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Smart Production Technologies

Sustainability

Global Future-proof Manufacturing

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Building Innovation Centers in Brazil

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INSTITUTE PRODUCTION SYSTEMS AND DESIGN TECHNOLOGY

IWF
INSTITUTE FOR MACHINE TOOLS AND FACTORY MANAGEMENT
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Editorial

Prof. Dr. h. c. Dr.-Ing. Eckart Uhlmann

Dear Readers, turning interdisciplinary know-how into customer-tailored solutions is a key area of our expertise at the Production Technology Center Berlin. Taking careful account of the tasks and challenges of specific industry branches and markets, we provide customized consulting and support services for the roll-out of new products, processes and techniques. We work closely with our customers to identify potential application areas and establish new ones for existing products and technologies. Both nationally and internationally, we provide training and transfer services that benefit users, manufacturers and research institutes alike.

»R&D for a healthy economy and prosperous region« could well be the tagline for our engagement in the building of national innovation and knowledge systems in Asia, Latin America and the Middle East. Our latest project is profiled in this edition of our FUTUR magazine and shows how we will be assisting SENAI, Brazil's National Service for Industrial Training, in building 23 research institutes across the country over the next seven years. The aim of this partnership is to provide a pool of opportunities for professional vocational training which will serve to drive applied research and thus innovation in Brazil. Last but not least, German companies with local regional offices or partnering with local companies in joint ventures will also benefit – whether they be in Brazil, China or Dubai.

The Collaborative Research Center (CRC) 1026 on »Sustainable Manufacturing – Shaping Global Value Creation« coordinated by Prof. Günther Seliger of the Institute for Machine Tools and Factory Management (IWF) at the Technical University of Berlin is one of eight CRCs funded by the German Research Foundation (DFG). Established in January 2012 with a budget of about 10 million euro, CRC 1026 brings together scientists from a range of institutes – IWF, Fraunhofer IPK, the Konrad Zuse Institute Berlin, the Federal Institute for Materials Research and Testing, and the Social Science Research Center Berlin – who collaborate on the development of techniques and technologies for sustainable production across the globe. This is an issue that could hardly be more topical, given the present consensus that careful use of energy, raw materials, and human resources is critical for the conservation of our planet's environment. Even so, in many parts of the world, sustainability still does not play a major role in manufacturing technology. The project aims to scientifically validate the superiority of sustainable manufacturing embedded in global value creation over traditional paradigms of management and technology.

Read more about the new sustainability project in this issue of FUTUR, and explore the rich range of our latest R&D solutions in manufacturing, automation and quality management.

Yours,

Integrated Process and Machine Simulation

To succeed in competitive markets, it is essential that companies steadily improve the productivity of their machining processes and the quality of their products. In metal-cutting manufacturing this can be achieved by raising the material removal rate while maintaining machining accuracy. Yet the dynamic behavior of the machine tool structures, process parameters and the complexity of the process itself can give rise to instabilities which restrict the dimensional accuracy and the performance of machines. Integrated process-structure simulation models can help to optimize process planning and control. These models need to be parameterized and validated using a measurement-based analysis and they have to consider the relation between process and structure to ensure they are as realistic as possible. Furthermore, real-time simulation of structural dynamics also enables in-process diagnostics and monitoring of the machining process.

► Parameterization and validating

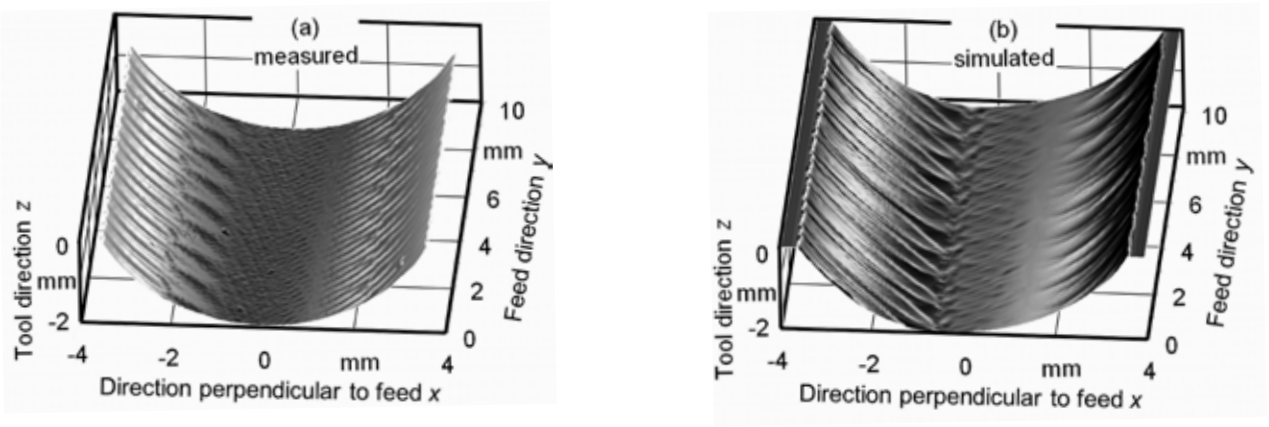
Metrological determination of unknown model parameters for description of the structural dynamic behavior of machine tools is the basis for simulation of interaction between process and structure. The dynamic behavior of the machine tool structure can be derived from the measurement of the transmission behavior between stimulating force and system response at the tool center point (TCP) of the machine. Impulse hammers and vibration exciters are the main tools used to stimulate the system. The influence of the type and amplitude of excitation on the capture of system response should not be underestimated. System response is mainly registered by laser triangulators or vibrometers and accelerator sensors mounted on the tool tip. With certain types of set-up, the weight of such sensors can exert a marked influence on the dynamic behavior of structure.

Analyzing the machining process with a dynamometer

A broad array of cutting-force models are available for process modeling whose cutting-force coefficients are determined by cutting tests. A dynamometer captures the respective cutting force yet its insertion in the system also seriously influences process behavior. Experimental stability maps are produced for validation, although laser triangulators or sound pressure measuring devices can also be used. In analyzing the degree of stability, it is also necessary to evaluate the amount of vibration the machining process itself produces.

► Modeling dynamic behavior

Once it has been metrologically measured, mathematical models can be used to map the dynamic behavior of a machine tool. These models provide the basis for simulation. The results so obtained offer a deeper understanding for optimization of the respective processes or machine tool structures. Furthermore, the influence exerted by specific sources of error on machining accuracy can also be analyzed.



(a) measured surface topography, (b) simulation of surface topography, unstable milling process using a spherical cutter

The most commonly employed method is the Finite Element Method (FEM) whereby a structure is divided up into more or less detailed volumes, in which a solution of the governing equation describing the physical behavior is possible. Multi-Body Simulation (MBS) is another widely used method. Even though this method drastically simplifies the structure, with proper dimensioning it can offer an accurate description of behavior. At the same time, it is significantly more rapid in computing dynamic behavior than FEM.

Another more abstract method is the modeling of the compliance frequency response function by using spring-mass-damper combinations. These are used in forms of Single Degree of Freedom (SDOF) or Multi Degree of Freedom (MDOF)-systems. This approach enables the mathematical mapping of the vibration behavior of the TCP in the time domain and in real-time.

► Simulation of dynamic behavior

Depending on the area of application, each of these methods brings its own advantages and drawbacks. The Finite Element Method is mainly used for design optimization as it can be used independently of whatever structures are given. Multi-Body Simulation, on the other hand, is primarily used for optimization of existing structures. SDOF-and MDOF-systems describe the transmission behavior at certain points in a structure such as at the tool tip and are thus primarily used for the simulative optimization of concrete processes.

To anticipate the description of the surface quality of the workpiece before machining, the whole process first needs to be simulated. To do this a MDOF system with 12 degrees of freedom is situated in a Matlab Simulink development environment and dimensioned so that the compliance frequency response function on the TCP of a 5 axis HSC milling machine can be reproduced with 95 percent accuracy. Furthermore, a geometric machining simulation is modeled in Matlab and coupled to the MDOF system. This enables the simulative determination of the surface topography as it would result during machining. In all test runs at least 80 percent of the results matched reality. What is more, it was also possible to map certain surface phenomena caused by process instability. ■

Higher Wall Thickness – Higher Safety?

A stable machining process requires a stable machine tool. The requirements for safety technology have increased rapidly along with the advance of high speed processing. This is particularly the case for the specific penetration resistance, which means the penetration resistance against ejected elements like parts of the tool, workpiece or machine. A higher wall thickness of separating safeguards, however, does not automatically entail a higher safety for the user. Researchers at IWF analyze this phenomenon called »kink effect« and develop solutions to improve the dimensioning of separating safeguards.

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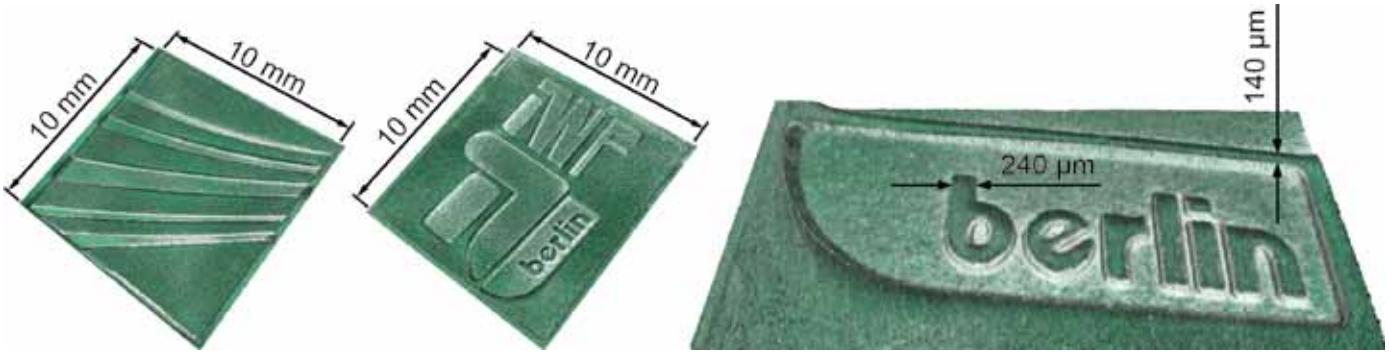
High-Speed Manufacturing

High-speed manufacturing techniques like magnetic pulse shaping and magnetic pulse welding offer a broad range of opportunities for extending the machining capabilities of metallic materials. A series of research projects at Berlin's Technical Production Center (PTZ) are now investigating a variety of issues in the field of the high-speed processing of metallic materials.



Geometries embossed in stainless steel at a depth of 120 µm

► Pulse magnetic manufacturing techniques

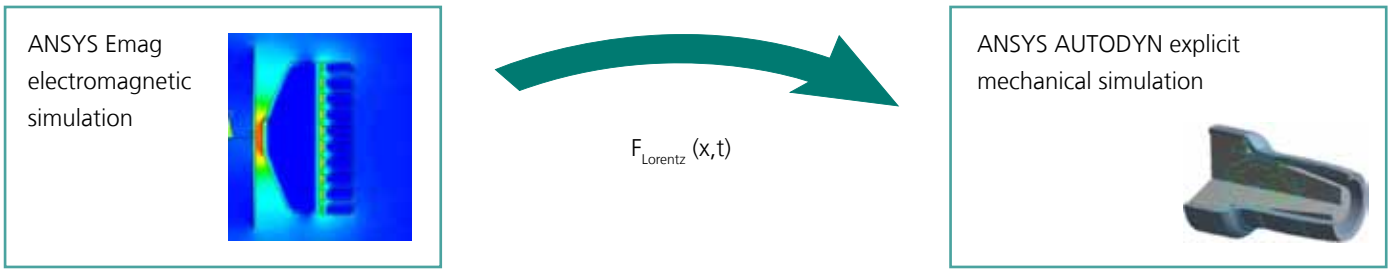
Magnetic pulse manufacturing techniques are based on the induction principle whereby the energy stored in capacitators is released by using a high-current switch, discharging bursts of high frequency high voltage current through the tool coils. The magnetic field so induced generates alternating current in the electrically conductive workpiece which shields the magnetic field. In just a few microseconds the Lorentz force thus produced exerts magnetic pressure on the surface of the workpiece which results in its reshaping or the welding of two pieces. Their extremely short process time makes pulse magnetic manufacturing techniques ideal for use in production processes where the only limit placed on productivity is the loading time taken the capacitators. As tool coil geometry can be varied, in combination with a flexible robot system this enables a variety of forming processes such as compression and flat shaping to be introduced to the assembly line. And as process parameters such as loading energy or the distance between welding partners can be precisely set, this also enables exact replication of manufacturing results.

► Pulse magnetic shaping at room temperature

The use of various lightweight materials offers the opportunity to reduce the weight load across a range of application areas for manufacturing technology. Among metallic materials, aluminum and magnesium alloys are the favored choice for key components. Magnesium alloys also offer a further 30 reduction in volume over aluminum which makes them especially suitable for use in the automobile industry, and particularly in the e-mobility sector.

