Cluster (Smart, Energy and Resource Efficient Regional Value Chains in Industry). At the Fraunhofer Production Group's booth, they showed where potentials for energy savings lie and how the researchers from the Fraunhofer IFF are leveraging them. The Energy Quick Check enabled professionals who stopped by to identify potentials for savings in their own companies. (akw) ■

The experts use the data from development not only for planning and building but also for maintenance, repairs and training. This is possible because all of the existing data on the machine are available digitally.

2nd Electric Vehicles Day

Hundreds of visitors learned about the latest technologies and concepts for electric vehicles.

Saxony-Anhalt is electric vehicle capable. That was the message of the "2nd Electric Vehicle Day" in Magdeburg on October 16, 2013. The Fraunhofer IFF, the MAHREG Automotive cluster and the State Initiative for Electric Vehicles and Lightweight Construction ELISA had all invited regional companies, associations and research organizations to present the latest electric vehicle systems and concepts to the general public.

Hundreds of attendees learned about and tested commercial and experimental electric vehicles. There were many innovations from the region to see, from hub motors to new lightweight composites to logistics control centers that locate unoccupied charging stations. The diversity of exhibits made one thing particularly evident: Electric vehicles are a complex topic and broad market success is still far off.

Saxony-Anhalt Minister of Transportation Thomas Webel also stressed the impact of the undertaking: "Refining electric vehicles is an important undertaking for the entire economy. After all, electric vehicles mean nothing other than a reorientation of transportation. As we now see it, three points are important: the development and implementation of innovative transportation concepts, the establishment and expansion of an electric vehicle charging infrastructure and the networking of electric vehicles. The Ministry of Transportation will be supporting this undertaking, "said Webel at the event.

"Many of the state's research organization are working very successfully on the development of new technologies and solutions for electric vehicles," emphasized Prof. Michael Schenk, Director of the Fraunhofer IFF. The institute is intensively researching new solutions for reliable electric vehicle charging infrastructures in close cooperation with Otto von Guericke University Magdeburg. The results of their joint work have boosted Magdeburg's national reputation as a leading center of electric vehicle research. (mar) ■

Smart Grid: Stabilizing Regional Distribution Grids with Renewable Energies

The more we recover energy from volatile sources such as the sun or wind, the more complex the management of electrical grids is becoming. Operators of regional grids are especially facing major challenges. What is actually good for the environment, affects the stability of distribution grids adversely in certain situations. This is the reason the research project SECVER was launched. SECVER stands for "Security and Reliability of Distribution Grids toward an Electrical Grid of Tomorrow".

Since the majority of distributed and renewable energy is produced above 110kV in distribution grids, the effects of possible fluctuation during power production primarily appear in regional distribution grids.

The research organizations and utility companies In the project consortium intend to develop new methods that boost the reliability of grids with exactly these green power sources. Essentially, they will identify approaches to optimization taking the form of innovative algorithms and systems that monitor and control grids. They will monitor distribution grids reliably and forecast short and medium-term grid instabilities.

Project manager Dr. Przemyslaw Komarnicki from the Fraunhofer IFF says,"Ultimately, grid operators will be able to analyze and evaluate the stability of a grid in real time. If it is not stable, a signal indicates where concrete actions are needed and how the system state can be improved. Wind and solar power plants will contribute to this themselves by optimizing their supplied power and additionally ensuring that the system voltage remains in the permissible range."

The SECVER project will run almost two and a half years and is being coordinated by the Fraunhofer IFF. Other partners are Otto von Guericke University Magdeburg, the Fraunhofer IWES, distribution grid operator AVACON AG, wind farm operator RegenerativKraftwerke Harz and Siemens AG. The project is being funded by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (project reference number: 0325631A). (mar) ■

Volker Werner, project manager at BKR Ingenieurbüro GmbH, Mario Schedler, Laser Scanning and Virtual Reality Manage at DOW Chemical Company, and Florian Edeling from Fangmann Energy Services GmbH & Co. KG.

Prof. Wolfgang Gerhard, Senior Vice President of Engineering at BASF SE in Ludwigshafen, and ...

Impressions

of the 8th Plant Engineering of the Future Conference from March 6 to 7, 2014

Prof. Bernd Sankol, Hamburg University of Applied Sciences, and Dr. Lutz Hoyer, former manager of the Process and Plant Engineering at the Fraunhofer IFF.

Helmut Rauschendorf, CEO of Planets GmbH, and Edgar Ludwig, Manager at of Quarzwerke GmbH.

Bettina Reckter from VDI News and Anke Geipel-Kern from the professional journal PROCESS reporting on the conference.

Maria Wedekin, Energy Manager at Symrise AG, and Dr. Dieter Traub, Digital Plant Director at BASF SE in Ludwigshafen.

Prof. Gerhard Müller, Deputy Director of the Fraunhofer IFF, Thomas Waldmann, Executive Director of the Large Industrial Plant Manufacturing Group at the VDMA, Jörn Lehmann from VFI GmbH and Dr. Julian Fuchs, SAMSON AG.

... Thomas Waldmann, Managing Director of LArge Plant Manufacturing at VDMA delivering their opening remarks.

Fraunhofer IFF Director Michael Schenk and Marco Tullner, State Secretary at the Ministry of Research and Economics.

Andrea Urbansky, conference organizer from the Fraunhofer IFF, Axel Franke, Senior Engineering Manager at BASF SE, Joachim Borgwart, Senior Engineering Manager, and Jörn Lehmann from VFI GmbH awaited a festive evening event.

Christian Szibor, Manager of the Festung Mark (r.), recounting the history of the fortress.

"Attention! Welcome!" – guests at the evening event were greeted very correctly at the Festung Mark.

The state and prospects of Industry 4.0 being discussed by Andre Karger, Siemens Industrie Software GmbH & Co. KG, Joachim Betz, Dassault Systems Deutschland GmbH, Torsten Hellenkamp, INDOSIM Consulting GmbH, Markus Herrmann, AVEVA, and Patrick Müller from CONTACT Software GmbH. The chair was Prof. Ulrich Schmucker, manager of Virtual Engineering at the Fraunhofer IFF.

Manfred Busche, Dassault Systems Deutschland GmbH, Christian Seemann, Vice President BASF SE, and Dr. Marco Schumann, manager of Virtual Interactive Training at the Fraunhofer IFF.

All people are named from l. to r.

When **Robots and People** ...
The Future of Manufacturing at Daimler

Interview with Dr. Michael Zürn,
Senior Manager, Materials and Processes, Daimler AG

Faster, more flexible, more sustainable. Those are the challenges for Germany, a center of manufacturing. Dynamic markets demand faster marketability of products, shorter product life cycles and more models of products. This is confronting German carmakers with the challenge of manufacturing custom vehicles cost effectively. Moreover, they have to deal competitively with the risks of volatile markets in their production base, Germany. What is more, the average age of employees in German plants is rising. This means that the conditions in plants will have to be adapted in the medium term.

René Maresch

Dr. Zürn, manufacturing is changing in the automotive industry. The dynamic of markets is confronting carmakers with major challenges. As flexibility is rising, efficiency has to be increased. What challenges will production engineering have to face in the future?

Automation in the automotive industry using industrial robots has been advanced and perfected with very great success in the past thirty years. They are predominantly suited for the execution of frequently recurring, identical activities such as welding, bonding and bolting. At present, standard industrial robots' are able to execute varying or delicate assembly jobs only to a limited extent or only with considerable effort. That is why the axiom has been that automated manufacturing systems are highly productive but rigid and capital intensive, whereas manual manufacturing systems are adaptable but limited in their productivity. Neither of the two approaches is sufficiently satisfying for Mercedes Benz. We are therefore continually working on innovative solutions in order to take advantage of visionary latitude in combination of humans and robots.

How are you tackling these challenges and the essential change in production engineering?

For years, a team of experts in production and materials engineering has been working on the development project "Adaptable Factory". Our experts agree that a profound, conceptual change is needed in production engineering and that far reaching decisions have to be made for the product and production strategy of tomorrow. Mercedes Benz was the first carmaker to recognize the potentials of KUKA's sensitive lightweight robot years ago and to test it successfully in groundbreaking, innovative pilot applications in mass production. As a result, Daimler and KUKA decided to collaborate strategically, focusing on human-robot interaction to execute the most delicate assembly jobs jointly.

How should we imagine the factory of the future? Will service and assistive robots still be zipping around there? What role will people play?

Adaptable manufacturing systems, novel robots and our workers will work together very closely in the future, without robots replacing people. We call this holistic manufacturing system "robot farming". Just as farmers use their animals and machinery on different fields and for different jobs, workers will use robots in different places for different jobs in robot farming. Depending on the quantities and range of items they have to manufacture, they will add one or more robots, put them to work at one station or another, or even work together with them in a work area without protective barriers. Robot farming goes far beyond established manufacturing concepts because it combines humans' cognitive and physical capabilities with robots' repeat accuracy, precision and endurance.

» Adaptable manufacturing systems, novel robots and our workers will work together very closely in future, without robots replacing people. «

What advances has Daimler made toward the adaptable factory?

In our strategic cooperation with KUKA, we are scrutinizing typical job contents and stations, which appear in the production of a vehicle. Based on reference applications, we are developing methods and standards for safe and cost effective human-robot cooperation, HRC for short. All of the selected reference applications are currently being built as working pilot systems in plants and in serial trials.

What research topics are particularly interesting in this regard or what are you hoping for from the research?

We are very satisfied with the advances and impressed by the solutions developed but also realize that a good HRC application requires more conceptuallys than just getting rid of protective barriers! This is exactly where we still see need for research, namely the methodological support of plant engineers by, for instance, software tools to design entire plants suitable for HRC.

We are also taking a look at robot programming in and of itself. I'm talking less about motion programming than actual assembly operations. The question is how employee process know-how can be converted into a digital process map for sensitive robots.
I think that could be just as easy and intuitive in the future as operating a smartphone. In this respect, our employees can already look forward to more active support from their new "colleagues" today.

BRIEF CV

Dr. Michael Zürn

1991	University of Stuttgart: Diplom degree in Process Engineering,
1994	University of Stuttgart: Doctorate
1994	Fraunhofer Institute for Chemical Technology, Pfinztal: Director of Central Management
1996	Schäfer GmbH & Co. KG
2002	Daimler AG Untertürkheim: Manager of the Division of Produktion Support Quality Assurance, Logistics, Pipe Production
2003	Daimler AG Untertürkheim: Manager of V Engine Assembly Mass Production
2005	Daimler AG Untertürkheim: Manager of Forming, Joining and Assembly
2005 - present	Member of the Advisory Board of the Fraunhofer Institute for Chemical Technology
2009 - present	Daimler AG Sindelfingen: Senior Manager of Materials and Processes

Robots ...

... with Sensitive Skin

By Markus Fritzsche and Dr. Norbert Elkmann

The vision for industry of the future sees humans and robots working hand-in-hand. This will only be possible when robots detect people reliably, i.e. "see" or "sense" when a person comes dangerously close to them, and evade them appropriately, for instance, by means of a sensitive skin.

Photo: Fraunhofer IFF

Deserted factories are imminent, prophesied futurologists in the early days of robots. After all, the steel assistants would be able to complete manufacturing jobs faster, more efficiently and more cost effectively, and unceremoniously replace the people in factory buildings. That was – thank heavens – way off the mark. Robots may well have their strengths, such as the capability to repeat movements hours on end without tiring, but whenever robots are supposed to take over every step of production, humans always have a clearly advantage because of their own capabilities. Humans are better at perceiving an environment and responding to changes flexibly. Exactly this capability is essential for small batches, which are increasingly playing a role in manufacturing. Batches are growing smaller and smaller as products become more and more customized, .

Things have changed in the meantime and humans are once again the focus of manufacturing, especially the fourth generation of industry or Industry 4.0. In this scenario, technology is intended to augment people's capabilities rather than replace them.

Teamwork Is the Future

The future lies in teamwork. Both humans and robots will contribute their particular capabilities and work together in manufacturing. In the everyday routine, that might look like this: A robot lifts parts that are too heavy for people but too light for a crane. Its human colleague specifies the path, for instance, by taking it by the "arm" and guiding it. In short, the human decides and contributes his or her know-how. The robot takes over the heavy labor. This is also expedient in light of demographic change. Since the populace is growing older and older, workers will need to be able to work in factories as long as possible. One way this can be done is to leave the physically heavy labor to machines.

