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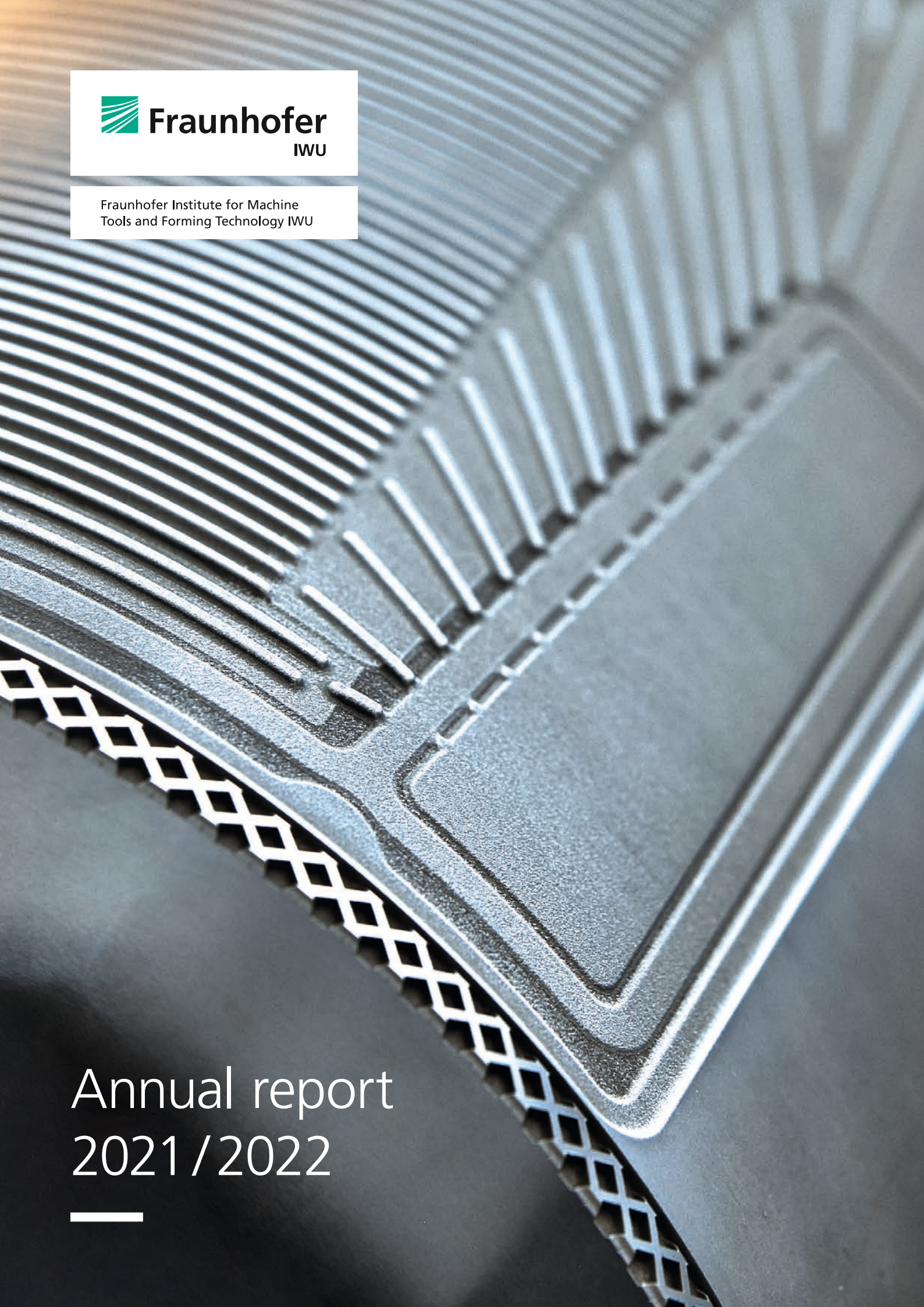
IWU

Fraunhofer Institute for Machine
Tools and Forming Technology IWU



Annual report 2021 / 2022

The Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft based in Germany is the world's leading applied research organization. Prioritizing key future-relevant technologies and commercializing its findings in business and industry, it plays a major role in the innovation process. A trailblazer and trendsetter in innovative developments and research excellence, it is helping shape our society and our future. Founded in 1949, the Fraunhofer-Gesellschaft currently operates 76 institutes and research units throughout Germany. Over 30,000 employees, predominantly scientists and engineers, work with an annual research budget of €2.9 billion. Fraunhofer generates €2.5 billion of this from contract research.

www.fraunhofer.de/en

Our lead projects and cooperative ventures in the Fraunhofer research network

Annual Report 2021/2022

Management Board (left to right):
Prof. Dr.-Ing. Martin Dix, Prof. Dr.-Ing.
Welf-Guntram Drossel (executive director) and
Prof. Dr.-Ing. Steffen Ihlenfeldt

Foreword

Dear Reader,

As a leading institute in resource-efficient production, we consider sustainability to be more than just a buzzword. Those who make the best possible use of available resources remain competitive in times of expensive raw materials. Those who also establish a closed-loop system for recyclable materials will continue to deliver. Last but not least, those who have well-trained and motivated employees can secure their business model in the long term.

At Fraunhofer IWU, we think the potential of digitization needs to be used to a greater extent. Automation and digitization, for example, enable highly qualified employees to work in a more creative and value-adding way. At the institute, for example, we are vigorously driving forward the intuitive programming of robots, whose use is thus becoming interesting even for tiny batch sizes. Additive manufacturing processes, which are also very efficient for small quantities, now make it possible to integrate functions into the component – in the same manufacturing step. In machining, we focus on intelligent, adaptive processes with as little need for post-control as possible and a minimum of additional rework for even greater efficiency.