Their hexagonal grid structure means that conventional forming processes like deep-drawing can only be realized at temperatures of 220°C for industrially relevant degrees of formation. Their circuit boards need to be heated with a special tool before the forming process begins which means higher costs and more energy for the forming of magnesium sheets.

One alternative is the magnetic pulse forming of magnesium alloys. The advantages offered by pulse magnetic manufacturing over conventional forming techniques lie in the process-specific mechanisms of action which result in the quasi-adiabatic forming of the workpiece. In other words, no heat is lost during the formation process. Thus it is also possible to realize the forming of magnesium alloys with industrially-relevant degrees of formation at normal room temperature. One basic research project is engaged in investigating the action mechanisms that take place in such a process. Scientists compare metal sheets formed by magnetic pulses with those formed by conventional processes. Pre-defined parameters (like the hardness of the forming zone) and applicable investigations of joints are used to delineate high-speed forming from quasi-static forming. The data thus produced



Schematic presentation of the coupling of an electromagnetic (left) and structural-mechanical simulations (right)

serves as the basis for the development of a material model for the AZ31 magnesium alloy into which the requirements of high-speed forming are also factored.

► Molding high-strength steel

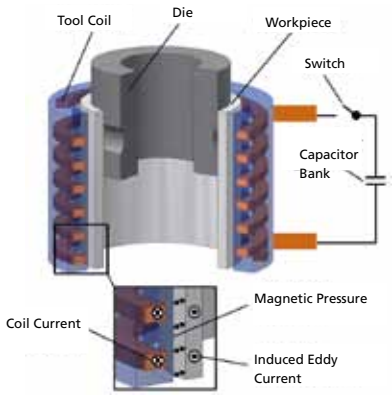
Another research project investigating the molding of high-strength steel with the aim of identifying the effects that higher energy input with the pulse magnetic drive have on the forming process. Here the behavior of the forming process is critically dependent on the speed at which forming takes place. On the one hand, high speeds trigger active thermal processes which generate heat. As this heat is concentrated in a minimal volume, it cannot spread through the whole workpiece if the process is of short duration. On the other hand, ductility and yield stress are also dependent on the speed of forming. And the frictional properties of the tool/workpiece also change as the speed increases. This is particularly relevant to the shaping of microstructures where a much larger percentage of the surface is affected.

A special system of tools has been developed for these investigations. A magnetic field is used to accelerate the forming tool from a few millimeters to speeds of up to 50 meters per second. The forming procedure then takes places within 60 microseconds. This enables better form completion than can be achieved with quasi-static forming methods.

► Pulse magnetic profile welding

Pulse magnetic welding creates an adhesive bond by propelling the atoms of two adjacent metals together to form an atomic bond. Unlike the explosive welding technique, which it otherwise resembles, pulse magnetic welding draws its power pulse from a transient magnetic field which is not only easy to operate but also ensures superb replication quality. Scientists use tensile testing, joint geometries, measurement of the degree of hardness and microscopy for characterization of the properties and geometries of joints in a variety of metal alloys. To cut back on lengthy sets of trials and follow-on analyses, at the same time work is going ahead on the advanced development of a Finite Element (FE) Model. Coupled with electro-dynamic structural-mechanical FE simulation, this model will help to generate forecasts about both procedures and quality of welding. The FE model will also be used in future to help implement parameter variations of relevant process parameters and to optimize the overall welding process. ■

Schematic presentation of magnetic pulse forming using a compression coil



Application Center for Microproduction Technology (AMP)

Modern machines today can work on components and structures that are as small as 100 nanometers. This corresponds to 10^{-7} m or 1/10th the thickness of a spider thread. The tools of microproduction technology are correspondingly small – and they react correspondingly sensitively to environment influences. The Application Center for Microproduction Technology (AMP) offers optimal conditions for the finest processing technologies and perfect prerequisites for top performance in research and development. The state-of-the-art laboratory building is geared to the special needs of high- and ultra-precision technologies. Precision machine building is one of the AMP's core competences. As a result, multi-talented precision machines are created in partnership with medium-size firms. They combine roughing and finishing cutters, ablation lasers, and optical in-process measurement technologies, or an ablation laser and a rotating, high-frequency oscillating pin for electrical discharge machining.

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MRO

Robot-assisted Repair of Turbine Blades

Turbine blades are highly specialized components which are subject to high mechanical and chemical loads. For an aerodynamically optimized design, components of modern turbo jet engines and stationary gas turbines have to comply with close production tolerances. Additionally, the number of highly complex parts such as »blade integrated disks (Blisk)« is continuously increasing. Such engine components are high cost products which are often cheaper to repair than simply replace. A group of researchers from the Institute for Machine Tools and Factory Management (IWF) and Fraunhofer IPK is investigating how to do the best job when repairs are needed.

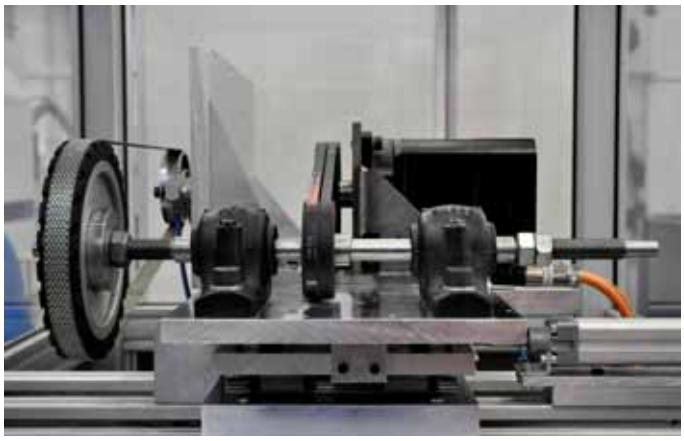
A typical repair process chain involves numerous manufacturing steps including cleaning, build-up welding, re-contouring, polishing, and possibly shot peening. Even today the production stages in this chain of repairs involving metalwork such as surface polishing are still mainly done by hand. This demands a great deal of experience and expertise on the part of the operator and thus constrains the number of personnel available for repairs. Accordingly one of the objectives pursued by engineers from IWF and Fraunhofer IPK is to make this stage of repair work fully or semi-automatic. This would free up repair resources and ensure the reproducibility of repairs, while also reducing repair costs.

Manual repair of turbine blades (© Siemens AG)

► Robot-assisted manufacturing systems

Each repair case is unique. This is why an automated repair system needs an adaptive process chain whereby individual process stages and parameters can adapt to the specific task in hand. With their high flexibility, robot-assisted processing systems are especially well suited for this line of work. They also offer advantages over conventional machine tools in terms of their larger working area and comparatively lower investment costs. The core of the demonstrator cell developed at the Production Technology Center (PTZ) is a six–axis articulated arm robot which is capable of working on even complex geometries like the free form surfaces of a turbine blade. A force torque control system developed at Fraunhofer IPK is used to ensure a sufficient level of path accuracy, even for high reaction forces. This also means that the risk of damage is lower than that associated with manual interventions. The workpiece guided process enables individual repair of components with the required surface quality at the respective working station. In addition,

Robot cell for adaptive belt grinding at the PTZ



Force-controlled abrasive head in the robot cell

abrasive belts can be used for force controlled robot-assisted machining processes on free form surfaces as they can flexibly follow all the contours of the surface.

► Planning repairs precisely

For the automated repair of turbine blades, the scientists first designed an intelligent process chain which began with complete measurement of the component to be repaired. This was done with an optical field measuring 3D scanner based on the strip projection measurement principle which can quickly digitalize the complex shapes of components with a high degree of accuracy. The network of polygons thus produced is transformed over reference points and aligned with the nominal CAD data set for target/actual comparison analysis. The high performance CAD environment, ROBOTMASTER for MASTERCAM, is used as the interface for path generation and simulation. As a result, robot-assisted machining is conducted only in those areas displaying significant deviations from the desired geometry – which saves both time and costs.

The next machining stage of robot-assisted belt grinding can be reiterated for as many times as it takes to reach the desired degree of component quality. To date, robot-assisted adaptive belt grinding of simple free form surfaces has shown results accurate to within less than 20 microns in less than three stages. At the same time localized material removal rates of just a few microns can be set with a combination of force control and feed rate.

► Technology database

High precision results can only be achieved through an optimal selection of machining strategies and parameters. Consequently, the next stage for the scientists is to build a comprehensive technology database from which users can extract all the key process parameters they need such as normal contact force, feed rate, and cutting speed.

As one example of data feed, a series of tests gave the exact material removal rates of a variety of abrasive belt and material combinations. Superhard diamond abrasive belts with their excellent stationary behavior and low grinding-in time have shown advantages over conventional corundum belts when it comes to machining of nickel based alloys. Gaining even more detailed knowledge of the particular material removal rate behavior of superhard abrasive belts, further research on machining nickel based alloys will be carried out. In future, the research engineers will particularly focus on a closer investigation of the impact of local geometries and their curvature change in free form surfaces. ■

Maintenance, Repair and Overhaul MRO

MRO has a great impact on both business and national economics: German enterprises spend a fortune every day to cope with corrosion, wear, and vandalism. Expensive products and goods with long lifespans, as are common in the energy and traffic sector, show a high economic and scientific potential for optimization which has so far been ignored by academic research. This is the point of departure for the Fraunhofer innovation cluster »Maintenance, Repair and Overhaul in Energy and Traffic MRO«. The cluster develops energy-efficient, sustainable solutions for promising innovative fields which are the very basis of MRO. Those include Condition Monitoring and Diagnosis, MRO Planning and Digital Assistance, Cleaning, and Repair and Overhaul Technologies. The innovation cluster incorporates seven research institutes and 14 industrial partners. A budget of about 16 million Euros for three years is provided by the industrial partners, Fraunhofer, and the federal states Berlin and Brandenburg. For more information please visit
☑ www.innovationscluster-mro.de

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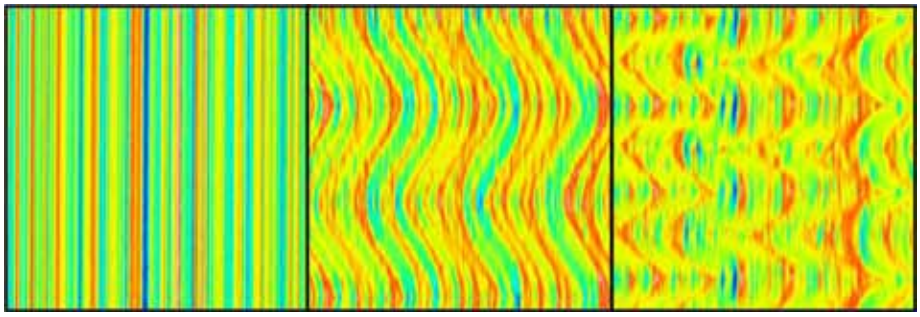
Micro-structured Gears for Offshore Wind Turbines

As the need for the sustainable use of resources becomes ever more urgent, issues like raising power density, functional safety and reliability, and lowering power consumption during production and operation are coming to the top of the scientific agenda. A priority program of the German Research Foundation is dedicated to the investigation of resource-efficient construction elements. In this program, research engineers from the Institute for Mechanics, and the Institute for Machine Tools and Factory Management (IWF) at the Technical University of Berlin have joined forces to research ways of optimizing the manufacturing and operational performance of gears for offshore wind power stations.



Various structures ground in the surface of gears

Offshore- wind power stations are a highly promising future market in the renewable energy sector, and can make a major contribution to the sustainable use of resources. One decisive factor underpinning the economic and ecological success of the plants is their operational reliability as maintenance and repairs on the high seas come with a very high price tag.

► Gear impact parameters

A gear's service life critically depends on its particular geometry and the surface properties of the tooth flank. The lubricant and the lubricant film spread also play a role. If the lubricant film on the gear tooth flanks is too thin, gliding motion between them can lead to what is known as »mixed friction with shearing« which results in microscopic damage to their surfaces. A reduction of surface roughness combined with tailored surface structuring and adaptive modification of the tooth geometry holds out a promise of longer service life and higher performance density for the gear pairs. Surface structuring offers a much shorter start-up phase, higher load capacity and an improved distribution of the lubricant film during operations. The challenge posed by the manufacturing of modified gears consists of ensuring the flexibility and efficiency of the machining process and improving the characteristics of the gears without unduly overtaxing manufacturing resources.

► Structure of research

Discontinuous profile grinding of tooth flanks is used for the industrial manufacturing of gears for offshore wind power stations. Yet this process leaves one-directional machining marks on the tooth flanks which have negative effects in the gear start-up phase and the distribution of lubricant film. The current research project kinematically modulates the grinding process in order to analyze and optimize the influence of various process parameters on the surface structure of gear tooth flanks. The project is also investigating interaction between the 3D tooth flank topography and frictional behavior during operations.