There are different forms of collaboration. Either humans and robots work on a part at different times or they assemble it hand-in-hand at the same time. Before robots and humans can work together, though, a risk anal-

The researchers from the Fraunhofer IFF use a special sensor skin to teach robots to "feel".

ysis has to be performed for every single workplace. What are the safety standards with which the robot must comply? How fast may it work and when must it stop its movements to keep people safe? This evaluation serves as the basis for decisions about the sensors a robot or robot cell ought to have.

sor skin and decelerates enough that the person is not injured by a collision. It also senses contact and evades it accordingly. Another advantage is that the sensor system gives the hard steel of a robot a soft surface, more or less a kind of crumple zone. This enables the robot to work faster and complete the short cycles desired. It only slows when a human

gle sensors detects contact. If a force acts on one of the single sensors, it changes its electrical resistance. Thus, a robot outfitted with the sensor skin not only senses when it is touched but also where and how firmly. The experts additionally integrated capacitive sensor elements in the sensor skin. They create an electrical field in their environment.

» Humans are once again the focus of manufacturing, especially in the fourth generation of industry or Industry 4.0: In this scenario, technology is intended to augment people's capabilities rather than replace them. «

Fast Cycles but Safety for Humans

Such teamwork will necessitate reconciling contrary demands. On the one hand, the robot may not work too quickly in the vicinity of humans so that it does not injure them in the event of a collision. On the other hand, as many products should be manufactured in short as time as possible. This requires the robot to move quickly. How can these two very conflicting demands be combined? The researchers at the Fraunhofer IFF in Magdeburg have created one possibility with their pressure and proximity-sensitive sensor systems. These sensor systems can be applied to the surface of a robot as a sensor skin. The robot senses a person's approach through its sen-

enters its space, thus keeping its human colleagues safe.
The researchers developed a prototype of this sensor skin on an ABB robot for BMW. The carmarker intends to use this prototype to test the technology's possibilities and limits and to pursue preproduction research. They want to study such a robot's capabilities and identify the best area of manufacturing for its use.

The Robot's Sensitive "Skin"

Like human skin, the sensor skin also consists of several layers. A patented, matrix sensor cluster with a multitude of sin-

The researchers outfitted an ABB robot with a prototype sensor skin for BMW.

This field changes when a human approaches. The change is measurable, thus making a human in the robot's environment detectable. Since the researchers installed not only individual sensors but also an entire sensor network here, too, the robot not only senses that a person is approaching but also from what direction.

Moreover, the sensor system has to be applied to a robot's complex geometry and supplied with power. Sensor shells modified for the robot's geometry have proven to do this effectively. They additionally allow easy maintenance and replacement of defective sensors. The sensors concealed in the sensor skin are robust and have a long service life. If one malfunctions at some point, the defect is detected by integrated monitoring mechanisms and the system issues a warning. Then, end users can replace the defective sensor shell themselves in a few steps, without having to wait on a service technician for days.

be integrated in flooring, thus making it possible to localize people and track movements.

The sensors could also be applied to robot grippers and thus give them a sense of touch. Then, robots would sense how they have grasped a certain object and, for instance, whether it is slipping. Producing innovative input devices based on this sensor systems is also conceivable. Pressure-sensitive surfaces on robots could provide not only a safety function but also fundamental interaction modalities. Workers could, for example, use certain buttons to control a robot's grippers directly. If they touched the robot on a certain spot, it would register this as specific input rather than a random collision and open or close its grippers.

Photo: Fraunhofer IFF



With the sensor skin, a robot not only senses that a person is approaching but also from what direction.

Complex Interplay of Sensor Systems

The complex interplay of the individual sensor systems integrating the different sensor functions in a compact, universally adaptable robot skin is the fundamental achievement of this development. The challenge is keeping the capacitive sensor elements and pressure sensors used for proximity detention from interacting. What is more, since a high range is desired for the proximity sensor system, the electrical field of the capacitive sensors elements ought to be as extensive as possible and directed away from the surface of the robot.

A Wide Range of Applications

The range of applications for the patented sensor technology from the Fraunhofer IFF is large. Industry has considerable interest in turning it into a product. The potential uses are not limited to robotics alone. The sensor system can, for instance,

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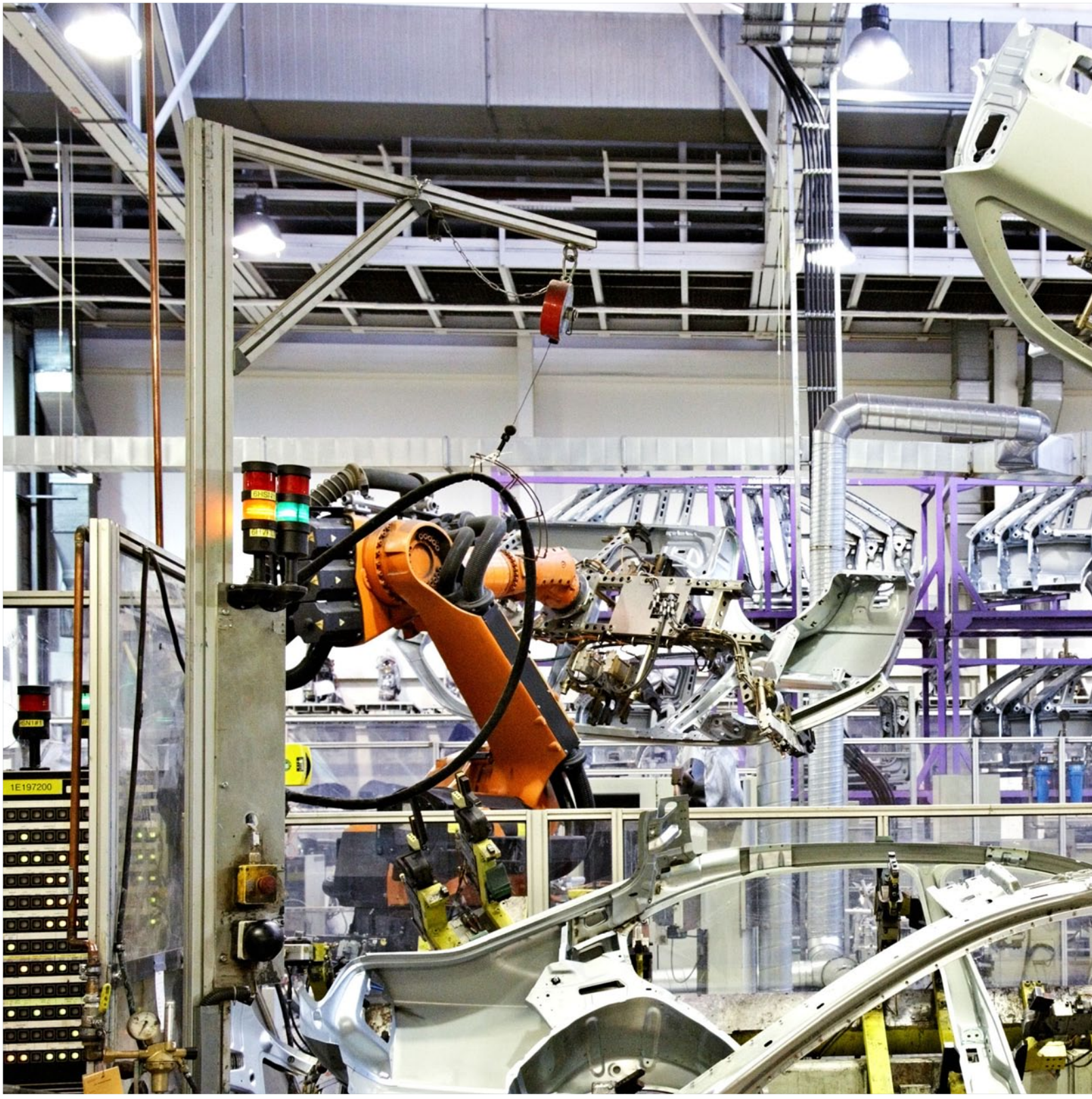
Collisions with Robots without Risk of Injury

Dr. Norbert Elkmann



Teamwork between humans and robots will be the maxim of the future. One crucial point: Robots may not injure humans at all. What constitutes an injury, though? Researchers from the Fraunhofer IFF are examining this in the first study of its kind in the world and laying the groundwork for humans and robots to work together hand-in-hand in the future.

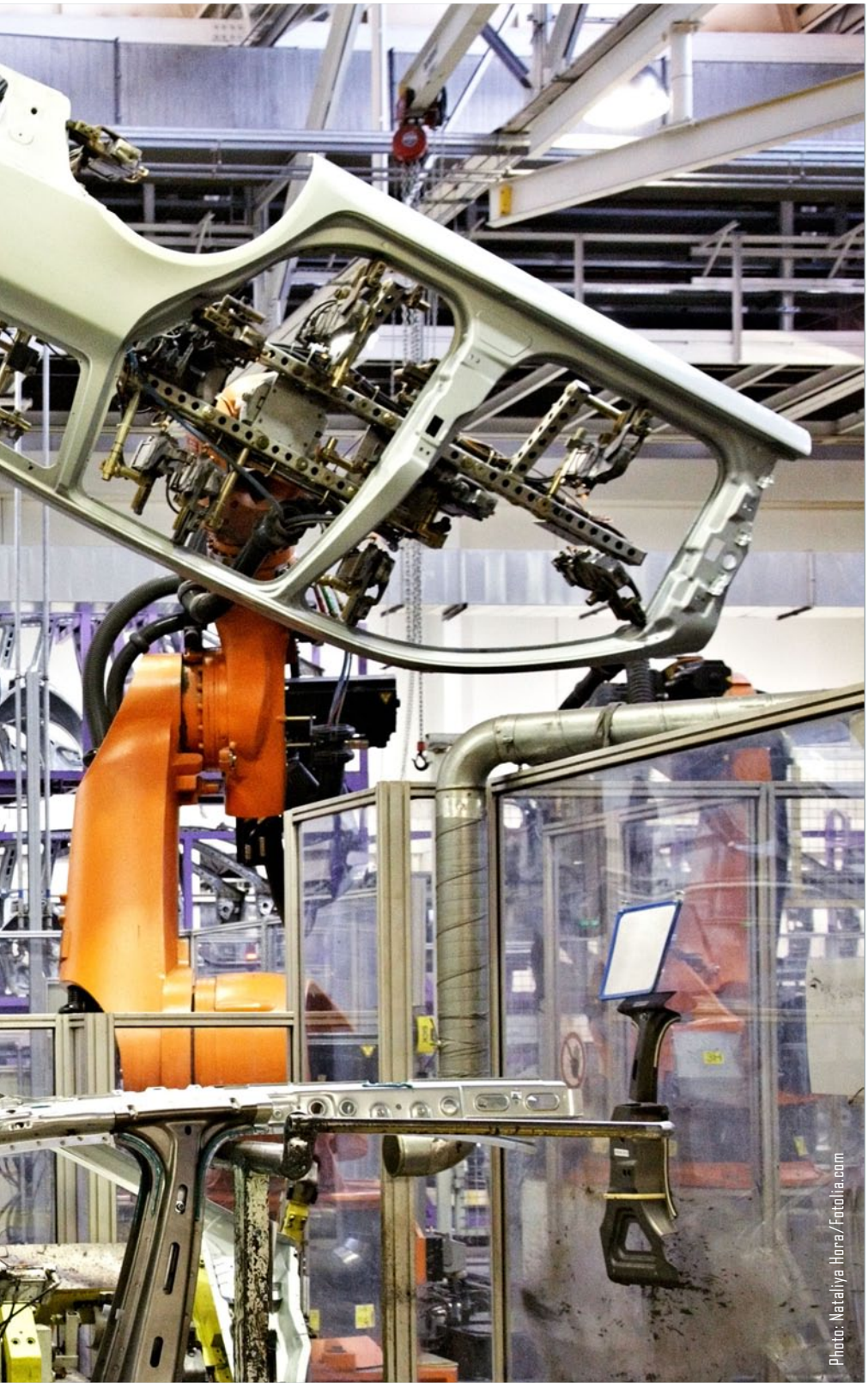


Photo: Nataliya Hora/Fotolia.com

Humans and robots have worked separated from one another not only in automotive manufacturing but everywhere in manufacturing. Protective barriers will soon be disappearing, though.

Everybody has experienced this: You aren't careful for just one moment and suddenly you run into the edge of a table. It hurts at first and a bruise starts to appear on the spot a little later. What falls into the category of "nothing bad, but aggravating" in the case of a table, takes on a new dimension when the colliding partner is a robot. Whereas a table stands immovably in one spot and any collision is entirely attributable to an individual's inattentiveness, a robot is moving and could possibly injure any body with whom it collides.

This constitutes an unacceptable risk that must be prevented by all means. On the other hand, human-robot interaction is increasingly becoming a focus of manufacturing, especially in light of demographic change. Skilled labor will be in short supply in the future. The workforce is growing older and older. Robots will relieve aging workers of physical labor, thus enabling them to perform their jobs into old age. They will assist people, thus enabling them to concentrate more on their jobs and to contribute knowledge and experience better. Robots can, for instance, hold and precisely position heavy parts during welding. The goal is for robots to take over heavy physical labor, while humans supply their know-how, insight and experience.