In our view, there is no alternative to resource efficiency in manufacturing because there is no plan(et) B – and no technological solution that makes climate protection superfluous. However, there are processes and technologies for climate-neutral factory operation or sustainable mobility concepts. And it all starts with an energy supply based on renewable energies. Hydrogen will play a decisive role in this. That is why we are working in the Reference Factory.H2 to transfer essential hydrogen systems to industrial series production. In H2GO, the National Fuel Cell Production Action Plan, our role is coordinating the activities of 19 Fraunhofer institutes. H2GO will accelerate the development and rollout of industrial technologies for the cost-efficient production of fuel cells for load mobility. In the upcoming Hydrogen Lab Görlitz (HLG), we will develop innovative solutions for large-scale industrial hydrogen technologies in the stationary sector. In all three projects, we are pursuing a very similar thrust: making companies of all sizes and from all industries the attractive offer of becoming part of the hydrogen value-adding community and thus building up a sustainable, extensive, and future-proof business field. We are also part of the partner network of the Hydrogen and Mobility Innovation Center (HIC) Chemnitz, one of four locations of the national innovation and technology center for hydrogen technologies.

For 31 years, we have been one of the drivers of application-oriented research in production. In 1991, Fraunhofer IWU started with just 37 employees at the Chemnitz site. In the meantime, we take pride in a team of almost 700 IWU employees at five locations. At the end of September 2022, we looked back on more than 30 years of IWU in a ceremony and gave an outlook with great enthusiasm. The solution to future challenges will require production technology, and we at Fraunhofer IWU will continue to make substantial contributions.

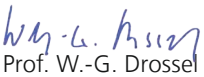
To be powerfully positioned for the future, we have already redefined our scientific areas in 2021. The business units located there focus on overarching research issues and pool the comprehensive expertise of our scientists. On the following pages, our business units present their key topics and provide insights and an outlook on trends, meaning trends we are driving forward and actively shaping with our production technology research.

Dear project partners, funding agencies, and project sponsors,

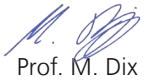
Dear employees,

It is time to say a big thank you for all the joint efforts in the past year, especially for bringing innovations in production technology to application in so many projects. Although the Corona pandemic continued to dominate our professional and private lives for long periods in 2021/2022, we were able to master the past year very successfully, thanks to the commitment of all of you. Our positive annual balance 2021/2022 and over 30 years of Fraunhofer IWU are shared successes!

Yours sincerely



Prof. W.-G. Drossel



Prof. M. Dix

Prof. St. Ihlenfeldt

Table of contents

About us

Profile

Identify trends. Driving innovation. Strengthen industry. The Fraunhofer Institute for Machine Tools and Forming Technology IWU is a driver for innovations in the research and development of production engineering. Around 670 highly qualified employees work at our locations in Chemnitz, Dresden, Leipzig, Wolfsburg, and Zittau. We open up the potential for competitive manufacturing in automotive and mechanical engineering, aerospace technology, medical engineering, electrical engineering, and precision and microengineering. We focus on scientific developments and contract research regarding components, processes, methods, and the associated complex machine systems and their interaction with humans – the entire factory.

As the leading institute for resource-efficient manufacturing, we bank on highly flexible, scalable cognitive production systems using nature as an example. We consider the entire process chain using regenerative systems and circular economy in this context. We develop technologies and intelligent production plants and optimize forming, cutting, and joining manufacturing steps. Our range of services includes the development of innovative lightweight structures and technologies for processing new materials, functional transfer to assembly groups, and the latest technologies of additive manufacturing (3D printing). We present approaches for large-scale production of essential hydrogen systems, thus contributing to the transition to renewable energies.

Our researchers rethink the factory of the future holistically to combine maximum added value and minimum use of resources: highly flexible and adaptive production scalable by the number of pieces, based on renewable energies. We demonstrate how digital planning processes and simulations allow for a particularly efficient factory design. We develop high-performance processes for highly flexible energy and load management to employ renewable energies effectively. Our Reference Factory.H2, with real plants and digital twins, offers numerous possibilities to enterprises of all sizes to contribute their competencies or to profit from customized processes and services to efficiently produce essential hydrogen components. Our applied research offers our partners measurable added value for their competitiveness. Manufacturing enterprises of all industries and sizes may rely on our innovative strength and over 30 years of expertise in optimizing production systems. Together with our partners, we are working on future production systems.

Advantage for companies

Organization chart

Directors

Prof. Dr. Welf-Guntram Drossel, Executive Director
Prof. Dr. Steffen Ihlenfeldt, Director
Prof. Dr. Martin Dix, Director

Scientific fields

Functional Integration and Systems Integration

Prof. Dr. Welf-Guntram Drossel

Production Systems and Factory Automation

Prof. Dr. Steffen Ihlenfeldt

Process Technology

Prof. Dr. Martin Dix

Business units

Symbiotic Mechatronics
Holger Kunze

Lightweight Design, Textile Technologies, Circular Economy
Prof. Dr. Lothar Kroll
Dr. Thomas Hipke