The first stage here involves numerical simulations through which possible 3D surface topographies can be evaluated for their suitability in improving distribution of the lubricant film. Building on the 3D structures given by the simulations, a universal cylindrical grinding machine is used to manufacture bearing rings employing a standard piercing process and a variety of axial oscillation kinematics. A two-disk test rig is then used to measure the influence the various structures have on the distribution of the lubricant film and to

An offshore-wind station (© Siemens AG)

check for correlations with the simulation results. Once the test phases have been concluded, comparable structures are produced with a type ZE 800 tooth flank profile grinding machine from NILES. Using this machine, conventional and kinematically modulated surface structures of the tooth flank will be ground. A gear test station is then used to identify the added-value offered by the structures. Long-term studies shall weight both traditionally ground and structured gears with a variety of load collectives for investigation of their mechanisms of failure.

By the end of the project, scientists aim to deliver some well-founded statements about the mechanisms of action at work in kinematically modulated tooth flank profile grinding, particularly with regard to chip formation, tool behavior and surface structuring. Moreover, a qualitative review will also be made of the overall benefits of surface structuring of gear tooth flanks in terms of manufacturing process and operational performance, with a particular focus on distribution of the lubricant film. ■

A Niles gear profile grinding machine (© NILES)

Machines, Tools, Processes – Complete Solution

NILES is one of the world's leading manufacturers of gear grinding machines. In 1994, the NILES product line was expanded to include gear profile grinders. As a member of the KAPP Group, NILES offers technical solutions e. g. for high-precision grinding of large gears with non-dressable CBN grinding wheels. Additionally, the ZP line of large gear profile grinding machines was extended to diameters up to 8,000 mm. The Production Technology Center and NILES have been cooperating for many years in research and development. Plant manager Dr. Frank Reichel appreciates the partnership: »Our core business is customized manufacturing of high precision machine tools. Fundamental R&D often falls short. It is always useful to have a partner who has the time to look at things systematically.« As is the case in the project on micro-structuring of gears for offshore wind power stations.

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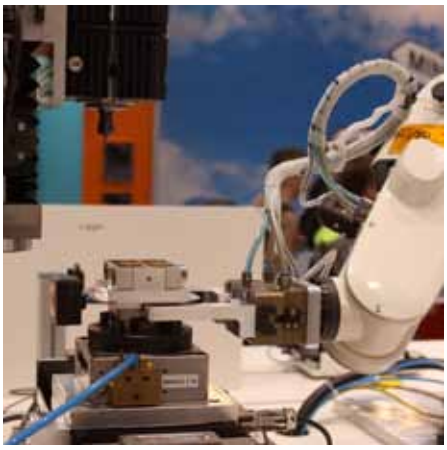
Intelligent Production through Smart Products

The idea that products themselves can coordinate and control manufacturing processes will soon no longer be just a sci-fi vision of things to come. Commissioned by the Federal Ministry for Education and Research (BMBF), the Self-organizing Production – SOPRO project has brought together scientists from various institutes in the Fraunhofer-Gesellschaft and the Technical University of Berlin to develop mature applications that will make this vision reality. The basic background idea is that machines and workpieces can communicate with one another, learn from one another and organize the workflow on their own. The decentralized intelligence that the workpieces and components require to do this comes in the shape of miniaturized electronic units known as »Process eGrains«. These can exchange information with other manufacturing units and autonomously carry out planning, coordination and monitoring tasks.



Detailaufnahmen des SOPRO-Demonstrators

▶ Product-controlled production

In a range of research scenarios such as product-controlled manufacturing and flexibilization of machine-based manufacturing flows, scientists have already demonstrated that this can work. The key role in these scenarios is played by the products to be manufactured and the workpieces that manufacture them. With the help of the Process eGrains they can call up the manufacturing information they need at anytime, and also have access to local intelligence that enables them to negotiate with the processing stations and navigate their own way through the production process to the machines. In these product controlled manufacturing scenarios, it is the workpieces themselves that take the initiative with the aim of completing the requisite processing stages on schedule. Selection of the next processing station is made through dialog between the workpieces and manufacturing machines and resources.

Product-controlled production eschews traditional central planning and control in favor of a multi-agent system with the possibilities this offers for auctions and negotiations as a means to self-organization. Such a highly dynamic production environment allows for quick-off-the-mark decision-making about order handling, as well as rapid responses to unforeseeable events that do not impede the actual production workflow. Decentralized coordination between the casts of players can rapidly compensate for such eventualities as the outage of a machine or workpiece, the lack of a component through delays in just-in-time delivery services or a sudden urgent priority order.

In marked contrast, the tradition type of control management plans workflows in the order network with probable expected times of arrival and queuing lines. This means that any significant delay in schedules requires a re-calibration of the order network and on-the-spot decision-making about delays in customer delivery

The SOPRO demonstrator at the Hannover Trade Fair 2012

deadlines. In self-organized production, on the other hand, orders are assigned to the appropriate machines as soon as present circumstances require a decision to be made. Due account is also taken of the availability of machines, the current status of their operating equipment and workload, as well as current waiting times and batch sizes. The advantages of such an approach to manufacturing organization are clear for all to see: processing operations are completed on schedule, optimal use is made of manufacturing resources and warehouse holding stock is reduced.

▶ Demonstrating results

In order to investigate the opportunities offered by self-organizing production, Fraunhofer IPK has built a demonstrator with simulated workpieces and processing machines. Netbooks serve as workpiece carriers brought to the machines by a rotary transport system. The »virtual« workpieces essentially consist of nodes of wireless sensors and the data stored in them. Their respective processing stages and communication with the machines are visualized on the Netbook's monitor. Workpiece processing operations are simulated on the virtual processing station which feed in and execute the requisite processing data. Once the parts have been processed, they are returned to the workpiece carrier. A virtual assembly station takes the in-coming parts and assembles them into the product whereby the sequence of the assembly line is flexibly adjusted to meet the in-flow of part-components and carry out operations in line with the workpiece information received.

This demonstrator and the scenarios it images can show that product-controlled production with decentralized provision of order and processing data is indeed a feasible proposition. With its approach that gives objects not just memory but embedded intelligence as well via Process eGrains, SOPRO solutions can point the way to the use of cyber-physical systems of the kind Industry 4.0 is now contemplating. First comparisons of self-organizing production with conventional methods of order planning and management can point the way to improvements in terms of expected more even workloads and increases in throughput. ■

Virtual Control of Real Production Sequences

In order to stay competitive in times of unpredictable market conditions, manufacturers need to develop new business and operation strategies to prosper over the long term. When forecasts become less and less accurate, it seems that the next generation manufacturing industry will require support for continuous changes. At the shop floor level, this translates to automation technologies and control systems that quickly respond to changes while maintaining a stable and efficient operation. Advanced knowledge-based technologies, information technology support tools and processes, as weel as highly skilled workforce capabilities are required to effectively integrate and apply these strategies. A nvoel solution here is the »Hardware-in-the-Loop (HIL)« concept developed by scientists at IWF. It can be used not only to start up production systems virtually, but also to directly control the real material flow by means of a material flow simulation software.

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Energy-efficient Automobile Production

Making better use of energy in existing production plants and industry supply systems, and cutting down on both energy consumption and energy costs – these are the aims of the collaborative research project »Energy Efficiency Controlling with Reference to the Automobile Industry (EnEffCo)«. In this project Fraunhofer IPK is developing analysis and modeling techniques for energy-efficient process control. This includes methods and tools for the modeling of production processes, machines and plants, use of data mining techniques for analysis of energy consumption profiles, and the identification and evaluation of alternative control and process management strategies optimized for the energy-efficient controlling of machines and plants.

▶ Energy-oriented process models

The increasing role played by renewable energy in the overall energy mix calls for companies in the manufacturing sector to become increasingly flexible in their use of energy. At the same time many companies have embraced the specific goal of year by year consistently lowering the amount of primary energy used for the manufacture of a single product. To these ends, the EnEffCo project has taken the automobile industry as a reference point in its development of methods and tools for streamlining the capture, processing and analysis of energy measurement data, and for specific investigations of how energy is actually used. The project engineers seek to use cutting-edge software-based instrumentation and control equipment technology to optimize existing plants and processes.

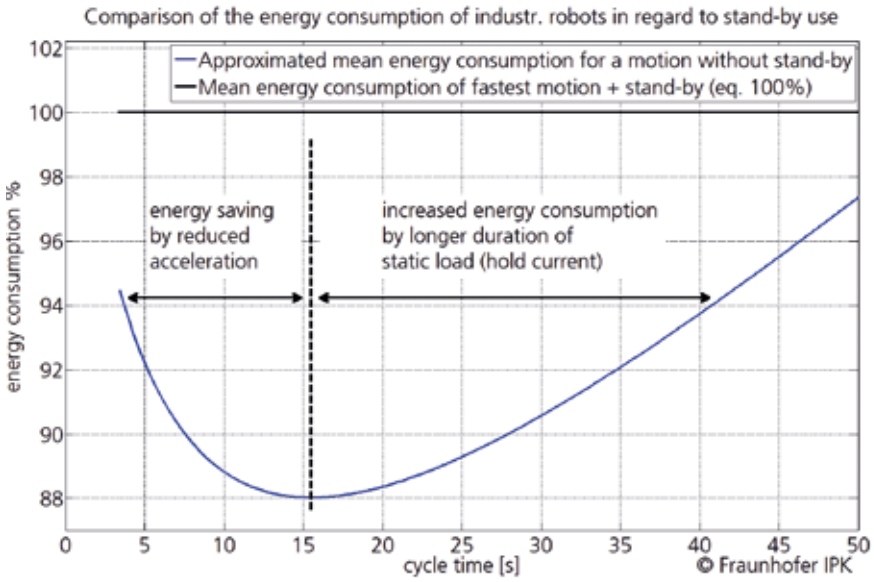
Example body construction: analyzing the energy consumption of industrial robots during production

▶ Uniformity of basic data

The starting point for energy-efficient production is the in-depth analysis of the overall manufacturing system using real energy consumption readings. One of the key problems in processing energy measurement data is that even today data is rarely available in a format from which the required information can be directly derived. More often than not, a great number of preparatory stages must be gone through before any meaningful information can be filtered from the raw data. Moreover, given the variety of disparate system on which it is captured and stored, there is also little uniform access to data and consistent data representation. Especially when it comes to basic data like quantities and energy consumption, tools are needed that give users effective support in the compilation and analysis of energy consumption profiles.

▶ EnergyMiner

In the EnEffCo project, scientists at Fraunhofer IPK are implementing tools to achieve this consistency in the representation of data. A database application has been realized for frequently measured data which retrieves data from existing systems and stores it in a uniform manner. This database system is connected to a variety of tools for analysis and simulation. The EnergyMiner is one such tool for automated analysis. Not restricted to use with the database system, it can also handle data from other sources such as CSV or Excel files. The EnergyMiner can also identify characteristic process patterns which occur frequently during analysis of energy data. These could be anything from individual working days to the cycle of a machine. The EnergyMiner helps users to recognize and analyze such cycles. The advantage here is that comparing characteristic patterns with actual process behavior enables pinpointing of anomalies at a very early stage. At the same time the EnergyMiner helps users compile and evaluate efficiency indicators and energy efficiency strategies for industrial robots.



Analysis of energy consumption by an industrial robot: energy savings can be achieved if optimal use is made of the dormant periods

Strategies for energy-efficient robots

Energy efficiency aspects play a role in industrial robotics both for installed systems and in the design of new closed-loop control strategies. In this context Fraunhofer-researchers use Fraunhofer's own experimental set-up with industrial robots, without any of the imposed restrictions of a real-world process, to conduct measurement of energy consumption and identify potential for savings in energy consumption. In doing so, they follow two different approaches: on the one hand optimization of free process parameters such as the cycle time; and on the other, energy-optimized planning and design of the overall process. The later requires a highly detailed knowledge very early on in the planning stage of all used subsystems. As this requirement cannot always be met, scientists are concentrating on improving existing robot programs – for instance, by varying the maximum speed of an industrial robot and investigating how energy consumption varies from one motion sequence to another. This approach also factors in the robot's kinematics and the influence of its control unit.

For precise results the whole time between two processing cycles needs to be investigated and not just the moment when the robot is in motion. Varying potentials for saving energy are identified depending on the type of robot and the flexibility in the manufacturing process to dilate the robot motion. To what extent this potential can be exploited depends on the dormant time in the whole process cycle. For instance, if the robot itself is not the system that determines the cycle time, it can either move at maximum speed and then wait or be in continuous motion the whole time. In this way, depending on the type of robot, the ideal level of energy consumption for each cycle time can be defined. One further possible option is to use the holding brakes and to waive the engine's holding current.