Desired Hand-in-Hand Work or Impending Danger?

The challenge to this is that robots may not endanger people. That is why these mechanical helpers usually still work behind protective barriers and cages. Additionally, approaches to monitoring a robot's work area with safety sensors already exist. A robot stops moving immediately whenever a person enters its work area – sticks a hand in it for instance. There are also applications, though, that intend for humans to come into physical contact with a robot, i.e. applications in which humans and robots literally work hand-in-hand. How is a robot supposed to distinguish whether contact is intentional or unintentional and discern whether there is any danger of injury? The robot must be programmed so that nothing happens to a human if the two of them collide.

Where exactly is the threshold between harmless contact and injury, though? To what degree can collisions be classified as harmless? The experts are discussing two thresholds at the moment as well as biomechanical thresholds. One example: A worker placing a part in a transfer station at the very moment a robot is approaching should not even sense slight pain in the event of a collision. Things are different when an unforeseeable collision occurs, i.e. a human acts carelessly. What is the maximum permissible load on a human during such a collision? Job safety experts, robot manufacturers and the user industry are agreed that nothing more than minor injuries may occur. Humans may not be allowed to suffer any abrasions at all, let alone bleeding wounds or bone fractures.

Minor Impacts Are Delivering Major Findings

Until now, no one has been able to say exactly how much force is necessary for an impact to produce a bruise and at what point a person would suffer a major injury. There are not any extensive studies on this topic. The researchers at the Fraunhofer IFF are now filling this gap and exploring wholly uncharted terrain. In their study, they are systematically studying the thresholds at which bruises form or pain, which people experience as discomforting, occurs. This knowledge is indispensable if humans and robots are to work hand-in-hand in the future.

The study applies the following approach: The researchers weight a pendulum with different weights, pull it back and allow it to strike different body parts of the participants of the study. They intend to cover the entire body in the future. A special sensor film on the pendulum's impact face measures the pressure of the pendulum when it strikes skin. A force sensor, also located on the impact face, measures the characteristics of the contact force. This enables the researchers to measure every relevant parameter such as force, pressure distribution, impact velocity, momentum and energy.

Otto von Guericke University's Ethics Commission has given the study its approval. Moreover, the tests are being supervised by physicians.

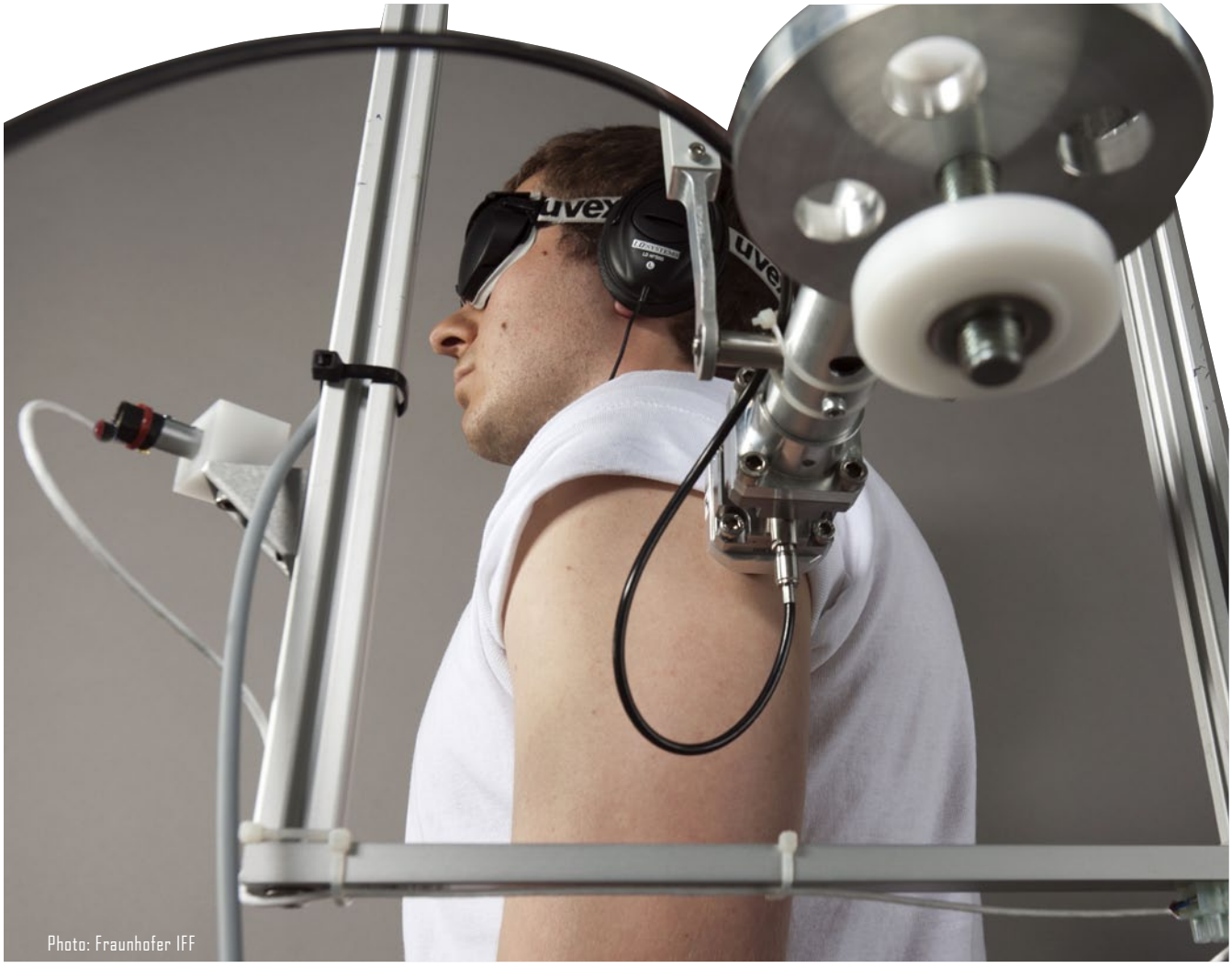


Photo: Fraunhofer IFF

A subject during the study's impact test. How much force can act on a human body before a bruise appears?

Where exactly is the threshold between harmless contact and injury? To what degree can collisions be classified as harmless?

How painful was the impact of the pendulum on a scale of one to five? Six hours after each test series, i.e. once every one of the body parts being studied has been struck by the pendulum, the skin at these spots is examined for swelling or hematomas. A week-long break follows before the researchers strike a participant with the pendulum again. Then, the pendulum has a higher weight or speed, which the researchers are able to set. Weights are hung on the bottom of the pendulum. Speeds are varied by way of the pendulum's swing. Tests are terminated the moment swelling or bruising appears or the subject experiences category five pain.

Six Human Subjects Already in the Preliminary Stage

In the pilot phase, the researchers first developed the measurement system and refined the methodology together with medical professionals. They are now producing the first findings with several subjects in a preliminary stage. At the moment, six subjects are participating in tests and others will follow. Afterward, the researchers will decide how many participants will be needed in the study to obtain representative results. The study is being supported financially by the robot manufacturer KUKA and the carmaker Daimler.

The study has already attracted a great deal of attention worldwide from standards committees, robot manufacturers, the user industry and the research community. After all, the researchers are systematically studying and specifying the thresholds of collisions between humans and robots with human subjects for the first time. The results will enter into the international standard and finally shed light on hitherto open questions: What is the maximum biomechanical load when a robot collides with a human? The researchers from the Fraunhofer IFF will be presenting their initial findings at the world's leading robotics conference, the ICRA in Hong Kong in June of 2014.

The Criminal Justice System Will Also Profit from the Study

The findings of the study will have great value to society, and not just where robotics is concerned. Criminal investigative agencies and medical examiners will also benefit: Whenever victims of violent crimes come to officials or physicians and their subdermal hematomas are hard to see. The intensity of a trauma can usually hardly be determined. Victims as well as physicians would be helped greatly if medical examiners were able to fall back on pertinent studies. Thus, the Department of Forensic Medicine at Otto von Guericke University Hospital Magdeburg is one of the partners in the study, along with the Dermatology Clinic, the Trauma Surgery Clinic and the Department of Neuroradiology.

The study could also be quite valuable for the consumer sector. After all, robots are now commonplace in many households: They vacuum, mop floors or mow lawns. Robots will likely take over far more jobs in households in the future but only if humans are safely protected against injuries from collisions with them. There is still much to be done.

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Assistance Systems

Are Lessening the Impact of Demographic Change

By Dr. Dirk Berndt

Photo: Monkey Business/Fotolia.com

Industry will be facing some major rethinking in the future. For instance, it will have to adjust to a steadily aging workforce and increasingly customized products. Assistance systems will help here. Physical systems relieve workers of physical labor. IT systems guide them through processes that are growing more and more complex. In the long term, assistance systems will even have a certain intelligence.

Challenges to society are compelling companies to change their thinking. Customers are demanding increasingly customized products tailored to their own particular needs. This demand can only be met, though, when the manufacturing equipment is correspondingly flexible. Humans have a significant edge over machines as far as such flexibility is concerned. Another challenge is demographic change: Employees are steadily growing older Companies therefore need support systems that enable employees to meet the demands of their jobs well into old age.

In the process, companies are facing many questions: How can products be manufactured as resource and energy efficiently as possible? How can efficiency be increased? And how can people be integrated in manufacturing so that their stress is minimized and they can perform their jobs into old age? The Fraunhofer-Gesellschaft is helping industry with these questions and working on a solution for a so-called "E^3 Factory". E^3 stands for carbon neutrality, efficiency and ergonomics in manufacturing of the future. Assistance technologies can do a lot to improve ergonomics.

More Customized Products and an Older Workforce

Consumers are demanding more custom manufacturing. Since everyone would like to buy products that are a perfect fit and match, manufacturing is becoming more customized and the variety of models is growing. As a result, lots sizes, i.e. the number of products

Demographic trends are confronting industry with challenges. Industrial companies are facing a steadily aging workforce. What conditions can we establish to enable older employees to do their jobs even when they are sixty-seven?

of the same type, are decreasing. Workers are thus constantly having to perform different activities rather than always completing the same actions. Such a wide range of models can hardly still be managed off the top of one's head, so workers use printed documents to complete their work steps – a situation that is anything but ergonomic. Another drawback is that errors creep in time and again because it is virtually impossible to assemble every module entirely free of errors when using printed documents. In short, people are required to be far more flexible and to complete more complex jobs than just a few years ago.

The demographic trend is also confronting industry with challenges. The populace is steadily growing older and there are too few children. This means that the workforce available to industrial companies is increasingly older than ten years ago. Thus, industrial companies are facing a steadily aging workforce. From the perspective of the manufacturing world, the question this raises is what conditions can we establish to enable workers to still be able to perform their jobs at the age of sixty-seven?

That is why reseachers at the Fraunhofer IFF are concentrating on creating smart work systems that directly help workers perform their jobs. The benefits are more ergonomic and efficient workplaces and increased product quality. Basically, a distinction is made between physical, information technology and cognitive assistance systems. Whereas physical systems take over thelifting of heavy or bulky loads for workers, information technology systems use virtual reality, for instance, to guide workers through constantly modified assembly operations. Cognitive systems, on the other hand, are assistance systems that are able to autonomously decide and discern what help a worker needs, i.e. they have a certain intelligence.

As different as these assistance systems are, they have one thing in common. The key element of every system is and will remain the human being. Workers are still central. Even though the robot does the lifting, humans interact with and guide it. After all, humans are far superior to machinery in many respects: They have a significant edge when problems require flexible responses. Machines have advantages, however, when precision and accuracy are needed. Assistance systems combine the advantages of humans and machines. Certain procedures are completed faster, resources are conserved and errors are detected at an early stage.

Information Technology Assistance Systems Help during Assembly

Mistakes that creep in when modules are being assembled can have serious consequences. This is the case when clamping systems are being built at Kolbus GmbH, a manufacturer of bookbinding machines. A multitude of different parts are machined on CNC equipment. The range of parts necessitates custom built clamping systems that hold parts during machining. Workers have to assemble custom clamping systems, into which blanks are inserted before CNC machining, out of standard components by hand. Any mistake made by the worker during assembly can damage in the machine and, in the worst case, put it out of commission for some time.

Contracted by Kolbus GmbH, the Fraunhofer IFF developed a visual assistance system that helps by providing workers support during complex assembly and helping them to avoid errors. Based on virtual reality, the system compares each real assembly situation with the digital plans and overlays them virtually. Workers see both the real and specified assembly situation on a display.