Adaptive Process Chains
Dr. Wolfgang Zorn

Task Force Hydrogen@IWU
Dr. Ulrike Beyer

Cognitive Production
Dr. Simon Harst

Climate-Neutral Factory Operation
Mark Richter

Agile Production Machines and Systems
Dr. Marcel Todtermuschke

Task Force Space Technology
Dr. André Seidel

Process Digitalization and Manufacturing Automation
Dr. Philipp Klimant

Cutting Technology and Surface Design
Carsten Hochmuth

Forming Technology
Prof. Dr. Verena Kräusel

Research Management and Communication
Angela Göschel

Services
Heiko Riede

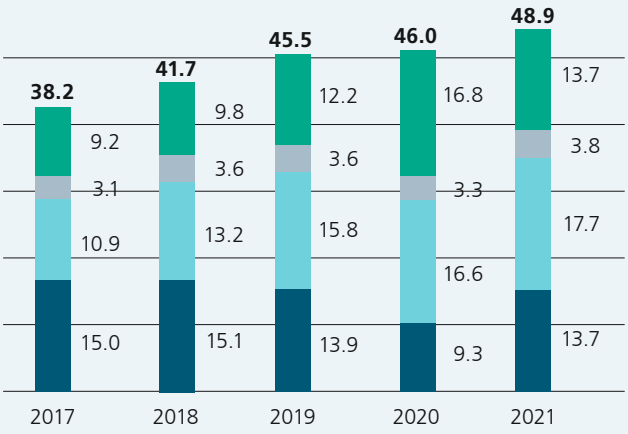
The Institute in figures

Employees

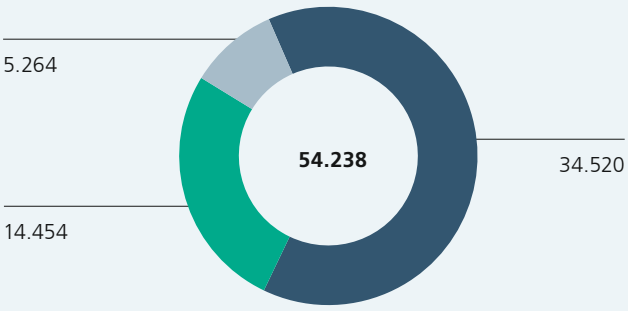
At the end of 2021, 658 people were employeed at the Institute, thereof 467 scientific, technical, and administrative employees, and 191 students..

Economic evolution

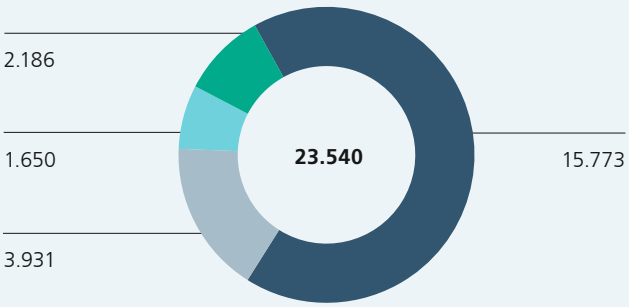
Operating budget in € million



Financial volume by budget in € million



Public project revenues in € million



Advisory board

Chairman
Prof. Hubert Waltl, FAWA Invest & Consulting GmbH

Members

- Dr. Stephan Arnold, ebm-papst Mulfingen GmbH & Co. KG
- Dr. Stefan Breu, Starrag Group Holding AG
- Dr. Carsten Czenkusch, Vitesco Technologies GmbH
- Dr. Gyula de Meleghy, Meleghy Automotive GmbH & Co. KG
- Dr. Basel Fardi, Intenta GmbH
- Andreas Friedrich, Daimler AG
- Walter Fust, Starrag Group Holding AG
- Dr. Babett Gläser, Saxon State Ministry of Science and Art
- Ulrich Grethe, Salzgitter AG
- Prof. Jochem Heizmann, Jochem Heizmann Consulting
- Hans-Peter Kemser, BMW AG
- Prof. Claudia Langowsky, German Automotive Industry VDA
- Klaus Linnig, Europäische Forschungsgesellschaft für Blechverarbeitung e.V.
- Klaus Löffler, Precitec GmbH & Co. KG
- Prof. Hans J. Naumann, NILES-SIMMONS Industrieanlagen GmbH
- Maria Piechnick, Wandelbots GmbH
- Gerd Rupp, Porsche Leipzig GmbH
- Dr. Christian Vollmer, Volkswagen Aktiengesellschaft
- Prof. Konrad Wegener, Eidgenössische Technische Hochschule
- Susanne Witt, METROM Mechatronische Maschinen GmbH
- MinR Christoph Zimmer-Conrad, Saxon State Ministry of Economy, Labour and Transport

Locations

Competence areas

Business units

Symbiotic mechatronics

Inspired by nature, designed for people
In our new Symbiotic Mechatronics business area, we are working on the technical prerequisites for a metaverse. We strive to make the interplay between electronics and mechanics more usable for people so that the real and virtual worlds can merge. Actuators and sensors remain key, notably for integrating mechanical feedback into software solutions such as virtual reality glasses. Nature often serves as a model for solutions that adapt technology to human needs.

We want to be able to integrate technical systems inspired by nature even better. With this in mind, we have combined medical technology, soft robotics, and shape-changing surfaces in the Biomechatronics department. An example: Today's robotics consists primarily of rigid limbs and defined joints. A fact that limits its usability, especially in tasks that require direct and safe contact with humans, such as in everyday life and care. With (jointless) continuum robotics, innovative structural concepts specifically applied sensor technology, and rethought motion mechanisms, we aim to close the gap between high-performance but potentially dangerous industrial robotics and safe but low-performance soft robotics.

Need another example? Because we see great potential in metal-based 3D printing processes, particularly when it comes to function integration, we have incorporated LBPF (laser powder bed fusion) into our business area.

By exploiting the geometric design freedom inherent in the process and the possibility of actuator/sensor integration, it is possible to manufacture new generations of products with unprecedented functions.

Regarding functional materials, we will fully exploit the potential of shape memory alloys (SMA). Our focus is on the determination of characteristic values. We also concentrate on the design, simulation, and enabling of series production of SMA systems, especially in semi-finished product conditioning, component manufacture, and automation.

In technical acoustics, we support the automotive industry on its way to electromobility. The focus here is on transmissions, electric drives, and control of these drives. Electric vehicles are significantly quieter than combustion engines. However, in the absence of the combustion engine as a masking (overlaying) source of noise, high-frequency sounds like whistling are even more unpleasant.

Our contribution to the transition to renewable energies in the field of acoustics is to reduce noise emissions from transformers, reactors, and wind turbines.