With its base in the lab results on energy consumption of industrial robots, continual energy data recording in real-world operations and their subsequent analysis, the EnEffCo project supports efforts towards energy reduction. ■

How to Manage Energy Efficiently

Fluctuating energy and commodity prices, a shortage in fossil fuels, and higher customer needs for a sustainable use of energy have turned energy efficiency into a top priority for industrial nations. In 2008, the European Union has passed a set of binding legislation which aims to ensure the EU meets its ambitious climate and energy targets for 2020. These targets, known as the »20-20-20« targets, set three key objectives: reducing the EU greenhouse gas emissions, raising the share of EU energy consumption produced from renewable resources, and improving the EU's energy efficiency – all by 20 percent. The German Federal Government has created a series of incentives to motivate companies to implement energy management systems. Fraunhofer IPK supports its customers in developing energy management systems which help to systematically monitor all energy-relevant data and to exhaust saving potentials.

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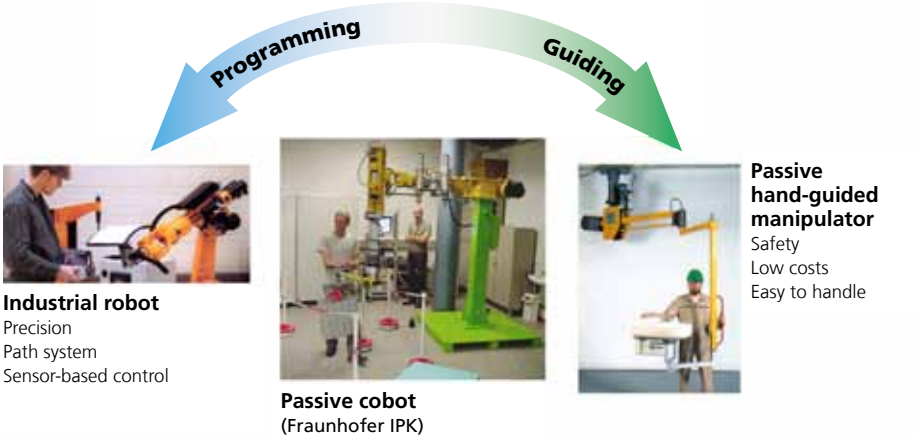
Cooperative Robots – Together We Are Stronger

Modern industrial robots are characterized by their precision, speed and performance. Even so, in the foreseeable future their capabilities will come nowhere near to rivaling the intelligence and abilities of humans. This is why the positive characteristics of the human being and the robot make for an ideal combination. Scientists at Fraunhofer IPK are researching novel approaches to such a combination and implementing them as prototypes. Two such prototypes are already in industrial use. The idea is based on direct human-robot collaboration with physical contact, as in the case of the joint handling or joining of an object.

► Cooperative robots – cobots

Cooperative robots, or cobots for short, are a new class of handling systems which combine the properties of industrial robots and manually controlled manipulators such as weight balancers or cable winches. The aim is to create a symbiosis of the best properties of both parties: with ease of use and low costs on the side of the manipulator, and programming, web guide rolling and precision on the side of the industrial robot. This should enable development of a novel handling system that is both economical and ergonomic. These innovative systems have recently been the object of much intensive research under the appellation »Intelligent Assistance Systems«.



A new class of systems that combine the characteristics and functions of robots and manually guided passive manipulators

The first cobot concept is based on intrinsically passive systems set in motion and propelled by humans. From classical robots these systems take the ability to define and regulate a trajectory along what are known as active barriers or virtual walls by shifting the end-effector – the device at the end of the robot's arm. The high precision of the cobot is also comparable to that of a robot. The functional principle used at Fraunhofer IPK is based on a novel continuous variable transmission (CVT) system built from modified differential gears that offers optimal web guiding on virtual walls and maximum force intensification without endangering human safety. Total drive output is limited to 100 watts. Force intensification serves here to offset process forces such as inertia forces in the handling of heavy parts or contact pressure in assembly. This reduces the human physical payload to a minimum while also enhancing ergonomics and increasing productivity and quality. This concept is suitable for the handling of lighter payloads of up to around 100 kilograms.

► Force intensification

Powerful active systems like industrial robots and power enhanced handling systems are used for the manipulation of heavier parts. Cooperation is based on the admittance principle whereby the motion commands or forces exerted by the human on the joint workpiece are captured by a force torque sensor and translated into robot movements. Robot behavior is regulated so that the human can sense the reactions of the virtual mass damping spring system in all degrees of freedom of movement. The parameters of the virtual system can be adjusted by the controls to fit the task in hand or the human. For easy maneuverability, maximum inertia of the object is never in excess of several kilos. Precision assembly and contact with a rigid environment require a higher level of

Semi-automatic windscreen assembly by cooperative robots

damping. A further advantage is that the controls can generate virtual active and passive obstacles – known as virtual walls and guides – as this facilitates human leadership in the assembly of complex parts.

Fruanhofer IPK has recently developed a flexible force intensified robot for the semi-automatic assembly of windscreens and rear windows for the automobile industry in the EU project »Flexible Assembly Systems through Workplace-Sharing and Time-Sharing Human-Machine Cooperation (IP-PISA)«. In this system the handling of the screen – from the bonding station to its transport to the car body and tracking of assembly line movement – is fully automatic and robot-controlled. Two human operators collaborate with the robot on the actual assembly.

► Safety

Stable and transparent robot behavior during interaction with humans, and the safety of human operators are critical for the acceptance and use of force-intensified cooperative robots in industry. Above all, particular attention must be paid to the high power output of robots which at several kilowatts can cause very serious injuries. ISO 10218-1,2, the new robot safety standard, sets the framework conditions for safe cooperation, including physical contact between robots and humans. On-going research at Fraunhofer IPK is focused on the evolution of algorithms which aid in securing such requirements by using sensor systems to monitor robotic and human movement on the one hand, and by limiting robot performance and speed on the other.

The new cobot systems were conceived to help people, not replace them. Their manual force control system is also intuitive which makes for short training times. They operate as smart, easy to use, »third hands of the operator« by enhancing operators' efficiency whilst simultaneously reducing their physical payload. Direct interaction with the workers and engagement with their human skills and abilities means that a very high level of flexibility can be achieved. ■

Machining with Industrial Robots

Industrial robots are now a standard product for automation and even for large work spaces available at low cost. There is an increasing demand to apply robots to machining processes which were previously reserved for machine tools or special metal-cutting machines. A particular challenge is the robot-based machining of hard materials such as stone or alloys and the resulting demands on task planning, programming, and real-time control. Engineers at Fraunhofer IPK engage in research and application development for robotic milling, grinding and polishing.They pursue in particular the development of innovative solutions using robust impedance and force control.

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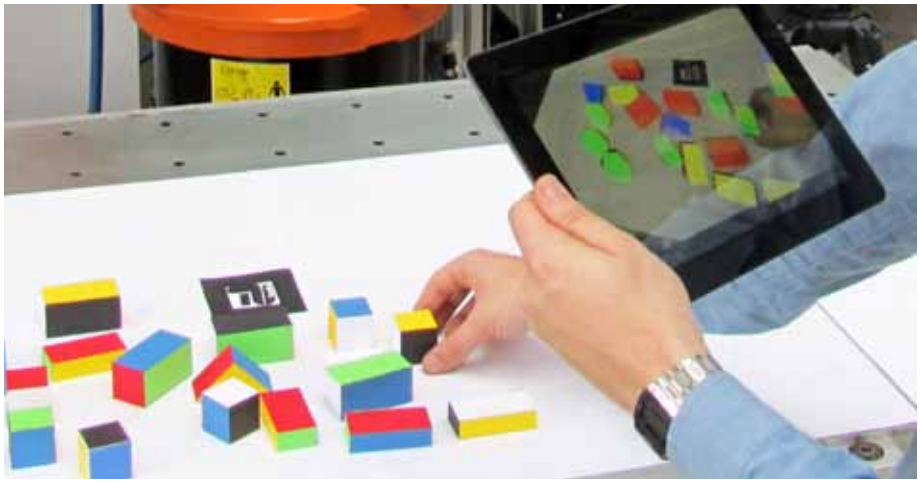
Intuitive Robot Programming on Mobile Devices

Smartphones and Tablet PCs are wowing private users with their high functionality, ever greater capability and ease of use. In an industrial context these handheld sets can be used as mobile control and programming devices. In view of the ever more rigorous requirements placed on the man-machine interaction (MMI), developers and users expect that such devices will put a new lease of life into the planning, programming and maintenance of automated production systems.



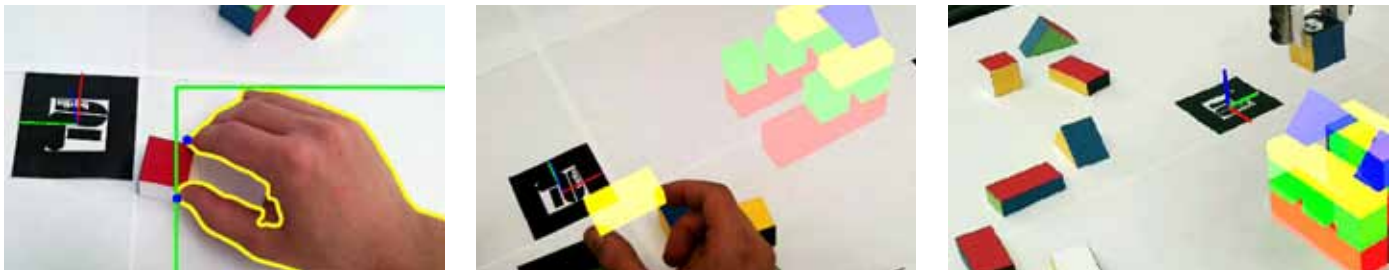
Easy programming: the human operator shows how it is done and the Tablet PC follows suite

► Multimodality – communication over multiple channels

The model on which the design of efficient ergonomic man-machine systems is based is nothing less than natural person-to-person communication using the mediums of language and gesture. Multimodality, or the simultaneous or sequential use of multiple communication channels, plays a major role in the design of high performance control systems. One prerequisite for the design of an efficient and user-friendly MMI system is an application and user-specific blueprint. Typically, multimodal control systems use movements of the fingers and hands, and gestures of touch as well as language for communication, but visualization is another form of interaction between humans and machines. Apart from classical displays, methods of Augmented Reality (AR) can also be used for the visual presentation of information in a camera image. In the field of industrial robotics, users are supported by spatial information as well as robot programs. In this way poses, trajectories, coordinate systems and other data for processing tasks in a real-world robot environment can be visualized. What is more, a virtual industrial robot can simulate the programs without the real robot having to make a move. In this type of evaluation, the user is not confined to any particular computer workstation as head mounted displays or handheld devices are quite sufficient for visualizing what is happening.

► Programming by Demonstration

One of the key focal points of R&D at the Institute for Machine Tools and Factory Management (IWF) at the Technical University of Berlin is control-by-gesture, visualization and virtual interaction for the programming of industrial robots. This engages with Tablet PCs but also with 3D motion tracking systems. Unlike standard programming techniques, these enable very rapid definition of poses, trajectories



Segmentation of hands and extraction of finger tips for gesture recognition (left), interaction with virtual objects for definition of an assembly operation (middle), transferring the task to an industrial robot (right)

Simulation of a robot program in Augmented Reality

and tasks as there is no longer any need to spend time moving the real industrial robot. Instead, the system uses simple gestures to produce poses and trajectories. At the same time, information is fed into the robot program of a handheld device for further administration and processing of the web data.

Scientists invoke the »Programming by Demonstration« principle to prove that robots really can be simply programmed using smartphones or Tablet PCs. In the PbD paradigm a person first demonstrates how a particular task is to be accomplished, and a smartphone or Tablet PC then automatically computes the corresponding program for the robot. This form of task-oriented programming requires no specific expertise which makes it especially simple for users to execute. All it requires are objects which the user can grasp, move and put down together with an image-assisted sensor system which can recognize and track them. Complex robot programs are extrapolated out of the recorded trajectories of fingers, hands and objects.

▶ Testing with Augmented Reality

Such a robot program is evaluated with an Augmented Reality application on the Tablet PC. During or after the interaction, it gives visual feedback by fading in current programming information simultaneously to the user interaction as virtual objects in the camera image of the Tablet PC. Virtual modeling of the robot in the AR application means that the robot programs can be simulated in a real-world environment. The robot programs can be simulated in a real-world context and checked for the achievability of individual poses, as the robot is virtually modeled in the AR application.

By combining the AR application with 3D gestures, a new form of interaction is created whereby the use can interact with virtual objects shown in the camera picture. This means the use can typically move, rotate or scale these objects and thus define single poses, trajectories and tasks. The robot program is adapted to each respective interaction while the AR application also enables simultaneous feedback. If the virtual programming is successful, it can be directly transferred from the handheld device to the industrial robot's control system.