Other information technology assistance systems from the Fraunhofer IFF inspect assembled modules such as aircraft fuselage shells and turbine components and detect errors (see the article on p. 24).

Such systems are called inspection assistants. A combination of both assistance systems would help workers when assembling fuselage shells . Errors would be prevented. Errors that might creep in nevertheless would be detected immediately and workers could rectify them on their own. Labor for inspections that would otherwise be necessary could be reduced accordingly. The Fraunhofer IFF is developing technologies for this, which make it possible to combine preventive information technology assistance systems with inspection assistants, even in large work areas.

Photo: Kadmy/Fotolia.com

Manufacturing is becoming more customized and the variety of models is growing.

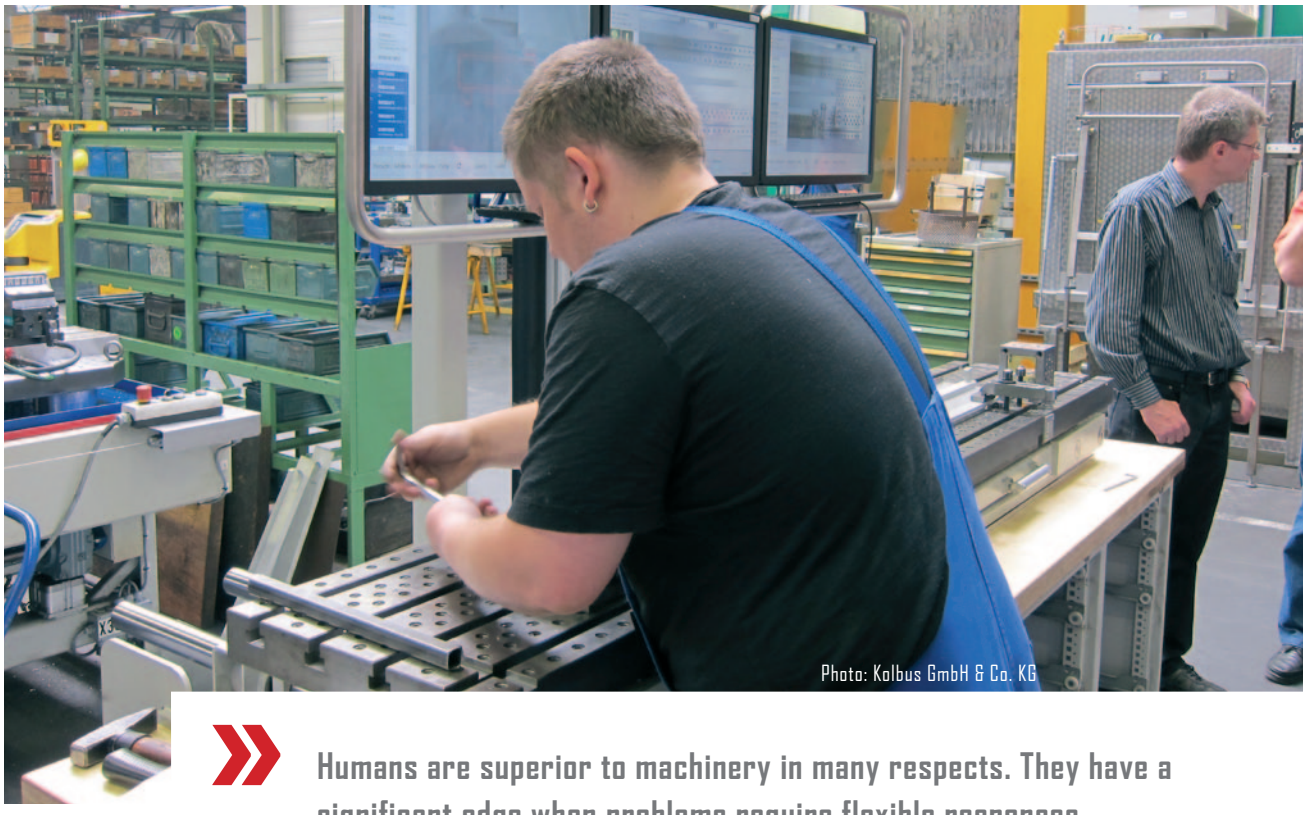

Photo: Kolbus GmbH & Co. KG

The visual assistance system guides assemblers virtually during their work in real time and inspects their finished work.

Humans are superior to machinery in many respects. They have a significant edge when problems require flexible responses. Machines have advantages however, when precision and accuracy are needed. Assistance systems combine the advantages of humans and machines. Certain procedures are completed faster, resources are conserved and errors are detected at an early stage.

Assistance Systems "with Smarts"

At present, the researchers at the Fraunhofer IFF are developing physical and information technology assistance systems. Long-range research studies are aimed at a system that additionally possesses intelligence. The outcome would be a smart, cognitive assistance system that autonomously recognizes what help workers need. This is not only contingent on their level of training and their physical fitness but also on their daily performance level. How tired are workers? Do they need more breaks than usual?

Until now, help has been the same for every worker. In the future, though, all workers should receive exactly the help they need at a given moment. To this end, the system analyzes the speed at which a worker is working at the moment and the number or errors the worker is making. Based on these indicators and empirical knowledge from prior events, it adapts to a worker's daily performance level. Systems intended to provide physical assistance should, however, also support physically fit workers so that they do not develop any physical problems in the first place.

The development of such smart systems necessitates interdisciplinary collaboration, not just among computer scientists, mechanical engineers, electrical engineers and mathematicians as has been the case until now but also among ergonomists, occupational medicine specialists and industrial and organizational psychologists. How can different genders and age groups be factored in? What forms of support do workers tend to accept more than others? Rather than viewing assistance systems in isolation, physical and information technology approaches have to be combined.

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Optical Technologies Expose the Minutest Defects

By Steffen Sauer and Erik Trostmann

Aircraft fuselage shells and turbines have thousands of bolts, rivets and mounted parts on them. Until now, workers have manually checked whether they fit correctly – a demanding job during which errors can be easily overseen. A novel inspection system will take over this job in the future and, thus, ensure that manufacturers can deliver aircraft fuselage shells and turbine parts without defects.

Although they bear standard designations such as Airbus A380, airliners are custom made. Every airline purchases just a few planes and wants them modified for their specific needs. While one airline wants to have as many rows of seats accommodated as possible, another emphasizes comfort and gives passengers somewhat more legroom. The situation is similar for interiors, e.g. monitors, luggage compartments and ventilation systems. Every wish enters into an aircraft manufacturer's planning at an early stage: Workers, assembling an aircraft fuselage shell, have to install the proper brackets for seats and for electrical cables. Until now, workers have gotten the information on the exact locations where they should mount particular attached parts from two-dimensional technical drawings. The problem is that a two-dimensional plan is not exactly clear and one mistake or another can creep in easily. Although there is quality assurance, it too is manual and mistakes slip through undetected now and then. After all, the number of parts is gigantic: Up to 40,000 rivets hold each of an aircraft's twenty fuselage shells together, and up to 2,500 attached parts have to be inspected. Are they located in the right spot? Have they been installed in the right direction or are they backward?

Photo: Fraunhofer IFF

Workers bear great responsibility. Any error they fail to catch entails a great deal of labor that costs an airplane manufacture time and money. Airplanes are not built all in one place. At Airbus, for instance, workers rivet the individual components of fuselage shells together in Nordenham near Bremerhaven. These shells are transported to Hamburg where they are assembled into so-called fuselage barrels, which, in turn, are sent to Toulouse, France where they are assembled into a finished airplane. A defect overlooked by inspectors in Nordenham is usually not discovered until the module is in Hamburg or even in Toulouse. That means a team from Nordenham must travel elsewhere just to rectify a minute but elementary defect.

Reliable Detection of Defects

In the future, workers will receive support when they are checking for errors and will no longer need to take a look at every single one of the thousands of parts. An automatic inspection system will reliably detect errors during assembly. Premium AEROTEC GmbH contracted researchers at the Fraunhofer IFF to develop it. Just as workers did earlier, the system gathers information from the available CAD data on fuselage shells. They include the locations of every part. From this data, the system creates virtual "photos" of the fuselage shells together with the attached parts –

Aircraft fuselage shells or turbines are held together by thousands of bolts, rivets and other small parts. An automatic inspection system from the Fraunhofer IFF will be reliably helping workers check for defects.

Photo: Fraunhofer IFF

Have all of the parts been assembled correctly? Workers can view an evaluation of inspection on their tablets directly on site.

between 1000 and 5000 pieces – so that every single rivet and every single attached part is recognizable. A specially developed sensor head delivers corresponding real photos: Mounted on a robot, this sensor head scans every single one of the 1,000 to 5,000 features and "photographs" the real attached parts. The system compares these real photos with the virtual images. When they match, i.e. the parts pictured have been assembled correctly, the system marks the photos green. It marks discrepancies it finds red, uncertainties yellow. Workers can view different evaluations in an inspection report, used interactively much like using an app: For instance, all of the relevant boreholes or all of the parts that were marked yellow and red. The system supplies users not only photographs but also coordinates of components so that inspected parts can be located again quickly. At present, workers prints out reports with features marked red and yellow and take these with them inside aircraft fuselages to rectify errors. In the future, reports will be displayed on tablet computers so that workers do not have to print it out.

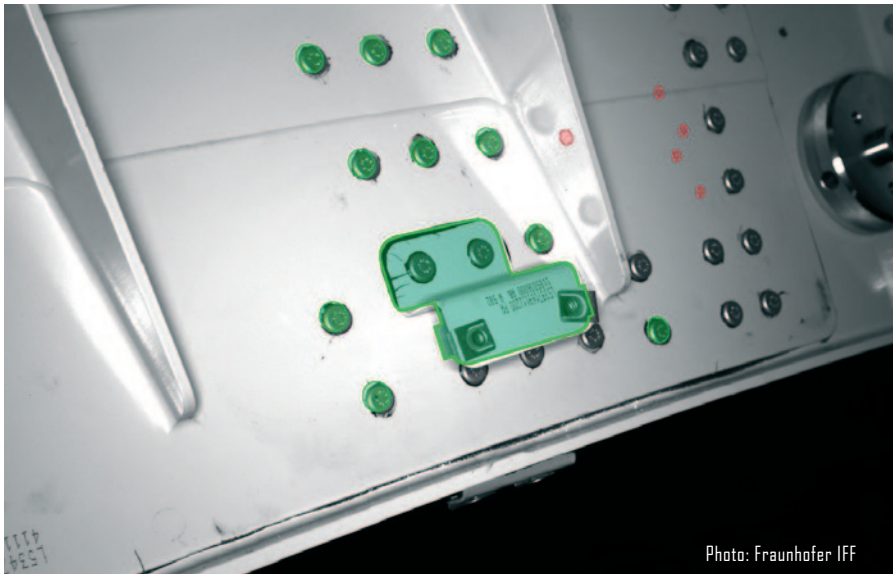
The digital inspection system is not only more reliable but also significantly faster than manual inspection: It needs approximately only three hours, instead of eight to twelve, to inspect the fit of every part. In the process, it not only tracks down errors but also helps eliminate them in the long run. Errors have been proven to occur with greater frequency in some places. Where and why, though? To find out, detected errors are fed into a database that analyzes whether they appeared just once or recur. During assembly, workers could be given pertinent information on things that are important to watch for in particularly critical spots. That is not the only thing that makes this inspection system special. The system also inspects all sorts of sizes, effortlessly analyzing volumes of up to 15 x 5 x 3 meters very precisely and with high resolution.

Tracking Down Defects in Turbines

Early detection of errors is extremely important not just for fuselage shells but also for parts for aircraft turbines. That is why MTU Aero Engines GmbH in Munich contracted the experts at the Fraunhofer IFF to develop an inspection system for turbine center frames or TCF, which is based on similar principles. TCF are manufactured in Munich by MTU employees and are used in the A380 and in the Boeing 787. Once they are fully assembled, the conical TCFs, measuring approximately 1.40 meters in diameter, are packed in containers and sent to customers who then install them in engines. Assembly errors cannot be tolerated and absolutely must be avoided in such parts that are relevant to safety.