Safe and powerful robotics with programmable materials

Our services

- Shape memory technology
  - Characterization and determination of characteristic values of SMA semi-finished products
  - Simulation, design and construction of SMA systems
  - SMA sensor technology for large strains
  - Control and regulation of SMA actuator systems
  - Manufacturing and production technology for SMA products
  - MEMS integration of actuator and sensor systems
- Laser Powder Bed Fusion
  - Processing/qualification of new materials for the process
  - Special exposure strategies
  - Prozess modeling
  - Sustainability (material cycle in the process)
  - Heat exchanger structures
  - Surface finishing
  - Functional integration
- Biomechatronics
  - Human-oriented robotics/soft robotics
  - Wearables
  - Bio-inspired structures and substitute materials (fungi)
  - Multi-material printing
  - Sustainable medical technology
  - Smart instruments
- Technical acoustics
  - Acoustics of (hybrid) electric drive systems as well as of vehicles and components
  - Reduction of noise emissions from transformers, reactors and wind turbines
  - Acoustic quality assurance in production
  - Sustainable sound absorbers

Highlight from our research

3D printing for food and pharmaceutical industry equipment

Additively manufactured metal components often require (time)consuming post-processing, for example, if the surface quality must be outstanding for hygienic reasons. Plants in the food and pharmaceutical industries are typical cases. Our solution: HygAM. For tubes, we rely on a combination of surface structuring and finishing to apply bulges or dimples to the inner tube geometry and then finish them only briefly. Both lead to turbulence in the tube, which supports cleaning flushing.

Manager

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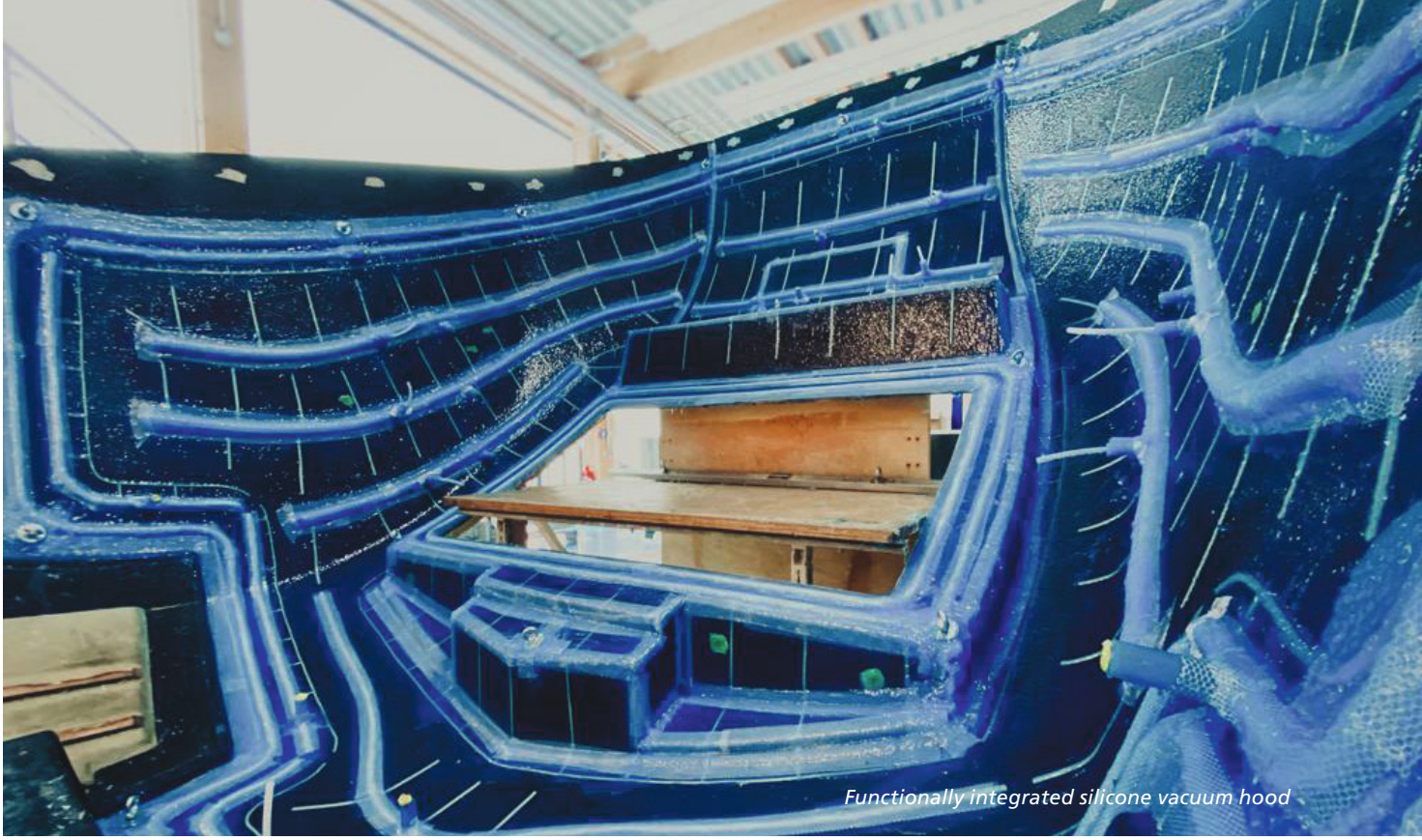


Functionally integrated silicone vacuum hood

Lightweight construction, textile technologies and circular economy

Do we want to carry on like that, wasting material and using resources inefficiently? At Fraunhofer IWU, we believe that we can no longer afford to do so. And not only because of the climate and the environment but also for economic reasons. Scarce resources and components are increasingly becoming a bottleneck for value creation, the foundation of our prosperity. That is why we should manage our resources better instead of using them only once.

Why not use the sheet metal of a car roof twice? Why not shred thermoplastics and reprocess them into new components using a super-fast 3D printer? How can a car battery be disassembled efficiently and as automatically as possible so that the bulk of its parts will be reusable? We are addressing these questions in a business area in which we are combining lightweight construction and textile technologies with the circular economy. Whether in smaller bilateral ventures or large publicly funded projects: Our ambition is to develop more sustainable solutions than before. Many paths lead to efficiency and sustainability. We help you do it.