▶ User-friendly apps

The result is a spatial program interface for industrial robots. The actual programming environment runs as an app on conventional smartphones and Tablet PCs and includes the Augmented Reality-application. The programs can be transferred from the app to the industrial robot over a common interface or to other simulation tools via additional interfaces. ■

Secure Identity – Uniqueness und Authenticity in the Real and Digital World

The Fraunhofer innovation cluster »Secure Identity Berlin-Brandenburg« is a collaboration between five Fraunhofer institutes, five universities, 12 companies, as well as the Länder Berlin and Brandenburg along with individual institutions in other federal states. Goal of the joint research and development projects is to provide technologies, processes and products that enable the unambiguous verification of the identity of individuals, objects and intellectual property. Such identity security ensures that identity can be used in many different ways to simplify processes in commerce, administration and daily life. The applications range from the next generation of tamperproof personal documents, the security of electronic business processes, through to communication between machines and vehicles, and product and brand protection. Find more information on www.sichere-identitaet.de

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Under One Common Roof

A model-based integrated management system can bring together various different management systems for quality, industrial safety, environmental, energy and risk management under one common roof. Model-based integrated management systems are built on a company model in which all relevant business processes are mapped. In a pilot project of the Fraunhofer-Gesellschaft, Fraunhofer IPK has developed an integrated management system precisely tailored to the particular needs and requirements of research institutes. First rolled out in the Fraunhofer Heinrich Hertz Institute HHI with support from experts at Fraunhofer IPK, the system will be established in other institutes in the near future.

▶ User-friendly and legally compliant working conditions

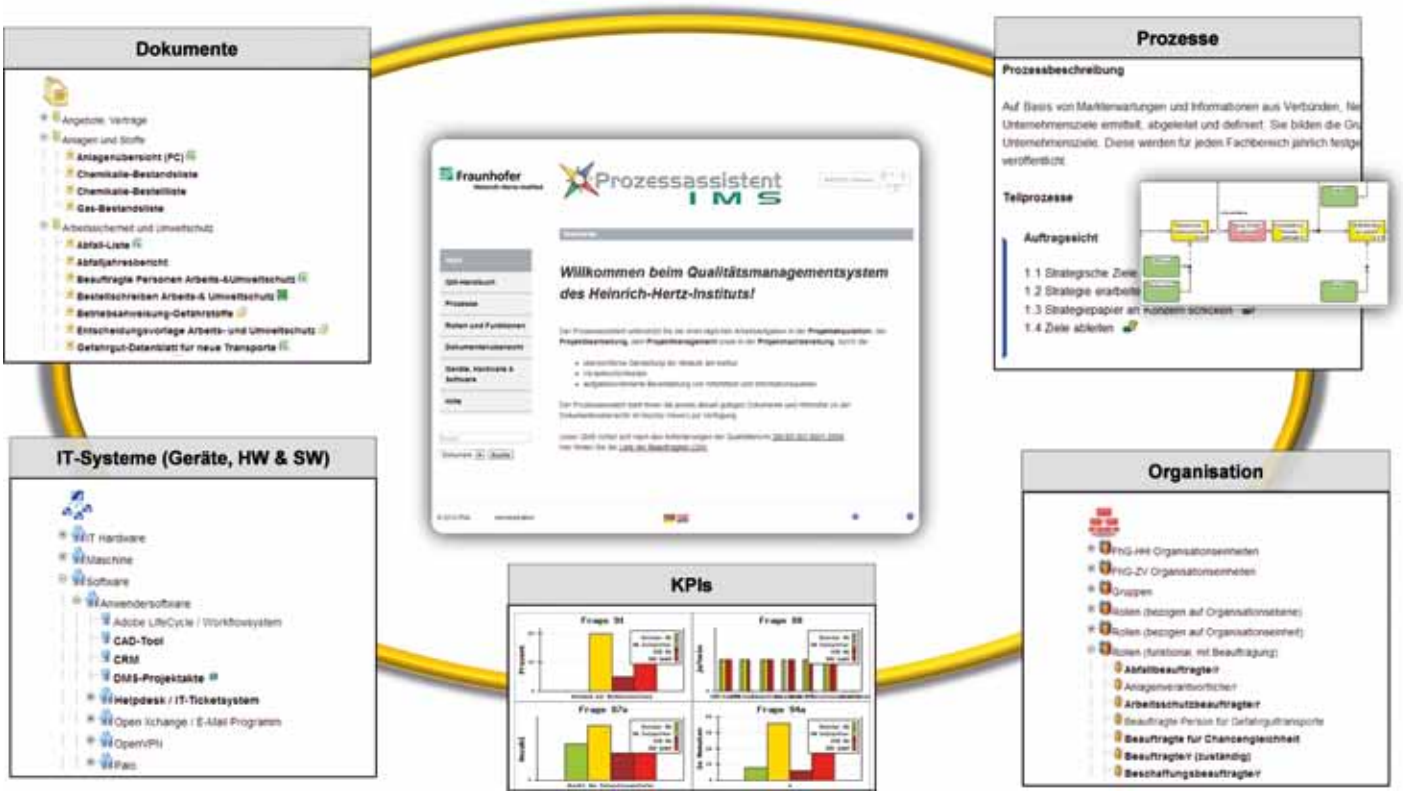
In the field of research, development and fabrication of photonics, Fraunhofer HHI has been working since 2010 with a Quality Management System (QMS) certified per ISO 9001. In this move Fraunhofer HHI has not only responded to the requirements of its key strategic partners, but also sought to raise the quality profile of its processes and products in the outside world. In April 2011 a certification level process-oriented Quality Management System was introduced covering the whole institute. In the next stage this QMS will be gradually extended to include management systems for industrial safety and environmental management. Roll-out for these systems is planned for 2013.

With the introduction of such systems, staff and management at Fraunhofer HHI want to create working conditions that are both user-friendly and legally compliant. Research institutes have their own unique set of requirements for integrated management systems. For instance, the relatively high fluctuation of personnel in research departments means that intuitive process architecture is of the essence if new staff members are to find their bearings quickly and easily. Functionalities for maintenance and upkeep are also needed that can be operated even under limited personnel resources.

▶ A process-oriented and participatory approach

Colleagues from Fraunhofer IPK used their own MO²GO software tool to engineer a corporate model as the information base for Fraunhofer HHI's integrated management system. Processes that already fulfilled the required quality standards were taken as benchmarks. Workshops with the whole cast of actors then used these benchmarks to adapt the model to the institute's own specific set of requirements. Use of these benchmarks and quality-related documentation saved resources and ensured that the whole model could be rapidly completed in just six months. All relevant documents were centrally

Advantages of an IMS over single systems



The Process Assistant as a model-based integrated management system

archived in a Process Assistant and software systems for workflow support were integrated to offer staff members optimal proactive assistance in their daily work. Such a participatory approach enables quality management for human resources to be simultaneously qualified for modeling methods and software tools.

At the same time a quality organization system with standardized role concepts was also engineered, modeled on various successful reference projects. This concept envisions that the role of quality management officers will be taken by various professionals who coordinate departmental system-relevant activities such as process optimization or internal auditing. Fraunhofer IPK assists HHI in the training and professional qualification of quality management officers, quality assistants and internal auditors. ■

▶ High customer satisfaction

Single processes of the integrated management system have already been activated in 2012. The entire system is planned to be available in spring 2013. The staff at the Fraunhofer Heinrich Hertz Institute's two sites in Berlin and Goslar are very happy with the implementation of the project. As Jörg Stohl, administrative director at Fraunhofer HHI comments: »Introduction of the model-based integrated management system has meant that we have been able to introduce greater transparency into our business processes for all our employees while also significantly cutting down on the time and effort needed for maintenance and updating of process-related documents. What's more, we have also achieved a much higher degree of legal certainty in the fields of workplace safety and environmental protection. The system makes a major contribution to certification and collaboration with public authorities.«

Eco-Quality – Quality Management goes Green

The quality of a product is more and more defined by the question, whether it has been manufactured in a sustainable way. Therefore, it makes sense to define quality management no longer exclusively along economic parameters, but along ecological ones as well. Energy efficiency, preservation of resources, and sustainability also become quality factors for products and processes. On behalf of its customers, Fraunhofer IPK delivers a foresighted quality plan as well as a comprehensive requirements and configuration management for the entire life cycle of products, which naturally includes sustainability aspects.

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Building Innovation Centers in Brazil

On 21 June 2012, Fraunhofer IPK signed a cooperation agreement with SENAI, Brazil's National Service for Industrial Training. Fraunhofer IPK will assist SENAI over the next few years in the construction of 23 research institutes in Brazil. Fraunhofer experts will draw up the business plans for national management as well as the planned SENAI institutes and develop management solutions for individual establishments.

▶ Fraunhofer know-how for Brazil

Brazil is one of the world's fastest growing economic regions and in 2012 its economy rose to become the sixth biggest in the world in terms of nominal GDP. SENAI, (the acronym for Serviço Nacional de Aprendizagem Industria) has a solid track record of providing vocational training to over 55 million people at 800 different operational units. SENAI is financed by the Brazilian Confederation of Industry which is responsible for professional and vocational training and which also seeks to cultivate international business relationships.

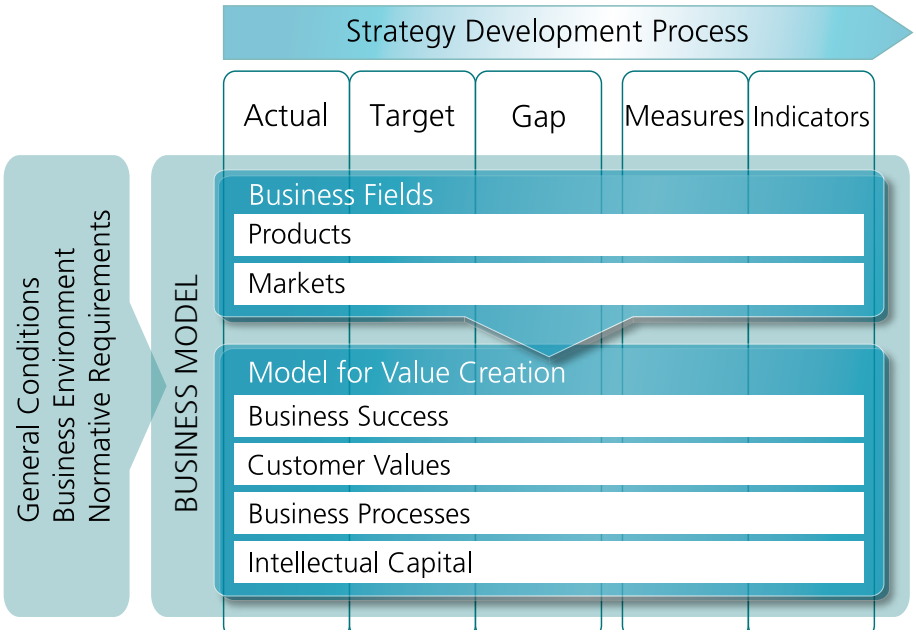
With the newly planned research institutes, SENAI intends not just to promote vocational training for industry and business, but also to promote applied research across the country. This is why a particular focus of these innovation institutes will be on drawing up development projects for Brazil's emerging industry sectors.

The strategic cooperation pact covers a seven year period in which Fraunhofer IPK will assist SENAI, its Brazilian partner, in the construction of a total of 23 innovation centers across nearly all federal states in Brazil, and in establishing a central administrative unit in Brasilia, the coun try's capital. In the first project phase from 2012 to 2013, experts from Fraunhofer IPK will develop business plans for an initial number of eight innovation institutes and a management concept for the central unit in Brasilia. Five other Fraunhofer Institutes are also providing additional technical know-how for the project.

▶ Best Practices in R&D Management

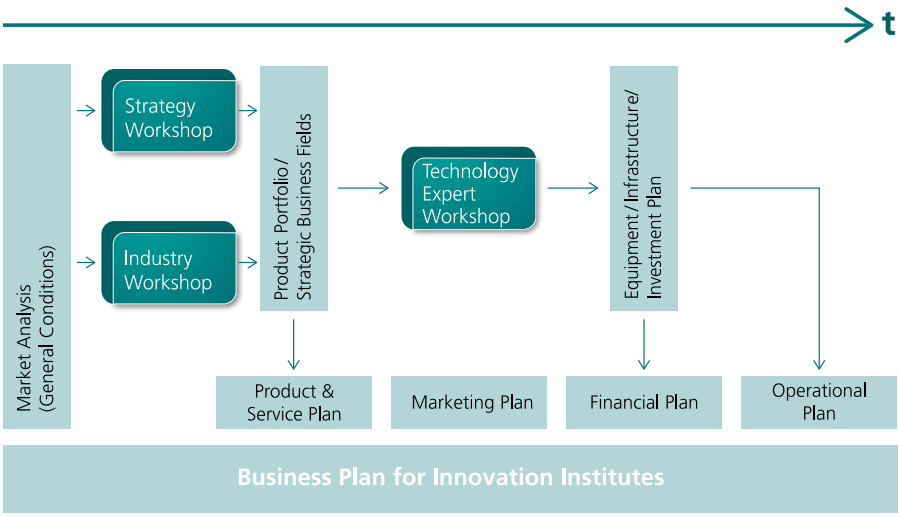
The start-up phase of the project involves the compilation of in-depth business plans for the innovation institutes specialized in the fields of automation technology, electrochemistry, renewable energy, lasers, micro-production technology, surface engineering, polymer technology and virtual product development. In a first stage, the directors and deputy directors of the institutes together with future staff members of the administrative unit were invited to a training seminar at Fraunhofer IPK for capacity building in the planning and management of research and development. In the seminar, Fraunhofer Best Practices in research and development management were presented for preparation and operational support while an analysis of the impact that political, economic, social and technological factors can have on the research landscape gave a clear idea of the framework conditions pertaining in Brazil. These results were factored into the evolution of a strategy planning process in the course of a moderated participatory workshop.