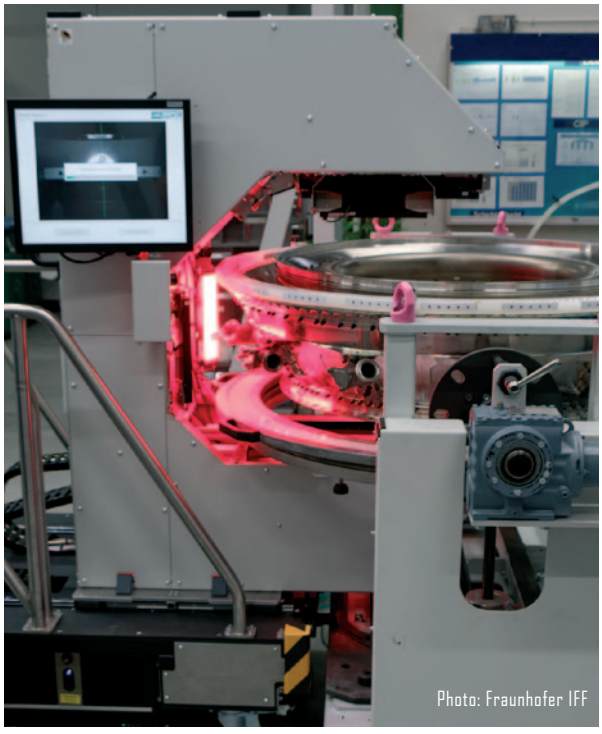
The optical system inspects assembly and ensures that none of the 570 different parts is in the wrong spot. An example of one such error: Since the TCF module is axisymmetric, a worker could start putting in bolts in the wrong spot, i.e. at the wrong angle. This is

» In the future, workers will receive support when they are checking for errors and will no longer need to take a look at every single one of the thousands of parts. An automatic inspection system will reliably detect errors during assembly. «



The digital inspection system operates based on the "traffic light principle". Parts marked green have been assembled correctly. Red clearly indicates stop, something has to be corrected here.

Inspection system for turbine center frames like those installed in the Airbus A380 and the Boeing 787 sind.



hardly noticeable at first but impedes assembly of the complete turbine. Whereas such an error might be overlooked during manual inspection, the inspection system finds it reliably. A worker guides the C-shaped inspection system in an initial position over the TCF module so that it "looks into" the tapered module a bit from above and below. Fourteen cameras take pictures of the attached parts from different perspectives and compare them with the "virtual photos", each of which was created by the system from the CAD data and has exactly the same field of view and camera angle as the real pictures exactly. Pictures are taken in around five seconds and each position is evaluated in around five seconds. Once finished with the first position, the worker rotates the module in the inspection system to the next position specified and the procedure begins anew. A complete TCF is scanned after approximately five minutes and twelve positions. The report shows the worker at a glance if and where a correction is needed. Development of this inspection system entailed a special challenge: Only CAD data of the TCF module and its cradle served as the basis. A real TCF module could not be made available for reasons of non-disclosure and security. Where will which camera be positioned? Which parts have to be recognizable and covered from what angle? The experts had to revert to the CAD data to answer these questions and test the needed developments virtually. With success: The inspection system is finished and in use at MTU in Munich.

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Sensors Are Replacing Stopwatches

By Manfred Schulze

Photos: Fraunhofer IFF

People holding stopwatches and meticulously recording and, thus, determining the time required for every one of a worker's actions are still widespread. This is how companies ascertain the time standards and specifications they use to plan and control operations as well as pay. The foundations of the system of manual time recording still in use today date to 1924. It is involved, imprecise and unduly geared toward the factor of time.

Such somewhat antiquated methods have been a thorn in the side of Uwe Gründler, engineer and owner of a consulting firm for corporate operations in Magdeburg, for some time. "Industrial practice as well as standards of occupational medicine have long required as comprehensive an analysis of time requirements as possible. We want to precisely record not only that but also data on as many of the physical stresses as possible," he says. Changes on the labor market are increasingly raising companies' awareness that jobs and operations have to be organized to eliminate fatigue or overwork as much as possible. "The otherwise impending costs from absence due to illness, disabilities or fluctuation are greater than the expenditure for optimal organization of work," believes Uwe Gründler.

Martin Woitag, an engineer at the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg, shows two black sleeves into which are sewn three small boxes barely the size of matchboxes. They are intended to allow an entirely new step in the recording of workflows in the future. Together with Dr. Gründler's engineering firm, Martin Woitag developed a complete system for this. Sensors capture acceleration and angular rate in the three Cartesian axes on various places on a worker's arm so that motion curves and joint orientation can be measured exactly. Software assures that these data can be compared with established table values and, thus, conclusions can be drawn about the actual load and forces generated by every single work step.

Researchers at the Fraunhofer IFF developed a new system that records the times of assembly procedures.

» We can also find solutions for workplaces where workers don't just sit quietly at desks, that is, in custom machine manufacturing or an assembly line in automotive manufacturing. «

Dr. Uwe Gründler, DR. GRUENDLER Ingenieurbüro für Betriebsorganisation

Special sensors are integrated in sleeves. The data collected reveals how much time is needed for every single step of work. This is intended to protect workers from fatigue and overwork.

"Stresses in the workplace are frequently still underestimated because the loads don't necessarily have to be great," says Gründler, naming so-called clips used in large numbers in the automotive industry as an example. "With just a little thumb pressure, the part fits," he explains "But performing the same activity a few dozen times per hour over the course of several years will cause arthritis in the thumb with great probability," says Gründler, describing a typical case in which nothing suggests overloading at first glance.

Typically, workers do not notice that something in the organization of their workplace is suboptimal until the damage is done. Provided they are recognizable during planning, such hazards can be eliminated during operations by simple measures.

In the first step, the researchers at the Fraunhofer IFF analyzed movement recorded by sensors during seated activities, compiled assembly times from this and acquired initial experiences in this still relatively simple level of use together with field partners such as the automotive company FTE in Mühlhausen. "All of the individual movements were recorded in order to retain precise and structured time recording. Our sensors need predefined measurement points but no additional infrastructure such as cameras or GPS and operate entirely without any reference," reports Woitag. The results even exceeded the first prognoses in terms of accuracy.

Photos: Fraunhofer IFF

Time recording at an assembly station.

"Naturally, we were aware at that time that this could only be the first step toward automated time recording systems because we will also need to record the forces exerted using such a system. In another step, we were also able to find solutions for workplaces where workers don't just sit quietly at desks, that is, in custom machine manufacturing or an assembly line in automotive manufacturing, for instance," says Dr. Gründler, pointing out that overhead work in automotive manufacturing, for instance, can entail very difficult postures for which sensors on arms would no longer be sufficient.

Development of suitable models that also measure and evaluate the forces applied from the perspective of occupational medicine required the researchers at the Fraunhofer IFF to modify the existing German Key Indicator Methods, which have been used more empirically to evaluate job stress. Table values for lifting forces, e.g. when a worker has to lift a work piece for assembly, already exist. "Unfortunately, there are not any specifications that correlate permissible loads on individual muscle groups with age, gender, posture and ambient conditions," explains Martin Woitag. The occupational medicine specialists will still have to make an important contribution here so that the measured values can be used in the future for reliable conclusions about necessary changes This is essential in light of dwindling skilled labor and later retirement ages in order to also be able to draw conclusions about ways to deploy older employees, too, so that they keep performing.

The hitherto manual analyses of such workplace situations are tremendously time-consuming for companies. What is more, participating employees often feel watched by the manual time recorder and occasionally react differently than in their daily routine. "We assume that we will be able to reduce the labor by up to two thirds, especially whenever multiple recordings are necessary, which will be taken fully automatically with our sensor system," assures Dr. Gründler.

Another of the researchers' medium range goals is to further miniaturize the little boxes' inertial sensors. The equipment used previously is more of a demonstrator and was produced in the labs of the Fraunhofer IFF. "Tiny sensors that transmit their signal wirelessly would make it easier to perform a workplace analysis as well as monitor the functions on hand and finger more precisely," says Martin Woitag, looking into the future.

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Guided Step by Step

Dr. Simon Adler

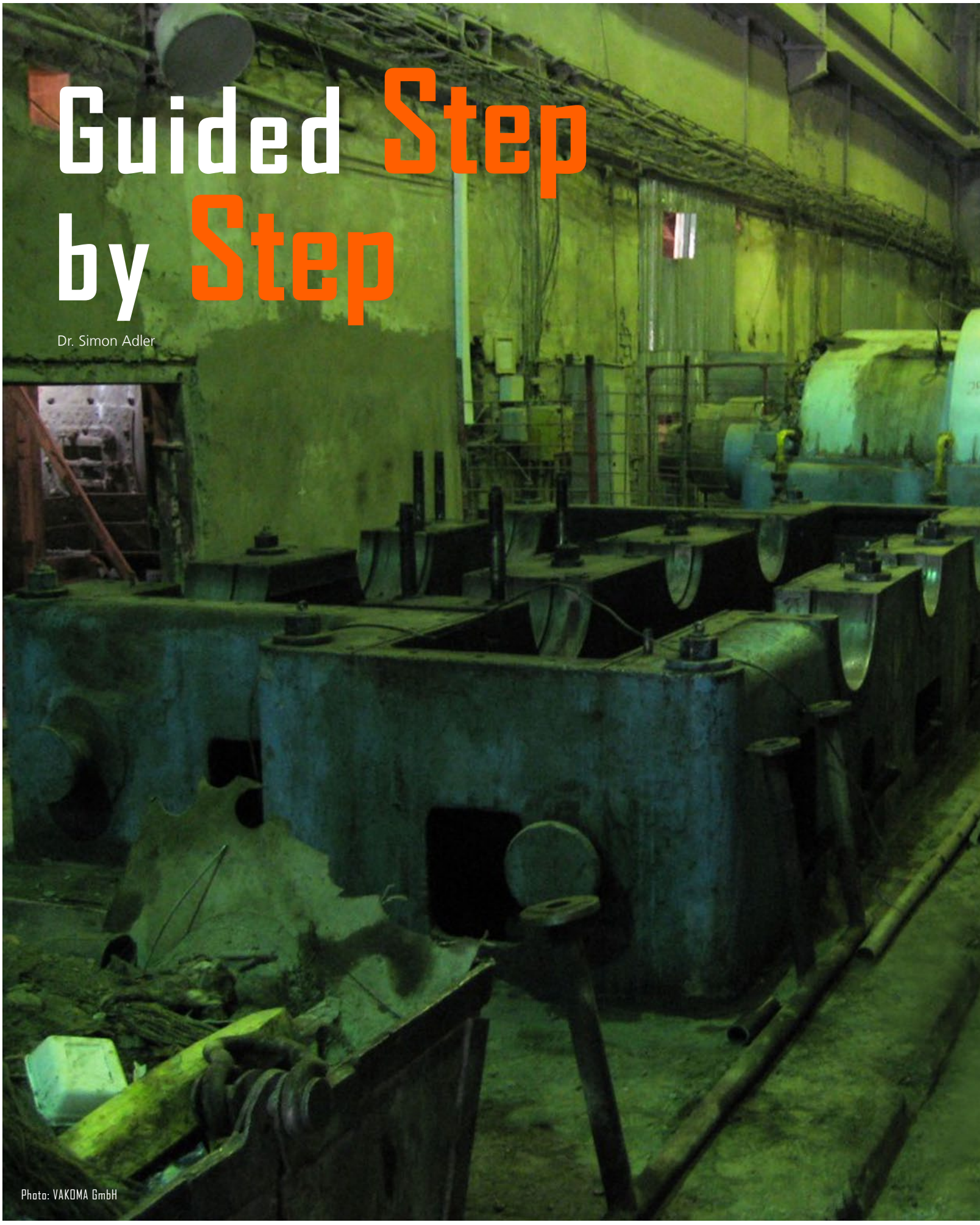

Photo: VAKOMA GmbH

Take a look in Russian factories and, in turn, at gear drive units and, with some probability, you will run across quite old models. They are often still from the GDR. Many of them are already thirty to forty years old. In most cases, the firms that once manufactured these gear drive units no longer exist. What is to be done when the gear drive units no longer function as they should?

VAKOMA GmbH in Magdeburg provides help. "We are marketing a new technology," says Gerhard Krossing, owner of VAKOMA GmbH. "It consists of a mobile manufacturing facility with which we can recondition Russian gear drive units." VAKOMA GmbH staff travel with this manufacturing facility, which brings 2.3 tons on the scale, to clients and get old gear drive units back in shape.

This is not an easy job. On the one hand, the gear drive units are often located in quite harsh environments such as cement plants. It is hot and stuffy, and dirty everywhere. The noise is deafening. In short, workers are subjected to extreme physical and mental stress. Then there are the gear drive units themselves: They are often up to two meters high and weigh seventy tons. The gears alone weigh four tons. The specialists have to disassemble such "monsters" completely and replace defective parts as well as the enclosures.

That is not all though: They also reduce the material. The inner workings of a reconditioned gear drive unit are reduced to only approximately twenty tons rather than the usually forty. "The original gear drive units are built much too complicatedly. So, we simplify them," explains Krossing. "This enables us to conserve valuable resources." The gear drive units' oil consumption is also greatly reduced: Whereas a gear drive unit needs 1600 liters beforehand, consumption drops to 800 liters, i.e. by fifty percent, after reconditioning.