Considering lightweight construction, we rely on our years of expertise to find better solutions for our customers. Whether with carbon, glass, or aramid fibers, with metallic foams or in a metal/plastic mix: We always privilege the optimum lightweight solution for our customers instead of committing ourselves to a specific material. We use state-of-the-art development approaches such as topology optimization and bionics. We conduct research into new materials and efficient technologies for processing them. All in the spirit of sustainability. Because lightweight construction always contributes to resource conservation.

Our services

- Towpreg technologies and applications
- SEAM – the world's fastest 3D printer
- Plastic 3D printing, technologies and application development
- Open and closed pore metal foams
- Radius pultrusion of fiber and hybrid components
- Battery development including lightweighting, thermal management and recycling strategies
- Novel vacuum resin infusion processes
- Efficient processing of natural fiber components
- Disassembly and recycling of fuel cells

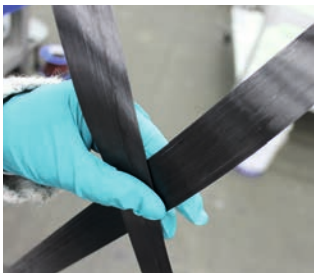
Highlight from our research

More economical series production of composite components

Large-scale production of composite components involves numerous process steps such as material preparation, impregnation, consolidation, cutting, shaping, and finishing. Thanks to the use of pre-impregnated semi-finished products such as prepregs or towpregs, an impregnation step is no longer needed, which means that process times and costs drop significantly.

Most towpregs consist mainly of reinforcing fibers impregnated in epoxy resin-based B-stage systems. These semi-finished products wound onto release film have a tacky surface; in lay-up lines, they stick to conveyor or clamping elements during the material feed, making series application in these areas virtually impossible.

We have developed pre-impregnated carbon fiber rovings with a completely tack-free surface to pave the way for the manufacture of a thrust field designed to meet the load path. In the first step, these are processed into a CFRP stack and then pressed to form the final composite part.



Manager

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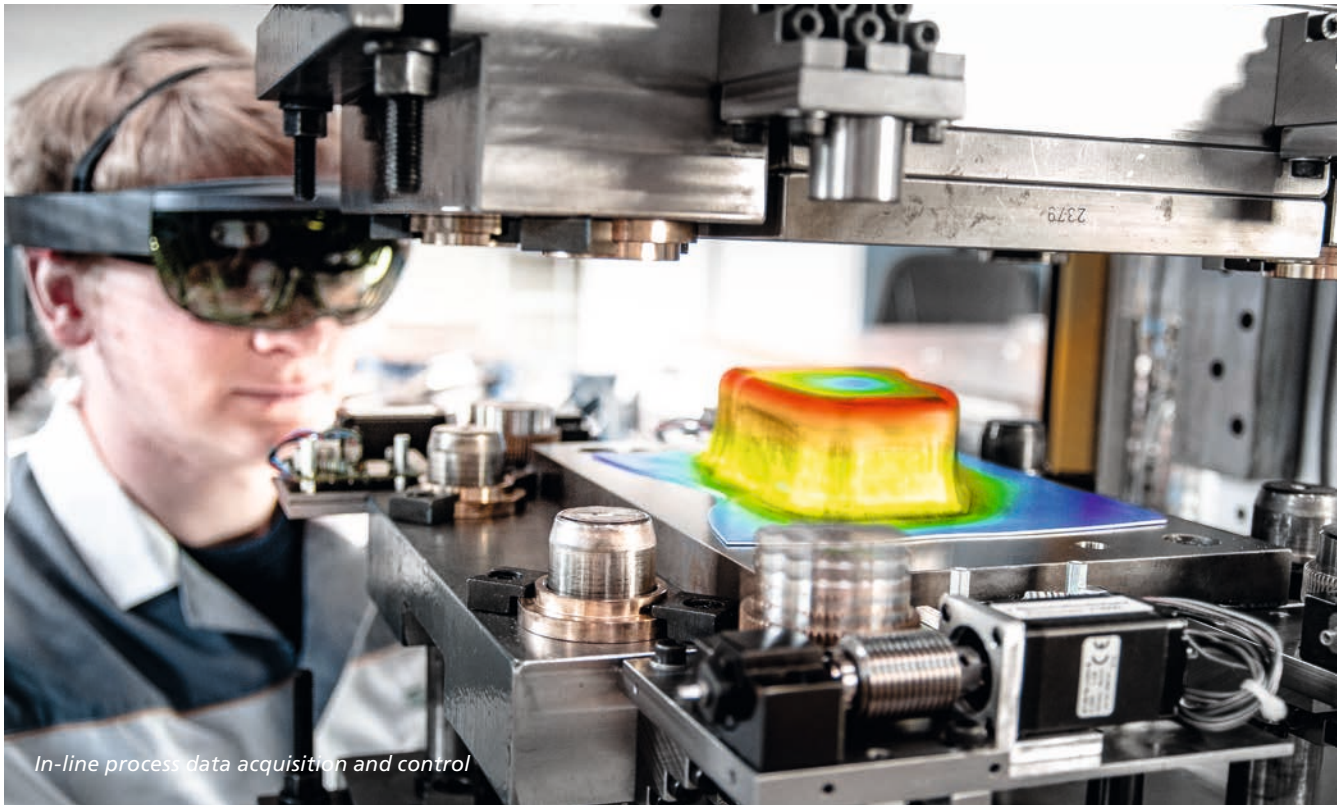
Adaptive process chains



In-line process data acquisition and control

The breakthrough of electromobility is inconceivable without adjustments to vehicle architectures: The necessary integration of battery modules leads to new requirements that directly influence vehicle design.

On the other hand, previously required components are no longer needed. Both aspects pose new challenges to assembly technology and tolerance management. Individualized products require flexible production facilities quickly adjustable to product modifications; near-shoring and re-shoring will question existing supplier relationships. These tendencies will also require greater flexibility in the manufacture of products. At the same time, the trend towards outsourcing production to nearby countries or relocating production back to these countries will require higher productivity and efficiency. In addition, there are new materials and increasing demand for more complex products.