Methods such as integrated strategy development which were originally developed



Integrated Strategy Development Mode

with the corporate sector in mind, were tailored to meet the specific needs of research institutes. Building on the insights gained in the planning of technology parks and national innovation systems, the strategic development process was then initialized for the innovation institutes. To validate this process and coordinate it with actual market conditions, Industry Workshops assessed the potential of the innovation centers in relation to industrial need. In this way, a detailed plan for products and services could be developed which both related the potential of the planned product portfolio with the specific needs of industry customers, and defined strategic business areas. Follow-on Technology Workshop, held in cooperation with selected Fraunhofer Institutes specialized in these fields, then established the specific requirements of the Innovation Centers in terms of human resources, equipment and infrastructure. A verified financing plan and an operational plan factored in both envisioned research activities and capacity planning for product and service delivery. Eight business plans were evolved out of this set of partial results which mapped strategic and operational planning on the highest level. ■



Roadmap of the Business Plan for the Innovation Institutes Integrated Strategy Development Mode

R&D Strategy for Dubai

In 2010, Fraunhofer IPK supported the Dubai Institute of Technology (DIT) in launching its new research and development strategy. This campaign aimed to build a platform to assist in the targeted promotion of research and development in specific regional segments. True to the motto »R&D for a healthy economy and prosperous region« IPK consultants advised DIT in the development of a technology framework to regulate both internal activities in the institute and university-led development of economic sectors closely related to the institute. Having developed the business plan and its related implementation plans, DIT in partnership with Fraunhofer IPK has now moved on to a further project stage and initiated research funding programs as well as first research projects.

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New Bridges to China

On 18 May 2012 the College of Mechanical Engineering at Tongji University in Shanghai, China, appointed Prof. Dr. h. c. Dr.-Ing. Eckart Uhlmann as its Advisory Dean. Tongji University, one of the most prestigious of China's universities, was founded in 1907 by German scientists. At present, over 55,000 students are enrolled there. In 2003, Prof. Uhlmann was appointed as Honorary Professor at Tongji University's Sino-German College. His new appointment as Advisory Dean is for a five year period. Futur talked to Eckart Uhlmann about his new responsibilities and the future of Sino-German collaboration in industry and science.

Prof. Yang Zhigang, Dean of the Faculty of Mechanical Engineering at Tongji University, hands Prof. Eckart Uhlmann his accreditation as Advisory Dean.

FUTUR: Prof. Uhlmann, how long does your association with Tongji University go back?
Prof. Uhlmann: For seven years I gave a series of block lectures there on rapid prototyping and rapid manufacturing. During that time I built up a comprehensive network of contacts, including contacts with industry. My work at Tongji University also led to my appointment in 2003 as an Honorary Professor at the university's Sino-German College. This College was founded in 1998 as a joint project between the DAAD and Tongji University in Shanghai, and sees its role as a bridge linking the German and Chinese education systems. Even when I had stopped working as a lecturer, I still continued to extend my network of scientific contacts in the fields of manufacturing technologies and mechanical engineering so that we now have quite an extensive R&D network in China at our fingertips.

FUTUR: What kind of work does your new appointment as Advisory Dean involve?
Uhlmann: My primary role as Advisory Dean is to advise the Dean, Prof. Yang Zhigang, on the development of strategy for the College of Mechanical Engineering. Apart from this, I am also responsible for furthering international relations at the College. Among other things we are striving to set up collaborative research projects – for instance partnerships which could be funded by the German Research Foundation (DFG), the Federal Ministry of Education and Research (BMBF) or the Chinese Ministry of Science and Technology (MOST). We are also developing research concepts that closely engage with Fraunhofer IPK. Another key aspect of my office is assisting curriculum planning. At the moment, we are involved in setting up a Dual Degree Master's Program in Production Engineering which will drive forward the structuring of curriculum planning at both Tongji University and the Technical University of Berlin.

Another focal point is setting up a Fraunhofer IPK project group at Tongji University which will involve colleagues from Tongji University and the Sino-German College in projects on manufacturing technology and machine tools. We are looking to work shoulder-to-shoulder with industry in these projects. The project group is mainly geared to German machine tool and plant constructors with a foot on the ground in China. Generally speaking, German companies in China do not have their own research departments, so we have made it our goal to work together with companies from Germany or companies involved in joint ventures with Chinese firms to strengthen their innovation and overall productivity.

Finally, it is one of my duties to maintain and develop the exchange of academic personnel. Today, the Production Technology Center hosts a large number of Chinese scientists who are very successfully working on their Ph.D.s there.

FUTUR: You touched on the Dual Degree Master's Program in Production Engineering. How far have you got with the planning?
Uhlmann: The idea for a Dual Master's Degree in Production Engineering came from a joint workshop held this summer with the Technical University of Berlin and Tongji University. At the moment we are working out the details. We are planning for equal numbers of German and Chinese students to take the five semester program at both universities. We expect the students who apply for such a Master's program to have not only excellent academic results, but also a high level of interpersonal skills which we will screen them for in individual selection interviews. On top of this, they will also need excellent language skills as the lectures will either be in English or German. Courses which teach the basics of the respective languages and cultures also form part of the curriculum. German companies put a big premium on engineers who can speak Chinese, and our Dual Master's Degree is a response to meet this demand. We fully expect that we will be able to start the program in the first quarter of next year.

FUTUR: As Advisory Dean you will often be in China over the next five years. How do you see collaboration with China developing in future?
Uhlmann: In terms of our own specific case, I see intense collaboration between Tongji University, the TU Berlin and the Fraunhofer-Gesellschaft. In five years our Master's in Production Engineering should be so well established that perhaps we will be taking as many as 50 students and not just the present five to ten. Obviously at the same time we also want to continue with our discussions and exchanges of views with other universities. At the moment, apart from Tongji University, we also have bonds with Jiaotong University in Shanghai and Xi'an, and are in close contact with the Technical University of Dalian and Beijing University. This means that we can extend our international network – not just between people but between institutions themselves. The world is growing closer and closer together; even today it is just one big global marketplace. And this does not just apply to business – it also applies to science. Our primary goal still remains to use the leverage of innovation through teaching and research to assist in the further development of German business in China and to sharpen its competitive edge. ■

Interview by Bettina Schmidt

The Sino-German College for Graduate Study

A joint educational program between the DAAD and Tongji University, ever since its foundation in 1998, the Sino-German College for Graduate Study (CDHK) has been the most successful academic exchange program between Germany and China. Students at the College from all over China can gain a Master's Degree at the Faculties of Electro-technology, Mechanical Engineering, Business Management and Commercial Law over a two to three year study period. Well over half of CDHK's students receive a scholarship for a semester of study at a university abroad or an internship in Germany. Furthermore, there is also the opportunity to take a Dual Master's Degree at one of the German partner universities, the Technical University of Munich or the Ruhr University in Bochum. One unique feature of the College is its range of some 30 professorships funded by over 20 leading international companies. Lectures and teaching are given by both Chinese academics who have either studied in Germany or taken their Ph.D.s there, and by over two dozen German visiting professors who give blocks of lectures.

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Global Future-proof Manufacturing

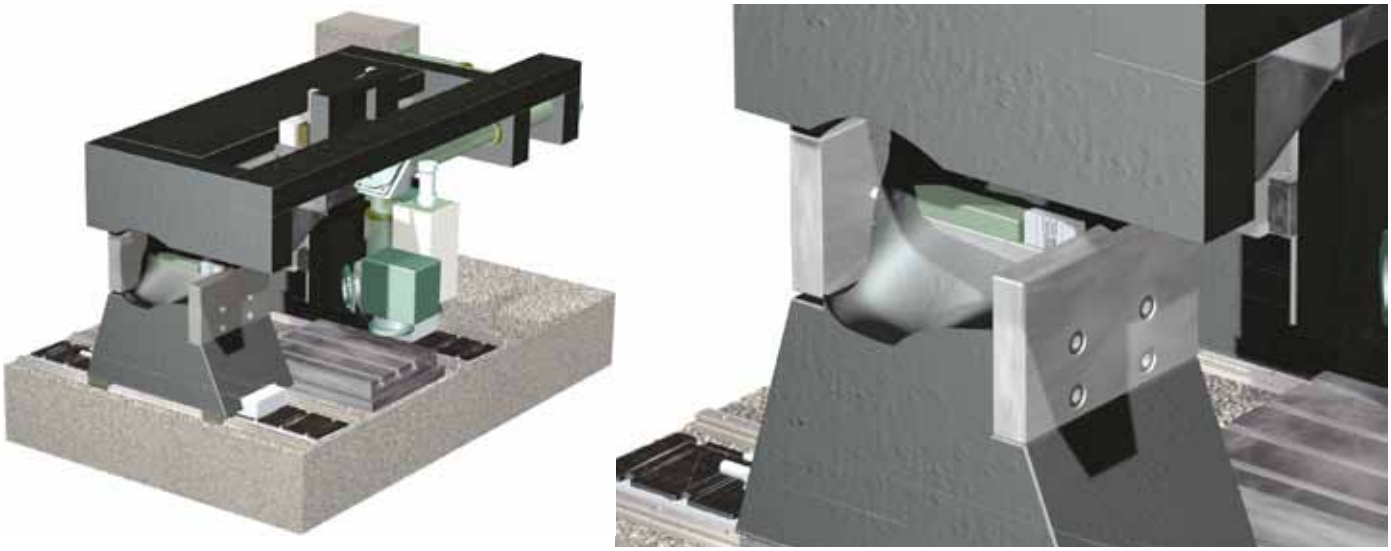
Turnabout in energy policy, electro cars, passive houses – the search for new ways of life compatible with the future dominates the public forum. The Collaborative Research Center (CRC) 1026 on »Sustainable Manufacturing – Shaping Global Value Creation« took up its work to coincide with the official »Science Year 2012 – The Year of Sustainable Energy for All«. In this interdisciplinary large-scale project funded by the German Research Foundation (DFG), 50 scientists are developing sustainable production technologies and strategies with the aim of enabling a higher level of global prosperity with less consumption of resources.

Future global development if continued use is made of present production technologies and paradigms

▶ More than just technology

Given the exponential growth in the markets of emerging countries and the staggering consumption of resources by industrialized nations, rationally considered, there is no alternative to more sustainable forms of production. As Professor Günther Seliger of the Institute for Machine Tools and Factory Management (IWF) at the Technische Universität (TU) Berlin, and spokesperson of CRC 1026 comments, »We understand production as an integral part of a global network of actors, interests and local conditions. Making a positive intervention in this network is the highly complex challenge which we have set ourselves.«

Sustainable production technology means a lot more than just pure technology. It must be oriented to future needs, and must fit in with, or be capable of transforming, existing production structures in the competitive global marketplace. It must satisfy social requirements, pass muster when appraised environmentally, and hold out the promise of financial rewards. Finally, like any other form of innovation, it must be compellingly presented if it is to find application in the real world. All these requirements are reflected in the holistic research program set up by the Collaborative Research Center 1026. Solutions for production technology are embedded



A blueprint for integrating adaptronic systems into machine tools from the CRC 1026 »Technological Solutions« project area

in the Strategy Development and Knowledge Transfer project areas. As Professor Seliger explains, »Only by keeping your eye on the big picture can you hope to drive sustainable processes. Sustainability is always multidimensional.«

► From theory to practice

Such a highly complex undertaking needs a crystal clear strategy. As the first step in the development of future-proof technology involves estimating the extent of future needs, IWF experts engaged in CRC 1026 use scenario techniques to project current development trends into the future, factoring in a broad array of possible political, social, ecological and technological influences. The resultant scenarios show which challenges await the global community and also provide the point of departure for the quest for solutions.

At the same time scientists at the TU Department of Environmental Technology and the TU Department of Landscape Architecture and Environmental Planning are working on giving sustainability ideas – which are often highly abstract in nature – a specific engineering and economic cast. This is done by defining the criteria for sustainability and applying them to the organization of technical production for global value creation networks. Researchers develop sustainability indicators, test them for utility and integrate them in evaluation procedures as orientation aids for global production.