As if these repairs were not challenge enough, two cultures also collide.

Old gear drive units in Russian firms are up to two meters high and weigh seventy tons. The gears alone weigh four tons. Experts from VAKOMA have to disassemble such "monsters"completely and replace defective parts as well as the enclosure. Here, a A2800 mill gear drive unit is going to be reconditioned.

> We wanted to have a tool that systematically guides workers through the process. The system supports staff technically, assures high process reliability, reminds staff to perform checks and makes billing easier through good documentation. Even when we are not on site, we can see which work step lasted how long and give technicians support and instructions to take with them.
>
> Gerhard Krossing, CEO of VAKOMA GmbH

German Precision Meets Russian Improvisation

VAKOMA staffers are routinely confronted by parts that weren't intended for the gear drive units at all but were added or replaced by Russian colleagues over the course of time. Such problems require flexible solutions that the German specialists, in turn, often fail to record accurately or at all. What procedures were performed? What problems arose? How were they solved? The experts usually find it hard to remember when they take on a similar job one or two years later. Staff are entirely thrown back on their know-how even when problems are foreseeable. Relevant information is usually inaccessible since it only exists in printed form and is lying in the office back home but is usually too heavy for the flight to Ukraine or Russia anyway.

Step by Step through the Repair

In the future, staff will receive support from a mobile assistance system: It will guide them through the involved processes step by step. "We wanted to have a tool that systematically guides workers through the process," says Krossing. Without further ado, they awarded the contract to the Fraunhofer IFF. "The system they built supports staff technically, assures high process reliability, reminds staff to perform checks and makes billing easier through the good documentation. Even when we are not on site, we can see which work step lasted how long and give technicians support and instructions to take with them," says Krossing, pleased.

Photo: VAKOMA GmbH

In the future, an augmented reality system will assist VAKOMA staff when they are on a job at their client's facility.

The AR worker assistance system for VAKOMA specialists. The company additionally uses it for interactive product presentation. It is supposed to be developed further to qualify specialists.

Photo: Fraunofer IFF

First, the supervisor enters the individual work steps together with a description of every single procedure in an authoring tool. As different as gear drive units are, the procedure is usually the same. The worker who is supposed to repair a gear drive unit on site takes the project file with him or her. It contains all of the relevant information but, unlike paper printouts, does not add any weight to luggage. The mechanic finds all of the media contents for every work step on his or her tablet or smartphone: Written directions, pictures and videos. If the worker wants to have his or her hands free, he or she can use a head mounted display instead of a tablet computer. He or she can see each of the next work steps on the display using augmented reality (AR), view pictures and videos on it or retrieve a spoken version of written information. He or she receives answers to such questions as: Where must measurements of the gear drive unit's dimensions be taken? When must the laser needed for this be calibrated?

Better Documentation Will Help in Future Jobs

Workers can add photos or videos to the system and notes to documentation. If measurements have to be taken during a work step, the system requires the worker to enter the measured values. If there are deviations, e.g. the measured radius of part of a gear drive unit is somewhat larger than it should be, the system inquires about the discrepancy. It does this not to criticize the worker but rather to reveal improvisations. After all, learning is the priority. Did the worker enter and then change a value afterward? An example: Years ago, the employees of a Russian company bolted a metal plate in front of a generator. Over time, the plate became so worn that it looked like it was part of the gear drive unit. The worker had therefore entered the dimensions together with the plate but noticed the plate later and then corrected the measurements. Information that this is a plate bolted in front might be important for future jobs, though.

Back at home, staff are able to discuss which of the notes and entries are interesting for their colleagues, too, and use the authoring tool to add them to company know-how.

The System Even Displays Risks and Hazards

The system not only gives workers instructions when they have to perform a work step but also practical information. An example: Gear drive units are usually well-oiled. The oil is often not visible under the dirty surface, though. The floor does not look slippery at first glance – a false sense of security. Any worker climbing in would quickly fall down. The system therefore issues an instruction to lay out non-skid mats first. Similarly, workers receive a warning to remove milling heads when they are not needed since they could injure themselves on them otherwise.

Not just its support has made Krossing a fan of the new system. "We are planning to expand our activities and purchase a second system," he reveals. "The AR tool could additionally serve as a training tool. The new system also makes it conceivable to outsource the gear drive unit reconditioning business completely to a local contractor." After all, the unit the workers need for reconditioning weighs 2.3 tons. It would be more convenient and cost effective if it remained with a contractor in Russia – right where it is needed. Its transport from Germany to Uzbekistan alone costs around € 10,000. Krossing is extremely satisfied with the new system: "We are offering the value added of the technical process having an internal logic that becomes evident in the AR application. The AR application is another pearl in our range of services, another gem so to speak."

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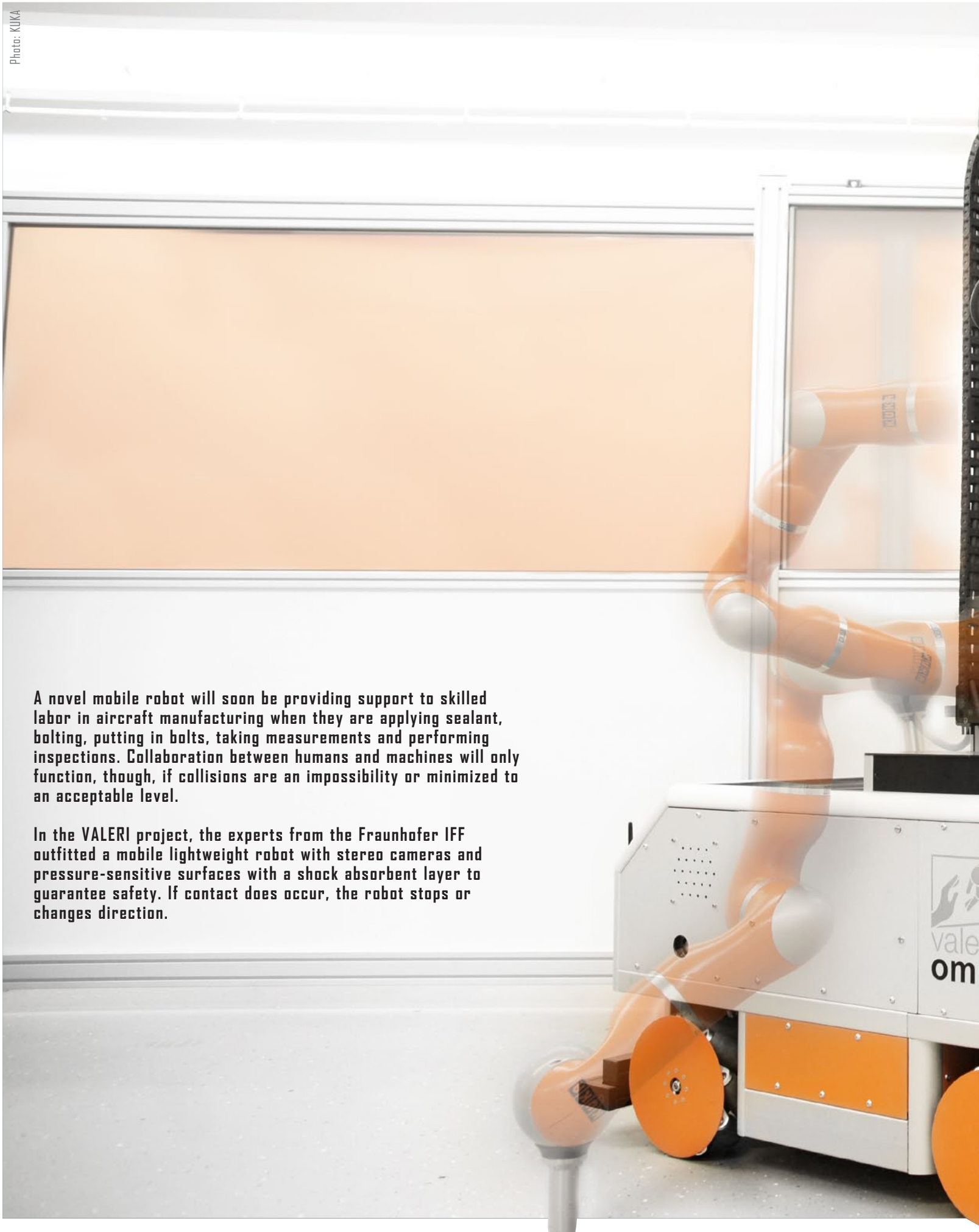


Photo: KUKA

A novel mobile robot will soon be providing support to skilled labor in aircraft manufacturing when they are applying sealant, bolting, putting in bolts, taking measurements and performing inspections. Collaboration between humans and machines will only function, though, if collisions are an impossibility or minimized to an acceptable level.

In the VALERI project, the experts from the Fraunhofer IFF outfitted a mobile lightweight robot with stereo cameras and pressure-sensitive surfaces with a shock absorbent layer to guarantee safety. If contact does occur, the robot stops or changes direction.


KUKA
omniRob

Photo: Fraunhofer IFF

Silvio Sperling is a specialist in the development and construction of optical 3D measurement systems at the Fraunhofer IFF in Magdeburg. Among other things, the engineer collaborated on the development of an automatic wheel scanner that optically scans the dimensional geometry of vehicle rims.

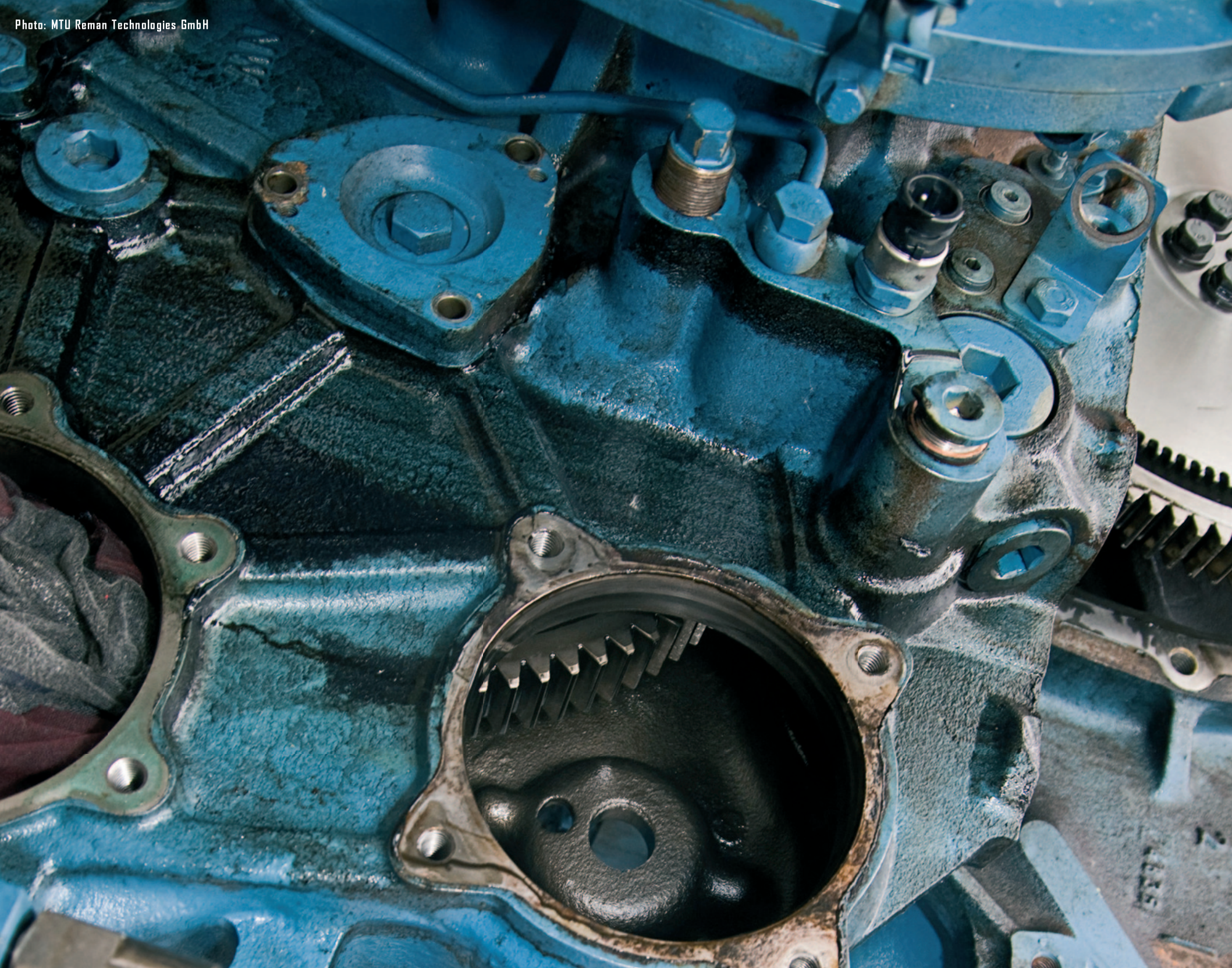


Photo: MTU Reman Technologies GmbH

Energy and raw materials are major price drivers in industry. Foundry operations, e.g. the manufacture of crankcases, consume a great deal of energy.