These trends make it essential to develop and implement new approaches to quality assurance.

Awareness of our planet's limited resources is also increasing within the industry, which is looking more and more closely at how it can produce sustainably. To this end, various strategies have become known in recent years. For production technology, two approaches are particularly relevant: greater efficiency through better utilization of available resources, and greater consistency when it comes to the recyclability of products. Concerning the role of people in production, ergonomics at the workplace and health aspects will gain importance, and as a result, the degree of automation will increase even further.

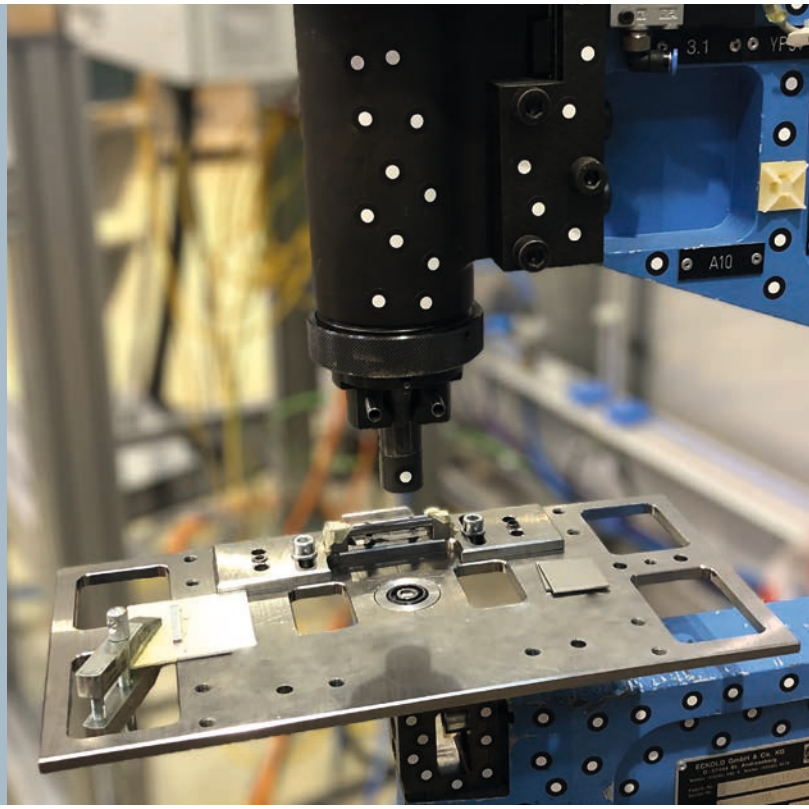
In our business unit, we focus on developing flexible methods and technologies for adaptable zero-defect production of recyclable products. In addition to mastering reconfigurable process chains and the ability to predict product qualities early on, this also includes process-integrated optimization concerning the intended function and product performance. In addition, detachable joints and the processing of biological materials are reaching the scientific spotlight.

Highlight from our research

Which is the influence of joining systems on the joining result?

If the general conditions remain the same, the tool kinematics, moving masses, and system stiffness kinematics resulting from the plant characteristics can influence the joining. Consequently, the transferability of process parameters from one plant system to another is only possible to a limited extent.

In a research project, we analyzed how joining systems influence the forming and load-bearing capacity of mechanical joints. The influence of the plant systems was determined using metrological analyses and numerical simulation. On this basis, we developed models for the transferability of process results for different plant systems.



Our services

- Analysis and control of process chains, with a focus on:
  - Development of methods for forecasting and optimization of process quality and product performance
  - Control of distributed systems under consideration of different optimization criteria
  - Mathematical methods for data reduction and analysis of heterogeneous databases
- Thermal, mechanical, and hybrid joining and bonding technologies as well as detachable and functionalized joints, in particular
  - Process development
  - Process simulation
  - Prognosis and assistance systems
- Flexible manufacturing and (dis)assembly systems
- Processing of biocompatible and functional materials

Manager

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Cognitive production systems

How to deal with increasing complexity in industrial value creation? The challenges posed by entangled supply chains and changing framework conditions make it increasingly impossible to foresee all eventualities and define rigid processes. For production technology, this means: It must be able to adapt to different situations and objectives in an agile and resilient manner.

That is precisely where cognitive production comes in. In human terms, cognition refers to all processes that relate to the absorption, processing, and storage of information. Humans can take in stimuli from outside, process them, and convert them into knowledge or action. In production, cognitive-technical systems can process digital information from sensor data and networks, derive conclusions and execute actions.

Specifically, we enable companies, for example, to transfer information from production processes to the digital twin and interpret it to conclude necessary adjustments. Digitization is of central importance to cognition: We are creating planning and control solutions that know both the historical and current status of production plants, evaluate them and optimize them using appropriate algorithms. The actions derived from the decision-making process require implementation – this is what we are researching and working on, for example, in control technology and robotics. Humans continue to be a central factor of production. The aim is to combine the capabilities of cognitive technical systems with those of humans: for efficiency in value creation. Today and in the future. Such systems are a decisive factor for Germany's competitiveness in technology.

Test scenario for the digital twin

Credit: Industrie Partner GmbH, photographer Martin Förster

Our services

- Digital twins, incl. interfaces and data models, for production processes and process chains
- Hybrid process models, combination of physical and AI-based methods
- New approaches in technical cognition through high-performance computing systems (like quantum computing)
- Control solutions and systemic automation for cognitive production
- Flexible, capability-based controls for modular machine and plant systems
- Virtual commissioning of control systems using physical digital twins with domain-spanning model extensions
- Establishment of semantic interoperability through OPC UA and Industry 4.0 management shell
- Knowledge modeling for the detection of causal relationships and derivation of action strategies
- Optimization methods for planning and execution of complex process flows

Highlight from our research

Robo Operator® – Independent, mobile, and flexible automation solution for machine tools

When skilled workers are on sick leave, machine tools often come to a standstill at medium-sized companies. With the Robo Operator®, manual operator tasks are flexibly automated and made available in a mobile robot cell near machine tools – without any time-consuming and cost-intensive retrofitting.