When it comes to the evaluation of sustainability and extrapolation of proposals for action, mathematicians at the Konrad Zuse Center for Information Technology Berlin and the Department of Mathematics at the TU Berlin play a special role in CRC 1026. As equal account must be taken of all three dimensions in sustainability – the economic, the environmental and the social – this can give rise to conflicts in the formulation of action proposals. Clashes of interest can occur, for instance, when a specific measure makes a process much more environmentally friendly but at the same time raises its cost, or when the way to improved working conditions necessarily involves a shift in environmental pollution. To arrive at the best possible forms of compromise in such situations, but also to include the time needed for the implementation of new measures in the evaluation, scientists apply the theories of 'Multicriteria Optimization' and 'Dynamic Systems' from previously separate fields of mathematics to this practical application. Together with the quality science specialists from IWF and experts in knowledge management from Fraunhofer IPK, they are developing a tool for the analysis of business processes in global value creation networks. This tool presents the repercussions of single actions in the overall context of the global production network, and thus helps actors assess the scope of their decision-making.

»With the methodological approach adopted by our research work, we cover the whole array of technological possibilities,« says Professor Seliger. »Such breadth is one important pillar of our project; its exemplary depth is another. We take selected examples of production technology and show the potential of technology rigorously oriented to sustainability criteria.« Exemplary solutions for production technology identified by CRC 1026 come in the fields of product development, manufacturing techniques and machine tools – focal points of IWF expertise and central elements in value creation.

► Concrete solutions

In this way, early in the development phase, the constructor sets product characteristics and parameters to define many properties of relevance to sustainability for the product's whole lifecycle or multiple phases of use. Modularization, for instance, can enhance subsequent functional product properties and either enlarge or limit

them depending on various local development levels.

The product development experts at IWF deal with such dependencies between the functional design of a product and its sustainable characteristics. They are working to develop an assistance system to support decision-making based on sustainability criteria in product lifecycle management. The aim here is to enable designers and constructors to get a clear picture and focus on the economic, environmental and social impact of a product over the whole product lifecycle.

Once a product is designed, its production can begin. Machining, welding, cooling and cleaning are all standard procedures in parts manufacture and assembly that are often associated with heavy use of resources. Use of a closed internal cooling system in the tool during turning or milling operations should largely do away with the need for cooling lubricants which need repeated chemical restoration during standard operations. IWF is developing the prototype of a system with an internally cooled cutting tool for lathes. Use of the modern dry ice blasting cleaning technique can further reduce the need for chemical substances. And when it comes to optimization of joining processes, scientists are concentrating on how to save energy through a combination of simulation and innovative process technologies such as combined welding methods.

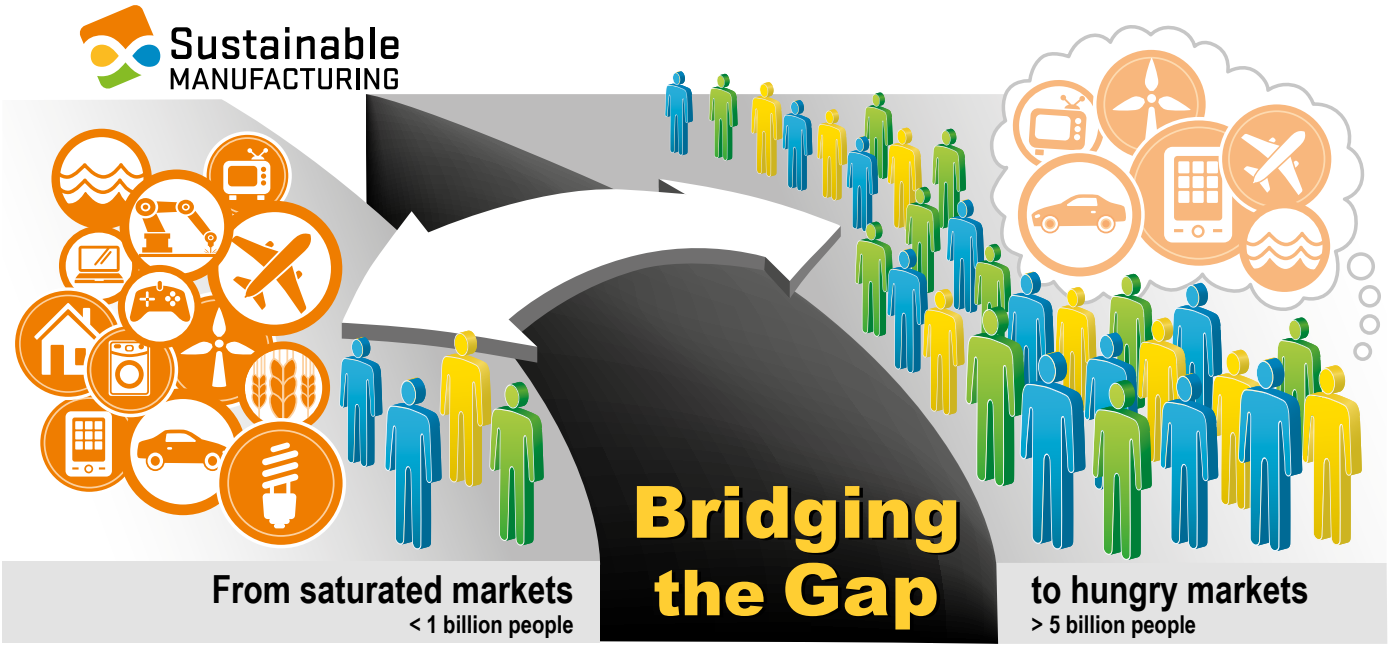
Machine tools are the heart of industrial manufacturing and are mainly highly robust in construction. A milling machine that comes on the used tool market generally has 30 years of service life behind it. Yet CRC 1026 follows a two track strategy in order to give sustainability to global manufacturing in the short term. On the one hand, IWF engineers focus on the reconditioning of used machine tools and increase the precision of old machines by fitting them with adaptronic components. Such a low cost method prolongs the lifecycle of existing machines and also opens the way to the global value creation network for actors who lack the financial resources to buy new equipment. On the other hand, researchers are joining forces with experts from the TU Department of High-Frequency and Semiconductor System Technologies in the construction of novel machine tool mounts with optimized microsystems. Their modular construction enables easy replacement of single high-tech components for efficient, needs-based configuration of the overall system. This makes plant equipment much more flexible and means that in future the roll-out of new sustainability solutions in existing production will be much quicker and less expensive.

▶ Knowledge is the future

Knowledge Transfer was anchored as the third key theme in the CRC research program from the very beginning. Professor Seliger explains the reasoning behind this rather unusual move, »Our strategic and technological work is all well and good, but it only makes sense if we can succeed in communicating our results to the outside world in ways that it can follow and accept. We might be the people developing the solutions, but it's other people who will actually use them, and it's them that we've got to communicate with!« In this context the CRC approach is squarely over education and qualification for the broad masses with the aim of dramatically raising the level of teaching and learning about sustainable production across the whole world.

Apart from the evolution of technical information tools that should help decision-makers keep their attention fixed on sustainability, another line of investigation lies in researching social phenomena like willingness to cooperate which is so critical for the success of sustainable business management. Scientists at the Social Science Research Center Berlin (WZB) are investigating incentive systems for sustainable courses of action. In a series of experiments modeled on game theory, they are exploring the conditions under which people can act together as a collective in order to solve certain tasks, and examining the factors which impact on their decision-making. At the same time experts at IWF are analyzing existing methods for teaching and learning in terms of issues connected with sustainability. And they are developing what are known as »learnstruments« – technical artefacts which automatically communicate their functionality to the user. With these tools, workers and private individuals alike can train themselves intuitively and autonomously in the operation of novel production machines and processes. Learnstruments, therefore, can overcome language barriers and address a variety of qualification levels.

Automated feedback of the kind modeled in CRC for man-machine interaction is yet another approach: camera systems and image recognition are used to analyze movements made by the worker. While the movement is being made, a monitor screen shows both the results of an ergonomic assessment and proposals for movement correction. Such a system is a major step forward in terms of enhancing safety at the workplace. And such feedback guidance can also be used for advanced operational training on the machines.



Objectives set by CRC »Sustainable Manufacturing«

Finally, in an effort to engage a much wider public audience in the issue of sustainable production, scientists at IWF are also developing learning materials and experimental programs for people in various age groups. The aim is to establish a learning and teaching internet portal which informs users about the risks and opportunities of global production.

▶ A vision of sustainable production

All the results obtained by CRC 1026 are fed into a so-called 'demonstrator': a part virtual, part real mapping of a complete production system based on sustainability criteria. This vision embodies both technical innovations and a paradigm switch in manufacturing industry which promotes mutual exchange of knowledge while also promoting cooperation in sustainability issues as a competitive advantage. This paradigm shift moves not just product manufacturing but its associated responsibilities and opportunities to the local level anywhere in the world. Professor Seliger is convinced that, »Such an understanding of global work organization and value creation has the potential to bring about a fundamental change in the way we humans live together on this planet. We have the opportunity to offer prosperity to a great many more people – whilst at the same time also consuming far fewer resources than ever before through the use of innovative production technologies. And CRC 1026 is laying one of the foundations stones.« ■

11th Global Conference on Sustainable Manufacturing GCSM
23 – 25 September 2013, Berlin

Visit the Global Conference on Sustainable Manufacturing GCSM and learn more about the increasing significance of sustainable manufacturing as a global mega theme. GCSM is geared towards representatives of science and industry from all continents interested in the ecological, economical and social dimensions of sustainability. The conference offers keynote speeches, panel discussions, parallel sessions and a poster forum. Discussions and exchange of ideas between the participants are an integral part of the meeting. For more information please visit www.gcsm.eu

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From Silicon Valley to Silicon Sanssouci

In February 2011, SAP AG, the world's leading business software company, officially founded its first Innovation Center in Potsdam. In summer 2013, staff will be moving into the new building located on the banks of Lake Jungfernsee. In close cooperation with the Hasso Plattner Institute for Software Systems Engineering (HPI) and the HPI School of Design Thinking, new collaboration models with partners and customers are applied at the Innovation Center. Specific projects are also being run with other research institutes in the Berlin-Brandenburg region. For instance, scientists at Fraunhofer IPK are now collaborating with SAP in the field of Secure Mobile Identification, one of the increasingly important challenges in information technology. FUTUR talked with Cafer Tosun, managing director of the SAP Innovation Center in Potsdam, about the center's mission and future.

FUTUR: Mr. Tosun, in early 2011 SAP announced the establishment of the SAP Innovation Center as the first of its kind globally, here in Potsdam. The new building is slated for opening in Q3 2013. What is so special about this new building?
Cafer Tosun: Working closely with Professor Kembel and his team at the d.school in Stanford, we put much effort into figuring out a design that would reflect both our working style and our projects. One of the key features is a combination of concentration and collaboration spaces, allowing our employees to focus and interact when the need arises. It is important for us to maintain such dynamics. Communication is another key aspect of successful collaboration in distributed teams. One of our staff members researched that topic in his dissertation. And our students have also evaluated it in a special project. In effect – we refer to this as a marketplace theory – we are going to set up a central venue for people to exchange their views. We are thinking about a central coffee corner.

FUTUR: How does this affect the architectural design?
Tosun: Flexibility is crucial. Concentration and collaboration spaces must be kept in balance. We have even gone so far as to use wheeled walls that can be moved and folded as required. The collaboration spaces are extremely transparent, as lots of glass has been incorporated into the design. The benefit is twofold – glass acts as a sound barrier, but still allows plenty of light into the collaboration and concentration spaces. The entire side of the building that faces Lake Jungfernsee is very open and bright. Sometimes we deal with small projects, sometimes with big ones; sometimes a whole bunch of people work together, sometimes it is just one individual – this is where the big challenge lies in terms of flexibility.

FUTUR: Who will be working there?
Tosun: We are planning for 100 full-time staff members plus 200 students working in multidisciplinary teams, according to Design Thinking principles. We treat students in exactly the same way as regular staff members. After all, as digital natives, they are not just tomorrow's users; they also build tomorrow's software. That makes them extremely important for us at SAP and for the entire software industry. Their communication structures are much more networked. Social media platforms like Facebook, Twitter & Co are a natural part of their daily lives.

FUTUR: Why did SAP choose Potsdam as the location for the Innovation Center?
Tosun: One of the region's many interesting facets is the scientific and academic landscape, with renowned research institutions like Fraunhofer, and its universities with over 140 000 students. There is also a growing number of thriving startups with whom we collaborate applying our in-memory technology platform SAP HANA. SAP HANA allows for new innovative solutions to analyze and process huge volumes of data at lightning speed. This is a breakthrough considering the ever-increasing amounts of data which are being produced in ever-shorter times. The global data volume roughly doubles every 18 months. The enormous amount of data that the Fraunhofer IPK reconstruction team will process with its

»Stasi-Schnipselmaschine« is just one example of an interesting application enabled by SAP HANA's in-memory technology.