The experts at MTU Reman Technologies GmbH refurbish engines or components for reuse. That is a step toward the energy transition, protects the environment and saves money.

This company in Magdeburg is a partner in the Fraunhofer ER-WIN Innovation Cluster (Smart, Energy Efficient Regional Value Chains in Industry). Together, they are seeking solutions for energy optimized manufacturing.

Robot Annie Is Drawing Young Researchers to the IFF

Alexander Schäfer has been at the Fraunhofer IFF since February of 2013. The young researcher from Friedrichshafen became aware of the Fraunhofer IFF's work through its assistive robot "ANNIE". After graduating with a degree in mechanical engineering from the Technical University Munich, he applied to our institute and knew immediately after his job interview that he wanted to stay. "Robotics has always fascinated me. Unfortunately, there wasn't a comparable degree program in this direction at the Technical University Munich at the time," explains Alexander Schäfer.
His work is accompanied by respect for the challenges of robot development. "Time and again, I realize how much we can actually do without realizing it." In his Diplom thesis, he developed the control system for an assembly robot that installs computer chips. Alexander Schäfer is now working on developing fault tolerance mechanisms for software, thus enabling complex robotic systems to interact with their environments. This is also benefitting the demo robot ANNIE. The robotics specialists are using the mobile manipulator to study and demonstrate how future assistive robots will have to be engineered in order to support us in manufacturing, in the service sector or even at home.

Alexander Schäfer's next goal is his doctorate. The twenty-six-year-old has the creativity that requires: He has been playing the organ since he was a teen. "To me, interpreting a Bach composition and programming a robot are very closely related. To me, creativity means making something new out of a body of rules," says Alexander Schäfer, describing what his job and hobby have in common. (tf/akw) ■

Alexander Schäfer is collaborating on the development of new robotic systems.

The Cinderella Principle

Katharina Holstein is new to the Biosystems Engineering Business Unit.

Katharina Holstein knows how seeds can be sorted quickly, namely according to the Cinderella principle of "The good into the pot, the bad into the crop," but far faster. This is done with hyperspectral scanning, which additionally distinguishes good, i.e. viable, seed corn from bad far more reliably than Cinderella's doves.

Katharina Holstein has been researching in the Biosystems Engineering Expert Group at the Fraunhofer IFF in Magdeburg since September of 2013. Her colleagues and she employ hyperspectral scanning to make various constituents in plants visible. Katharina Holstein is, for instance, studying the viability of sugar beet seeds in a project with the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) in Gatersleben. The researchers are exploring whether this can be automated in a system with hyperspectral scanning. This would enable seed producers to inspect seed quality and the harvest would be more abundant.

Born and raised in Güsen, she was interested in STEM fields at an early age and attended pre-collegiate courses at Magdeburg's Max Planck Institute as a school student. Katharina Holstein started studying in Magdeburg in 2003, majoring in systems engineering and technical cybernetics. After graduation, she went to the Max Planck Institute. In graduate school, she wrote her dissertation on a systems biological topic. Her defense is scheduled for this summer. In the meantime, the young researchers had begun taking a closer look at applied research and this drew her to the Fraunhofer IFF. "The close relationship with practice inspires me. The difference between these two worlds is immense. I wouldn't have thought that. Fraunhofer is very close to industry," says the thirty-year-old, describing her new job.

In her free time, her love of plants and their seeds bear real blossoms and fruit. Then, you'll find Katharina Holstein in a community garden. She shares a plot of 500 m^2 planted with beets, strawberries and pumpkins with two control engineers and a process engineer. Her personal harvest ought to be more abundant. Katharina Holstein is presently working on a small hyperspectral installation for household use. Then she will scrutinize pumpkin seeds and, soon, only the good ones will be planted. (akw) ■

Contact for Questions about Energy Efficiency: ER-WIN Business Office at the Fraunhofer IFF

Rising costs of energy and raw materials are endangering the competitiveness of entire industries. Companies that manufacture energy efficiently have a tremendous competitive edge. Many companies are often utterly unaware of their potential to save energy, though. In the ER-WIN Innovation Cluster (Smart, Energy and Resource Efficient Regional Value Chains in Industry), the Fraunhofer IFF together with industry and research partners is helping companies reorganize for this. "Many companies have great potential to improve energy and resource efficiency in manufacturing itself," explains Dr. Jörg von Garrel. The human resource developer and mathematician is a specialist in innovation management and corporate development. His colleague Carsten Keichel and he have been managing the ER-WIN Innovation Cluster's business office at the Fraunhofer IFF since 2013 and are the primary contact for companies with questions on energy efficiency. Keichel is a process engineer and an expert in energy conversion technologies. He stresses that "the state of energy and resource efficiency in manufacturing companies is extremely heterogeneous. Although the majority have already launched pertinent actions, other, hitherto unused, potentials also frequently exist." The two have made it their mission to leverage these potentials. They are not only concerned about simply saving energy but also about raising companies' awareness of sustainable energy recovery. "Short-term cost cutting alone is not the solution," says Garrel. "We intend to help companies operate more sustainably in order to also make them less dependent on the factor of energy costs." His colleague Keichel adds, "We call it the ER-WIN symbiosis: Increasing energy efficiency in manufacturing plus supplying energy resource efficiency. Thus, the companies will also be ready for the future.« (mar) ■

Dr. Jörg von Garrel (r.) and Carsten Keichel (l.).are supporting companies that are converting to resource efficient manufacturing:.

"Group for Production" Has a New Business Manager

Fabian Behrendt manages the business office of the Fraunhofer Group for Production.

Fabian Behrendt is the new manager of the Fraunhofer Group for Production's business office. The business office also moved to Magdeburg when the director of the Fraunhofer IFF, Prof. Michael Schenk, became the chairman of the group on November 1, 2013.

This is not the first professional position with responsibility for the twenty-nine-year-old with a Diplom degree in engineering management. Right after graduating from Otto von Guericke University Magdeburg, the logistics specialist undertook a brief foray in the automotive industry. "That was an interesting experience but I quickly realized that was not what I want to be doing for the next ten years. Instead, I want to be helping create something myself, as I am now at the Fraunhofer IFF," summarizes the young engineer. That is why he returned to Saxony-Anhalt just a little later in order to become a member of and consultant for now-retired State Transportation Minister Karl-Heinz Daehre's commission "Future of Transportation Infrastructure Financing" commission. At the same time, he started working at the Institute of Logistics and Material Handling Systems (ILM) at Otto von Guericke University Magdeburg and the Fraunhofer IFF as a doctoral candidate and a member of the staff. Having concluded his work for the Daehre Commission, he is now managing the Group for Production's business office. This makes him, working closely with its chairman, the primary contact for inquiries to the group. He organizes its appearances at trade fairs in collaboration with the Fraunhofer-Gesellschaft's headquarters and coordinates the marketing of common research topics for the Fraunhofer Institutes involved in the group.

"The quality and amount of duties is demanding. You have to be able to get away from time to time in order to keep your concentration high," says Fabian Behrendt. He does this by climbing. "I discovered indoor bouldering in the winter. You have to climb a difficult route as quickly as possible without ropes and harnesses. It's a wonderful sport to clear your mind." (mar) ■

RobAG's Team "VIRus" Wins at FIRST LEGO League

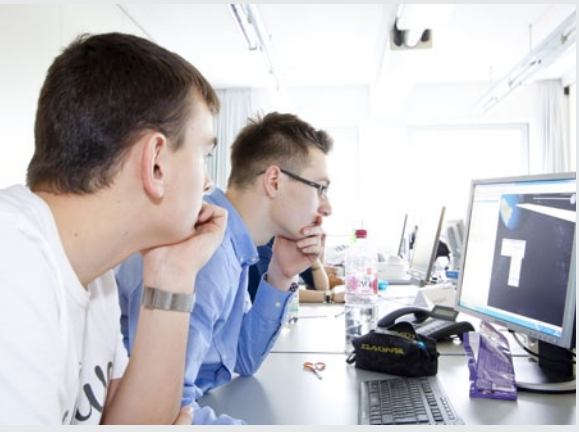
"VIRus" is one of twenty robot project teams or AGs established in Saxony-Anhalt in 2011 in response to an appeal from the Fraunhofer IFF. In the RobAGs project, the Fraunhofer IFF gave robot construction kits to its VIRus team and the other AGs in order to arouse children's interest in engineering through play.

That worked with the VIRus team members. The seven students from the grade school in Magdeburg's North Park met twice every week. They assembled electric motors, sensors, gears and all sorts of programmable elements into functioning robots and solved the problems posed, such as picking up pieces or overcoming obstacles.

When they attended the FIRST LEGO League in November of 2012 as guests, their advisers Thomas Seidl and Dr. Andriy Telesh from the Fraunhofer IFF convinced them to enter the following year. The kids even met three times a week – for a total of six hours – for six weeks before the competition in Magdeburg and worked on the competition challenges for the Robot Game. What is more, the students had to research a difficult research challenge dealing with "natural catastrophes", come up with proposed solutions and prepare a presentation.

Success came at the FIRST LEGO League in November of 2013. "VIRus" took first place in the Robot Game. They placed third in the research challenge for which the kids presented their ideas on precautions during tsunamis. "VIRus" was pleased at taking third place in the overall standings. "They weren't expecting that. Nor were we advisers," says a pleased Thomas Seidl, who has been advising this AG since 2011. "We are extremely happy that our work was worthwhile. All the hours, especially on weekends when families actually often had other plans. But we consider that to be an investment in the future and want to help the kids experience competition and success." Thomas Seidl and Dr. Andriy Telesh definitely succeeded in doing that – a great success for the RobAGs project. "VIRus" is now excitedly looking forward to the regional RoboCup competition in March. (akw) ■

The VIRus team: Hendrik Heiß, Maurice Schulze, Tobias Wilde, Volodymyr Telesh, Pavel Plakhuta, Michelle Walter and Tim Krüger (from l. to r.) after the award ceremony.



Are all the planets orbiting the sun, and where is the ISS? Mykhaylo Samostyan during the final test of the virtual solar system shortly before its presentation.

Tey Are Finally Orbiting!

Eleven students from six high schools in Saxony-Anhalt gathered at the Fraunhofer IFF's Virtual Development and Training Centre during their winter vacation. Together, they designed a virtual three-dimensional solar system and presented the result of their work on February 7.

"I'm happy! I can make planets orbit," exclaims Mykhaylo Samostyan with a laugh after the presentation. A few minutes before, his fellow students and he were still putting the final touches on the solar system and adding the ISS and a satellite to the scenario. "After our work, I appreciate how involved 3D visualizations are," adds Klara Mühlemann and smile.

Sabine Szyler supervised the project. The physicist researches in the field of virtual interactive training at the Fraunhofer IFF and is an expert on the virtual world and the physics of our solar system. She helped the students visualize the planets and moons and their movements. They didn't need much help, though. "The team was unbelievably motivated and divided up the work all on their own. It was quite a great week of work for me, too," she reports.

The "Research and Technology" project week was part of the model project "Steps to Work". It is one of several projects that cultivate young talent in which the Fraunhofer IFF is gladly involved to get young people excited about research and technology at an early age. "Steps to Work" targets tenth to twelfth graders from schools in northern Saxony-Anhalt and is supported by the Ministry of Labor and Social Affairs with funds from the European Social Fund and the state of Saxony-Anhalt. The project agency is the isw Institut gGmbH. (dm) ■

The Research Community Debates: A Trip to the Future of Industry

What's behind the concept of Industry 4.0? How is manufacturing becoming networked and what role are people playing? School students discussed this and other fascinating questions at the Junior Science Café at the Fraunhofer IFF.

Two eleventh grade classes from Werner von Siemens High School attended the Junior Science Café at the Fraunhofer IFF in November of 2013. On this day, the classroom was empty at the time history was actually scheduled. The students are learning about the Industrial Revolution in history class right now. What could be more fascinating than looking into the future from this vantage point? So, the high school students from Magdeburg made their way to the Fraunhofer IFF, accompanied by their teacher Angelika Häusler, senior class coordinator at Werner von Siemens High School.