The Robo Operator® operates the switches and doors of the machine tool independently and can react flexibly to changing requirements by using camera information.

Video of Robo Operator®

Manager

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Climate-neutral factory operation

Fraunhofer IWU has been working on energy and resource efficiency for around 15 years. In this respect, our business area pursues a topic that is not entirely new but continues logically many years of research and development work in this field.

With all issues addressed since 2008 and all solutions developed since then, we have been pursuing the claim of "climate-neutral factory operation." Climate change and current developments affecting our energy supply are forcing our business community to move to secure and sustainable energy as quickly as possible. Often larger companies are better equipped for this task than small or medium-sized businesses. We see it as our mission to help all companies achieve sustainable factory operations as quickly as possible. And there are many approaches to this. We should always begin with the unused efficiency potential – which still exists in many places. Increased use of decentrally generated renewable energies in combination with energy storage systems and converters is indispensable. Integrating hydrogen-based energy supply components into existing energy infrastructures will gain further importance.

We are already working on all these topics in different projects. For example, "ESiP – Energy Storage in Production" was launched this year. ESiP involves the development of a design tool for energy storage systems at various distribution levels in factories. With the "Clean Energy City" investment project, we are tackling the development of a hydrogen infrastructure at Fraunhofer IWU. Our development goal is the integration and operational management of electrolyzers and fuel cell systems for the energy supply of factories. Accordingly, we are working on the future topic of the "DC factory" – a factory that operates without exception with direct current. In short: We are working on the factory of the future.

Demonstrator for energy-flexible factory operation

Our services

- Efficiency first
  - Identification of efficiency potentials and derivation of measures to increase energy efficiency
- Life cycle assessments
  - for products and production areas in selected ecological effects or on specific life cycle phases
- Active energy management
  - Control/regulation of all energy flows across all energy sources to optimize energy costs (external procurement/ own generation) and use of energy flexibility
- Closed loops
  - Concepts for energy storage/recirculation/-conversion (also green hydrogen)
- Production/building infrastructure
  - Linking with intralogistics and production technology/ -systems
- Regenerative energies
  - Decentralized generation/use for energy supply of factories
- Digital energetic twins
  - at component, machine, plant and factory level as a basis for energy optimization in planning and operation
- Energy flow based design methodology
  - for resource efficient machine tools/machining centers
- Resource-efficient process design
  - like energy-optimized robot path planning
- Energy-optimized drive concepts
  - for hydraulic forming machines with electric servo drives

Highlight from our research

ESiP – Energy Storage in Production

The ESiP project aims to increase the use of energy storage systems in various distribution levels of factories to reduce peak loads, recover braking energy, increase supply stability, optimize in-house production of energy and trade on energy markets.

Key points are developing a design tool for energy storage systems of different technologies, optimizing the operational management of coupled energy and power storage systems, and constructing a demonstrator.

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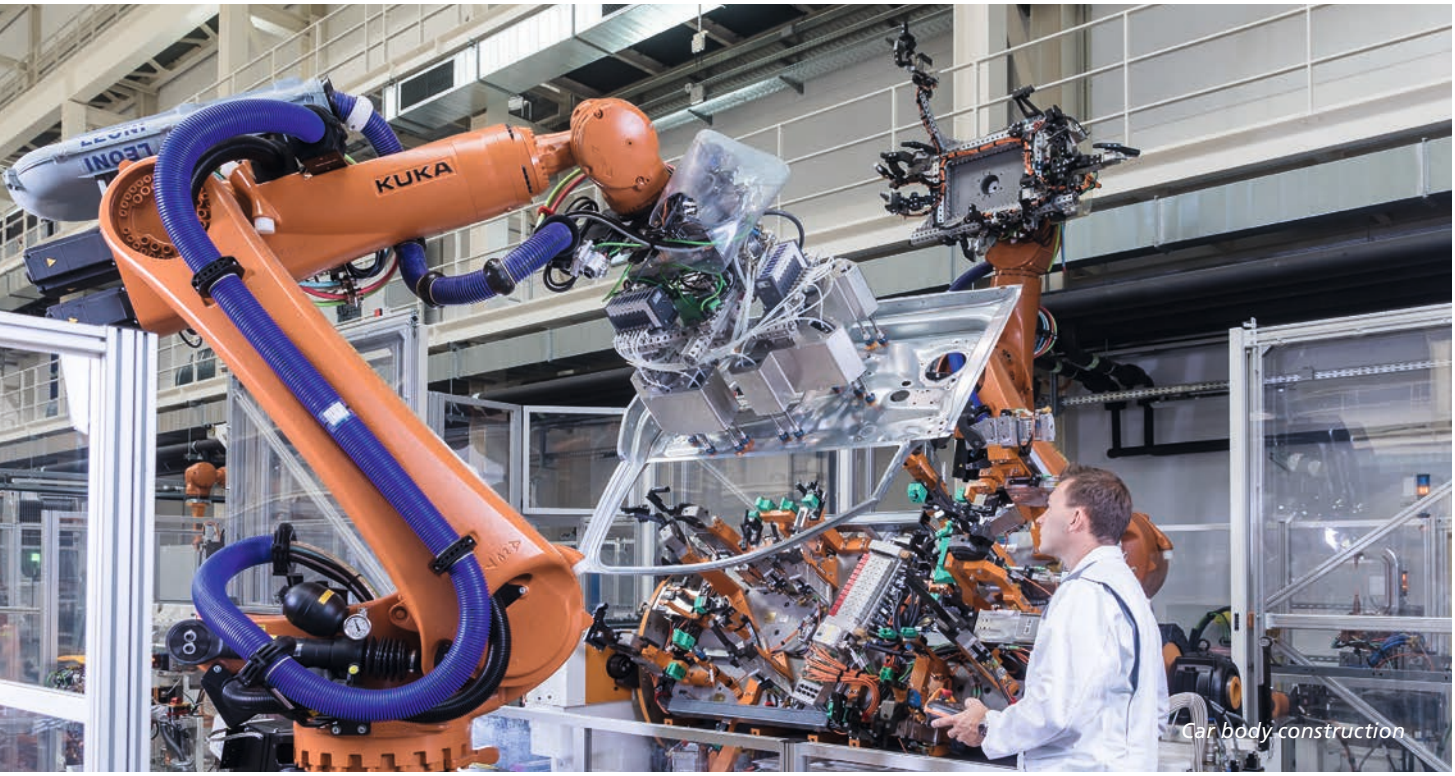
Agile production machines