FUTUR: In what other areas are you collaborating with Fraunhofer IPK?
Tosun: Secure Mobile Identity is one very exciting project. On our side, we are very interested in integrating joint developments into our own products. Mobility is a strategic topic for SAP. More and more tablets, smartphones, laptops, and ultrabooks are being purchased, while desktop sales are dwindling. It is a trend that can be seen across nearly all industries. Another project we are currently collaborating with the Charité hospital on is the »Oncolyzer«, which is a mobile application to help doctors and researchers identify the best therapy for cancer patients, directly at the patient's bedside. It also puts a special focus on security and data protection. Another challenge that really comes to the forefront with mobile applications is how to flexibly adapt security settings to any particular situation's needs. My kids, for instance, are crazy about the iPad. So when they want to work or play with it, it has to be both easy and secure. The same thing applies when doctors handle highly sensitive patient data. However, the security and data protection requirements are much higher in the latter case. In this context, we can greatly benefit from the results of our collaboration with Fraunhofer IPK.

FUTUR: Why do you partner with Fraunhofer?
Tosun: The answer to that is really simple: Fraunhofer is a well established research institute with an excellent reputation. And many of the results coming out of Fraunhofer are truly ground-breaking. Thus, a partnership creates synergies for both SAP and Fraunhofer, and these we want to use! We are already seeing these effects in our joint projects.

FUTUR: What made you leave Silicon Valley for Silicon Sanssouci?
Tosun: I lived and worked there for eight years. When I first moved to the US, I was fascinated by the enthusiasm and the spirit to seize new opportunities and start off to new horizons. Start-ups were mushrooming all over; people were developing business ideas and talking about the future of the internet. I can still remember an event back in 2002 when the theme of »social networks« cropped up. »LinkedIn« was new at that time and people would have long intense discussions about where the journey would lead, whether it would be accepted or what could be done with it. Now, I can very much sense the same kind of spirit here. For instance, we frequently meet with young entrepreneurs, develop ideas and try them out together. For me, it is extremely encouraging to see that a culture is taking root in Germany that allows things to be tried out – a culture that also pardons possible failure. I think that this growing mentality carries enormous potential. What we need more of is venture capital and an even greater readiness to take risks. At the moment, we are sitting in the same building as Hasso-Plattner-Ventures which look at and invest in promising start-ups. If we get more of that, we will be very well positioned in the region and in Germany as a whole. By the way, just like our colleagues in Palo Alto, we held a Start-up Forum on August 15th in Berlin. We want to work closely with the start-ups in the region and across Germany, and build a bridge to Silicon Valley by doing so. ■

Interview by Steffen Pospischil

Director of the SAP Innovation Center Cafer Tosun

Profile

Cafer Tosun, SVP, is head of the new SAP Innovation Center in Potsdam. He is also responsible for joint projects with the Hasso Plattner Institute in Potsdam. Tosun has been at SAP since 1993 and has held different development and consulting positions at the company in that time. He also worked at SAPLabs in Palo Alto, Silicon Valley for 8 years. He studied computer science and is a certified project manager at Stanford University.

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SAP

SAP Innovation Center – »Garage 2.0«

Think of a garage and you might think of things like cars, garden tools, stacks of firewood, or all kinds of old jumble. But in the IT industry the word »garage« conjures up a totally different set of associations – things like creativity innovation, pioneering spirit, and success. Even the big players in the industry like Apple, HP and SAP started out from humble beginnings – just a simple garage or in the case of SAP in 1972 a modest house in Weinheim.

Model of the new building for the SAP Innovation Center in Potsdam

▶ However, »back to the roots« would be an inadequate description of the first SAP Innovation Center's mission. Founded in Potsdam in 2011, it rather seeks to bring together the creativity and agility of a garage startup with the expertise and customer base of a world market leader in enterprise software. »Combine desirable, viable and feasible« is the mission – or in other words, anything that does not find its way to the customer is no innovation. This is why every project at the Innovation Center directly involves future users, from SAP and Non-SAP customers. Highly professional, mainly young, IT experts take the latest and most promising research trends in in-memory technology, cloud computing and mobility, and develop solutions with and for users. While close cooperation with research institutes like the Hasso Plattner Institute for Software Systems Engineering, the Fraunhofer-Gesellschaft, Berlin's universities, Stanford University and the Massachusetts Institute of Technology ensure that the projects remain pitched on the cutting edge of technology, customers like the Charité hospital and Bigpoint bring in their own specific know-how, and provide the grounding in local reality that's needed.

The SAP development department is also involved in project work from the very beginning. Once a prototype has been evolved in this way and put through its paces at the user (company), the baton is passed on to the colleagues at SAP development who transform it into a market-ready product.

The choice of the city of Potsdam in »Silicon Sanssouci« is part of the overall concept: its rich cluster of first class research institutions and companies, many within walking distance of one another, means that the projects of the new Innovation Center will find truly fertile ground here. Predefined processes and fixed development cycles with rigid deadlines are as foreign to the mantra as an aversion to taking on risky projects. Every project is different and that difference is recognized and respected, even if the outcome is uncertain. This would be called »artistic freedom« in the creative industry where the Innovation Center is already engaged in an on-going project with the Babelsberg Filmstudios.

Just by looking at the SAP Innovation Center's new building – whose groundbreaking ceremony was held in October 2011 – you can see that something totally new is taking shape. The future office building of the Innovation Center is being built on the grounds of a former barracks on the Campus Jungfernsee. When it's completed in 2013, the building will offer space for 100 fulltime employees and 200 students. It will not be fancy but inspirational and fostering creativity – the way a Garage 2.0 should! ■

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Ecuadorian Minister visits PTZ

On 15 October 2012, Prof. Uhlmann, executive director of Fraunhofer IPK, welcomed the Ecuadorian »Ministerio Coordinador de Talento Humano,« Augusto Espinosa, to the Production Technology Center (PTZ). In his address, Prof. Uhlmann informed the Minister about the opportunities offered by Fraunhofer IPK for innovation transfer abroad. Afterwards, Espinosa and his delegation were taken on a tour of the testing ground where the Minister himself operated the dry ice blaster and could see with his own eyes just how effective it was. At the following presentation of the Virtual Reality Cave, the Minister did not want to miss the opportunity to make his own trial run. In the Application Center for Microproduction Technology (AMP), the air-conditioning system was just one of the many things that excited keen interest: it can regulate the temperature of the ultra-precision laboratory with accuracy in the range of ± 0,2 °C. Prof. Uhlmann and Minister Espinosa both underscored their interest in collaborating together in the future.

A high ranking visitor from Ecuador: the Ministerio Coordinador de Talento Humano operates the dry ice blaster.

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A Guest from Costa Rica

Ambassador Chaverri Sievert at IPK

On 15 March 2012, H.E. José Joaquín Chaverri Sievert, Ambassador of the Republic of Costa Rica, visited Fraunhofer IPK. He was welcomed by Dr. Bertram Nickolay, head of the Security Technology department, who also arranged the visit. During his visit Chaverri Sievert was particularly interested in the innovative software solutions currently under development at IPK. These include the »ePuzzler« program for the virtual reconstruction of documents shredded by the Stasi, the security apparatus of the former GDR, and the »desCRY« und »Secure Mobile Identity (SMI)« projects. desCRY is a software for identification of child pornography on the internet. SMI enables secure authentication of the users of an enterprise company network via mobile end devices.

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Ambassador Chaverri Sievert (right) and Dr. Bertram Nickolay in the PTZ testing area

BentoBox tried, tested and proven

Prototype completes first test phase with flying colors

In cooperation with the logistics consultants LNC, Fraunhofer IPK has devised the »BentoBox«, an innovative solution for inner city logistics. This collection station for packets, packages and small parcels passed its first two month trial run in Berlin with flying colors: 85 percent of ourier delivery in the catchment area could be done by bicycles instead of vans. The BentoBox also enables bundling of delivery orders. And its docking station for six small containers helps to make urban logistics processes more sustainable and more efficient. It even withstood the rigors of the traditional stress test in the peak pre-Christmas period, and also gave excellent results in dealing with express and overnight deliveries. The BentoBox is targeted at both logistics providers and business and private end customers. At the moment it is being tested in Lyon, France, after which it will go to Turin, Italy.

One of Messenger Transport + Logistik's bicycle couriers demonstrates how the Bentobox is used.

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2. International Conference MRO

23 – 24 May 2013

In terms of products and goods with high investment costs and long lifecycles, MRO – maintenance, repair and overhaul – accounts for a large part of company expenditure. A product's lifecycle also includes unexpected repairs and not just regular schedulable maintenance, while an overhaul can not only restore a product to its original condition but also incorporate improvements that bring it into line with the latest technical and economic developments. MRO processes make a significant contribution to conserving resources and enhancing energy efficiency while at the same time bringing tangible economic benefits. The Conference offers an international cross-industry meeting point for all companies, suppliers and customers with a stake in MRO. Its objective is to reflect on current developments, to tap new potentials and to pave the way to a successful future. Leading speakers from industry and science will present innovative concepts and strategies in:

- Products: MRO-compliant construction
- Concepts: MRO processes and IT
- Technologies: Adaptive and flexible MRO solutions
- Condition Monitoring: Intelligent MRO systems.

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▶ 13th International Conference EUSPEN

27 – 31 May 2013

The 13th conference and exhibition of the European Society for Precision Engineering and Nanotechnology (euspen) will provide a leading forum for industrialists and academics alike to review the best of world-wide industrial innovation, progressive research and technology developments. It offers information on the latest precision and ultra-precision developments, reports and discussion on progress, and room for starting and continuing international cooperation between researchers and industrialists. Delegates will gain an insight of the precision engineering and nanotechnology priorities of Europe's leading industrial nation, Germany. With the country's high importance of energy generation and efficiency in mind the special session topic of the 13th euspen conference and exhibition will focus on precision engineering for the advancement of energy generation, renewable energy and energy efficient systems

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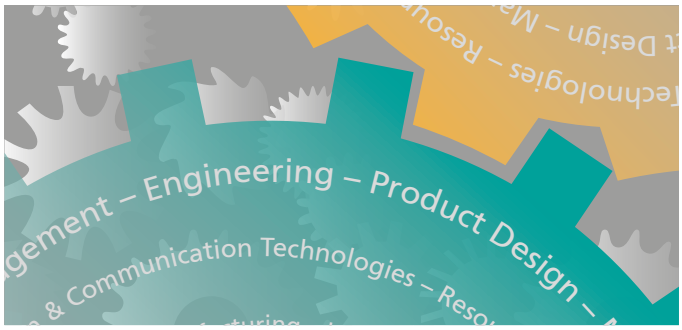
▶ PTK 2013 Effective Factories – Knowledge, Tools, Value Creation

25 – 26 September 2013



The competiveness of manufacturing industry is increasingly shaped by the efficient use of knowledge and tools. Knowledge and tools are key factors which determine value creation in production. Showing how important the close connections between knowledge, tools and added-value are in the design of efficient manufacturing plants is the goal of the Colloquium on Technical Production PTK 2013. How can we successfully develop and manufacture global and regional products in the future as well? What resources shall we need? How can we achieve sustainable value creation? Directly following the 11th Global Conference on Sustainable Manufacturing, experts from industry and science will be giving answers to such questions at PTK 2013. They will present new concepts for handling knowledge, together with the tools and methods that translate knowledge into added value, and they will also discuss scenarios for tomorrow's efficient factory. Apart from the talks during the plenary session, three further sessions focused on »Technology«, »Information Technology« and »Management and Organization« will explore the interactions of knowledge, tools and value creation from their respective perspectives. Furthermore, the Colloquium will also give you the opportunity to explore the Technical Production Center's testing area and gain insights into our extensive range of research and teaching programs, and to meet and exchange ideas with international players at the traditional Berlin evening.

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Profile

Production Technology Center PTZ Berlin

The Production Technology Center PTZ Berlin comprises of the Institute for Machine Tools and Factory Management IWF of the Technical University of Berlin and the Fraunhofer Institute for Production Systems and Design Technology IPK. The PTZ develops methods and technologies for management, product development, production processes, and design of industrial manufacturing plants. Furthermore, we also leverage our proven expertise to engineer novel applications in emerging fields such as security, transport and medical technology.

The PTZ is equally committed to making its own contributions to application-oriented basic research and to developing new technologies in close collaboration with industry. The PTZ works together with its industry partners to transform basic innovations born in research projects into fully functional applications.

With the methods and techniques we develop or improve, we offer our partners comprehensive end-to-end support from product development and fabrication through to product recycling. This also includes the conception of means of production and its integration in complex production facilities, and innovation of all corporate planning and controlling processes.

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