Prof. Ulrich Schmucker, manager of the Virtual Engineering Business Unit, received the students in our glassed-in testing facility. He took them on a trip to the age of Industry 4.0. What's behind this concept, though? Prof. Schmucker explained how industrialization will continue developing and additionally showed what manufacturing operations might look like in the future. Schmucker explained that digital engineering is a key prerequisite for Industry 4.0 in which all production systems will be interconnected for self-controlled manufacturing. In conjunction with this, they then had a lively discussion about the role of people in industry of the future. Their teacher Angelika Häusler was delighted at the young people's great interest and enthusiastically described their visit as a complete success.

Informally chatting about research is the idea of the Junior Science Café. The initiative Science in Dialogue goes beyond this and offers "research debates", a format that enables ninth through twelfth graders to establish contact with researchers and discuss current topics from research and practice with them. (ms/akw) ■

Award Winning and Full of Energy

Old batteries from households are disposed of properly in collection boxes. Old batteries from electric vehicles get a second chance from Stephan Balischewski. He interconnects the batteries in storage arrays and uses them as temporary energy storage systems.

Rather than continuously, renewable energy sources only delivers energy when the sun is shining or the wind is blowing. Private households, for instance, need energy primarily in the evening hours when solar energy is no longer available. Optimal use of such fluctuating energy flows requires a system that stores energy temporarily and supplies it to the grid whenever it is needed.

This is where Stephan Balischewski's development comes into play. He is majoring in electrical engineering at Otto von Guericke University Magdeburg and has been working as a student assistant at the Fraunhofer IFF since 2012. He works on electrical power systems in the Process and Plant Engineering Business Unit. For his Bachelor's thesis, Stephan Balischewski developed a distributed energy storage system using scrapped electric vehicle batteries. After all, even if they are no longer any good for electric vehicles, they aren't worn out yet. "Why shouldn't they be reused, here, in a stationary storage system where the requirements are not quite as high? This more or less enables you to recycle and continue using the batteries," explains the student.

Stephan Balischewski not only received an A+ for his idea but also the city of Magdeburg's 2013 Environmental Award in the "Research" category. At present, he is working on his Master's thesis and developing a management system that controls and monitors the battery storage system.

Recent award winner Stephan Balischewski is now devoting all of his energy to his Master's thesis.

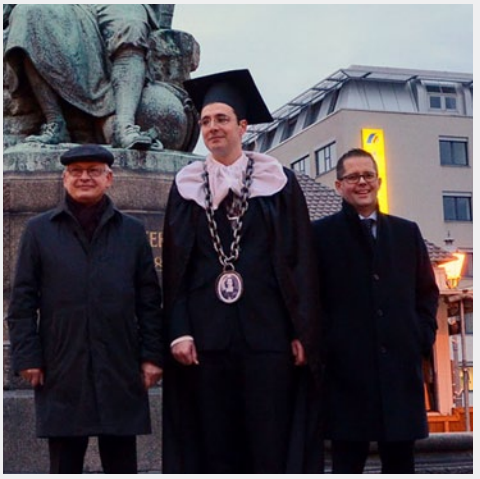
The capital city of Magdeburg has been conferring its Environmental Award since 2011. The award goes to contributions to particularly effective and innovative energy use or production. (dm) ■

From Doctorate to "Fishing License"

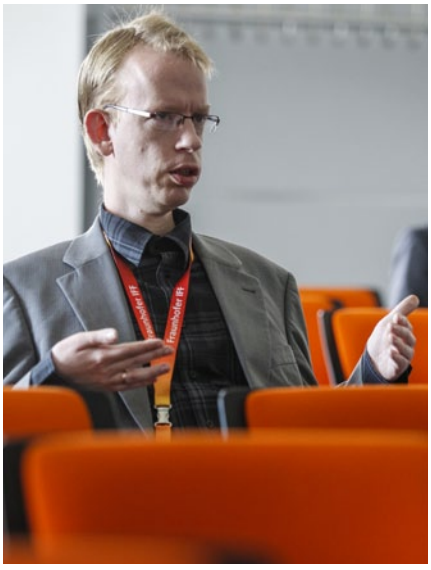
"What hobbies did I actually have earlier?" Dr. Christoph Wenge asks himself of late. Now that he has successfully defended his dissertation, he is looking forward to spending more time with family and friends. He has devoted a great deal of attention to the topic of his dissertation, "Optimal Operation of Mobile Storage Systems in Smart Grids: Vehicle Control Center", in recent years. In addition to earning his doctorate from Otto von Guericke University Magdeburg, the thirty-year-old has been pursuing research in the Process and Plant Engineering Business Unit at the Fraunhofer IFF.

Dr. Christoph Wenge was born in Haldensleben in Saxony-Anhalt. He lived in Hundisburg, known for its Baroque palace, in the heart of the Magdeburger Börde until he completed the eight grade. After spending two years abroad in the Dominican Republic with his father, he returned to Germany and graduated from a vocational high school for civil engineering in Magdeburg. He started studying electrical engineering at the university in the capital in 2003. Upon graduating in 2009, the young researcher became a doctoral candidate under Prof. Styczynski in the Department of Electrical Grids and Alternative Sources of Electricity. The department and the Fraunhofer IFF have been collaborating closely for years. Their staff, including Dr. Wenge, are jointly researching issues of information and communications technology (ICT) in smart grids of the future, renewable energies, and electric vehicles in many projects such as Harz.EE.-mobility and RegModHarz. His Diplom thesis led him to the Fraunhofer IFF in 2009.

The "Polish school" at the university shaped Dr. Wenge. Not only their doctoral and collaborative research but also a friendship has created a bond between him and his fellow doctoral candidate and colleague Bartolomiej Arendarski at the Fraunhofer IFF. He now appreciates the Polish speciality "barszcz z uszkami", a red beet soup, and is getting his fishing license along with some colleagues so they can go fishing together in regional bodies of water. (akw) ■



Dr. Christoph Wenge (center) with his doctoral adviser (left) Prof. Zbigniew A. Styczynski from Otto von Guericke University Magdeburg and Dr. Przemyslaw Komarnicki from the Fraunhofer IFF.



Simon Adler from the Virtual Engineering Business Unit at the Fraunhofer IFF earned his doctorate.

Career with Fraunhofer: From Game Developer to Doctor

Simon Adler did it. The new doctor is bubbling over with energy and satisfaction and his satisfaction is absolutely justified. The thirty-four-year-old defended his dissertation "Development of Methods for Interactive Simulation of Minimally Invasive Surgical Methods" with "magna cum laude" in February of 2014.

Born in Bargteheide, Schleswig-Holstein, Simon Adler attended a business vocational high school. He completed his Diplom degree in digital media at Wedel University of Applied Sciences in 2005 and became a freelance modeler and worked as a computer game developer and project manager. He couldn't stop thinking about earning his doctorate, though, and decided to enroll in the essential Master's program at Otto von Guericke University Magdeburg. He came to the Fraunhofer IFF as a student assistant in 2006 because its applied research appealed to him. Once he completed his Master's, he started working on his dissertation on interactive medical simulation here in 2008. Since 2012, he has additionally been concentrating on mobile assistance systems with visualizations based on virtual and augmented reality for manufacturing system. For instance, he developed an AR based worker assistance system together with his colleagues for the machine manufacturer VAKOMA in Magdeburg (see the report on p. 32).

The young doctor really likes Magdeburg: "It is so wonderfully green here. I live ten minutes from the Elbe. Try that in Hamburg!" says Adler with a happy smile. Do his family, his research on medical systems and his work on mobile assistance systems leave him time for hobbies? Dr. Adler takes it all in stride: "My work is my hobby. I program at home and try out a lot of things. Some of it winds up in my work at the institute. Time and again, a new challenging job arouses my curiosity and leaves me no rest." That's just like him! (akw) ■

Bernd Zorn (right), owner of Zorn Instruments, congratulating Dr. Blümel.

Dr. Achim Clobes, CEO of RKW Sachsen-Anhalt, and Dr. Bernhard Beckmann, CEO of Europäisches Bildungswerk Sachsen-Anhalt, in conversation.

Dr. Rolf Küster, former director of the TBZ Magdeburg, with Prof. Burkhard Scheel, chairman of the Fraunhofer IFF's advisory board.

Prof. Peter Lorenz once taught computer science at the Technical University Magdeburg. He didn't pass up the chance to congratulate his former student on turning sixty.

IFF Congtaulates Dr. Eberhard Blümel on Turning 60!

Dr. Eberhard Blümel is a member of the Fraunhofer IFF's founding generation and has been one of its defining figures for twenty-two years. He celebrated his sixtieth birthday on October 7, 2013, reason enough for current and former colleagues, partners and friends to wish him all the best!

A mathematician, Blümel earned his doctorate from the School of Natural Sciences at the Technical University Magdeburg in 1985. He joined the staff of the just founded Fraunhofer IFF in 1992. From then on, the specialist in virtual reality, simulation and digital engineering for manufacturing and logistics worked in different management positions and research fields at the institute and was instrumental in shaping its future. Dr. Eberhard Blümel has headed the Fraunhofer IFF's EU Office since 2012, contributing his vast experience with national and international technology transfer. That same year, the Technical University of Riga, Latvia awarded him an honorary doctorate. (mar) ■

Colleagues, partners and friends: the assembled crowd of well-wishers during Prof. Michael Schenk's congratulatory remarks.

Reiner Storch, CEO of AEM Dessau and longstanding partner of the Fraunhofer IFF, presenting a gift.

Richard Smyth, retired Airbus vice president and member of the Fraunhofer IFF's advisory board at the reception.

Editorial Notes

IFFocus 1/2014

Publisher: Fraunhofer Institute for Factory Operation and Automation IFF
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Layout: Ina Dähre

Photos:
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Title/U 1– U 3: Dirk Mahler; U4: Dirk Mahler (1–2), itestro/Fotolia.com; Page 1: Dirk Mahler; Page 2: Bernd Liebl, Monkey Business/Fotolia.com, 3 Dirk Mahler; Page 3: Daimler AG, Dirk Mahler; Page 4: Viktoria Kühne; Page 5: Handwerkskammer Magdeburg, MEV Verlag; Page 6: Anna Mahler; Page 7: Viktoria Kühne, Dirk Mahler; Seiten 8 – 9: Viktoria Kühne; Page 11: Daimler AG; Page 12 – 13: Bernd Liebl; Page 14 – 15: Markus Fritzsche; Page 16 – 17: Nataliya Hora/Fotolia.com; Page 18: Bernd Liebl; Seite 20 – 21: Monkey Business/Fotolia.com; Seite 22: Kadmy/Fotolia.com; Page 23: Kolbus GmbH & Co. KG; Page 24 – 27: Erik Trostmann; Seite 28 – 31: Dirk Mahler; Page 32 – 34: Alexander Gshibowski/VAKOMA GmbH; Seite 35: Simon Adler (1); Page 36 – 37: KUKA; Page 38 – 39: Dirk Mahler; Page 40 – 41: MTU Reman Technologies GmbH; Seite 42: Dirk Mahler; Page 43: Daniela Martin, Dirk Mahler; Page 44: Andriy Telesh, Daniela Martin; Page 45: Daniela Martin; Page 46: Toralf Winkler, Dirk Mahler; Page 47: Daniela Martin

Printing: Harzdruckerei GmbH

Bibliographic information published by Die Deutsche Bibliothek: The Deutsche Bibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data is available on the Internet at www.dnb.d-nb.de abrufbar.

ISSN 1862-5320

Outlook

Meet up with researchers from the Fraunhofer Institute for Factory Operation and Automation IFF at these events.

May 3, 2014
AUTOMATICA International Trade Fair for Automation and Mechatronics, Munich

May 3, 2014
MAINTAIN International Trade Fair for Industrial Maintenance, Munich

May 19 – 23, 2014
CeMAT World's Leading Fair for Intralogistics, Hannover

June 16 – 19, 2014
10th ITS European Congress, Helsinki

June 17 – 19, 2014
transport logistic China International Exhibition for Logistics, Mobility, IT and Supply Chain Management, Shanghai

June 23 – 26, 2014
22nd European Biomass Conference and Exhibition, Hamburg

June 24 – 26, 2014
17th IFF Science Days, Magdeburg

July 16 – 17, 2014
Embedded Systems Symposium, Munich

September 23 – 26, 2014
SECURITY 2014 World's Leading Fair for Security and Fire Prevention, Essen

October 6 – 8, 2014
EXPO REAL International Trade Fair for Property and Investment, Munich

October 7 – 8, 2014
Digital Plant Kongress, Würzburg

October 15 – 16, 2014
Fraunhofer Vision Technology Days, Munich

October 22 – 24, 2014
31st International Supply Chain Conference, Berlin

Photo: Fraunhofer IFF

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17TH IFF SCIENCE DAYS

JUNE 24 – 26, 2014

Fraunhofer IFF

How can energy and raw material use be reduced in manufacturing and logistics? Discuss current research and solutions from the field with experts from industry and research at the 17th IFF Science Days.

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