Car body construction

Production systems, technological processes, organizations, and people are described as agile if they can react to new events and requirements, which can be predicted only to a limited extent, at short notice, and adapt accordingly. Ideally, they can do so immediately and autonomously. This way, agility is also a prerequisite for resilience. Among developments that require agile reaction methods are in particular:

- new market requirements – product diversity and shorter product life cycles,
- general effects of globalization (with all its advantages and disadvantages), notably on supply chains and sales markets,
- ever-increasing digitization,
- all urgently needed sustainability efforts to curb the waste of resources and limit climate change

On the one hand, in agile production systems, all levels of the automation pyramid must be considered, from the tiniest sensor/actuator in a machine via the control of the machine up to integration at the enterprise level.

The selection of the best level of automation, both economically and from a long-term point of view, plays a decisive role here. On the other hand, full automation is not a goal or a panacea of agile production systems. The reason is that humans – whether for their experience or due to their diverse cognitive abilities – make the difference between the shortest possible return on investment (ROI) and efficient, sustainable, and robust – in a nutshell: agile – production.

Agile production systems fit in all industries – with a focus on the automotive and aerospace sectors – but also in the skilled trades. One requirement is considering different, primarily value-adding technologies and secondary processes such as handling, adjustment, and control. It takes adaptive machine components, novel control concepts, and innovative planning methods to master this complexity from planning and commissioning to safe, quality-controlled operation.

Highlight from our research

smartNOTCH – Transparency in the forming process

Whether tool tryouts, process start-ups, or error cause analyses: Transparency in the production process is the basis for efficient production and high workpiece quality. A flexible measuring system such as the smartNOTCH developed at Fraunhofer IWU helps to detect errors at an early stage and prevent costly machine downtime.

smartNOTCH is easy to integrate into the T-slots of the press table and slide. Its operation is robust. It records trends and changes in the forming process and captures the elastic machine reaction. The measuring system responds particularly sensitively – an ideal supplement to existing monitoring systems.

Our services

- Structural concepts for agile machine tools
- Intelligent sensory and actuator machine tool components
- Intrinsic process data acquisition and processing
- Smart maintenance for data-based prediction of maintenance intervals
- Property analysis and digital twins
- Intelligent, AI-based robot end effector allowing for decentralized response to process variations
- Flexible, efficient, and clever operating equipment, like grippers, fixtures and joining tools
- Intuitive and multimodal robot programming – using gestures and speech, and without classic command line programming (no-code programming)
- Planning methods/assistance software for the design of conventional and adaptive equipment/robot cells
- Autonomous assembly: robot system realizes autonomous assembly tasks based on product data
- Safe, efficient teaming in the production process between humans and intelligent (AI-based) machine systems

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Automated quality assurance with the software framework XEIDANA®

Process digitalization and manufacturing automation

The business unit combines the institute's expertise in automation, control technology, artificial intelligence, and visualization technologies in the interaction between man and machine.

Automation and control technology
Combined with application-specific motion kinematics (meaning: linear, rotary, parallel, robotics), we automate, among other things, the quality monitoring of components utilizing inline inspection and integrate it into the production line without any losses in cycle time or rejection. In addition to commercially available control systems, the software framework XEIDANA® (eXtensible Environment for Industrial Data ANAlysis) is used as the core technology. Among other things, XEIDANA® compares the target state of a component stored in an image database with the actual parts produced. Thereby it detects defects and enables 100 percent inspection of components.

Gathering data and drawing the correct conclusions: Data mining and artificial intelligence
How is a machine or system doing? What is the quality level of the produced component? Answers to such questions lie in process data. Artificial intelligence makes it possible to process the considerable amounts of data that accumulate and make them usable. Condition monitoring or predictive maintenance are options for use cases. If wear is foreseeable, data allow for determining the best moment for maintenance – to avoid waste (replacing tools too early) and quality defects (caused by excessive wear).

User-specific visualization makes complexity manageable: Virtual and Augmented Reality (VR / AR)
VR and AR are relevant technologies for visualizing complex issues and optimizing communication between people. AR, for example, enables visualizing relevant information in 3D to the user at the place of operation. To ensure the best possible implementation of our VR and AR projects, we cooperate with Technische Universität Chemnitz.

Highlight from our research

HZwo Initiative: Cost-efficient and reliable measurement and control concept for automotive fuel cell systems

In Project EcoCC, we are developing an economical and reliable measurement and control concept for low-temperature PEM fuel cells in automotive applications. The goal is to improve the efficiency and robustness of these systems against external disturbances. For this purpose, we developed a model simulating the fuel cell stack in MATLAB/Simulink and verified it using real measured data. The model is a tool to perform sensitivity analyses for the process parameters to be monitored.

Our services

- Industrial inspection systems
  - Inline inspection systems
  - 100 percent detection of surface anomalies and geometry deviations
  - Completeness and position control
- Cognitive systems
  - (Worker) assistance systems
  - Robot vision
  - Face recognition
- Predictive maintenance
- Big data analysis
- Machine learning for quality prediction
- AI-based, situation-dependent control of process parameters
- Heuristic optimization methods in production
- Virtual and augmented reality
- Control and regulation technology
  - NC, MC, PLC controls
- CAM systems
  - Post-processors (like 3D printing, free-form bending, and forging)
- Maintenance and servicing tools for production machines

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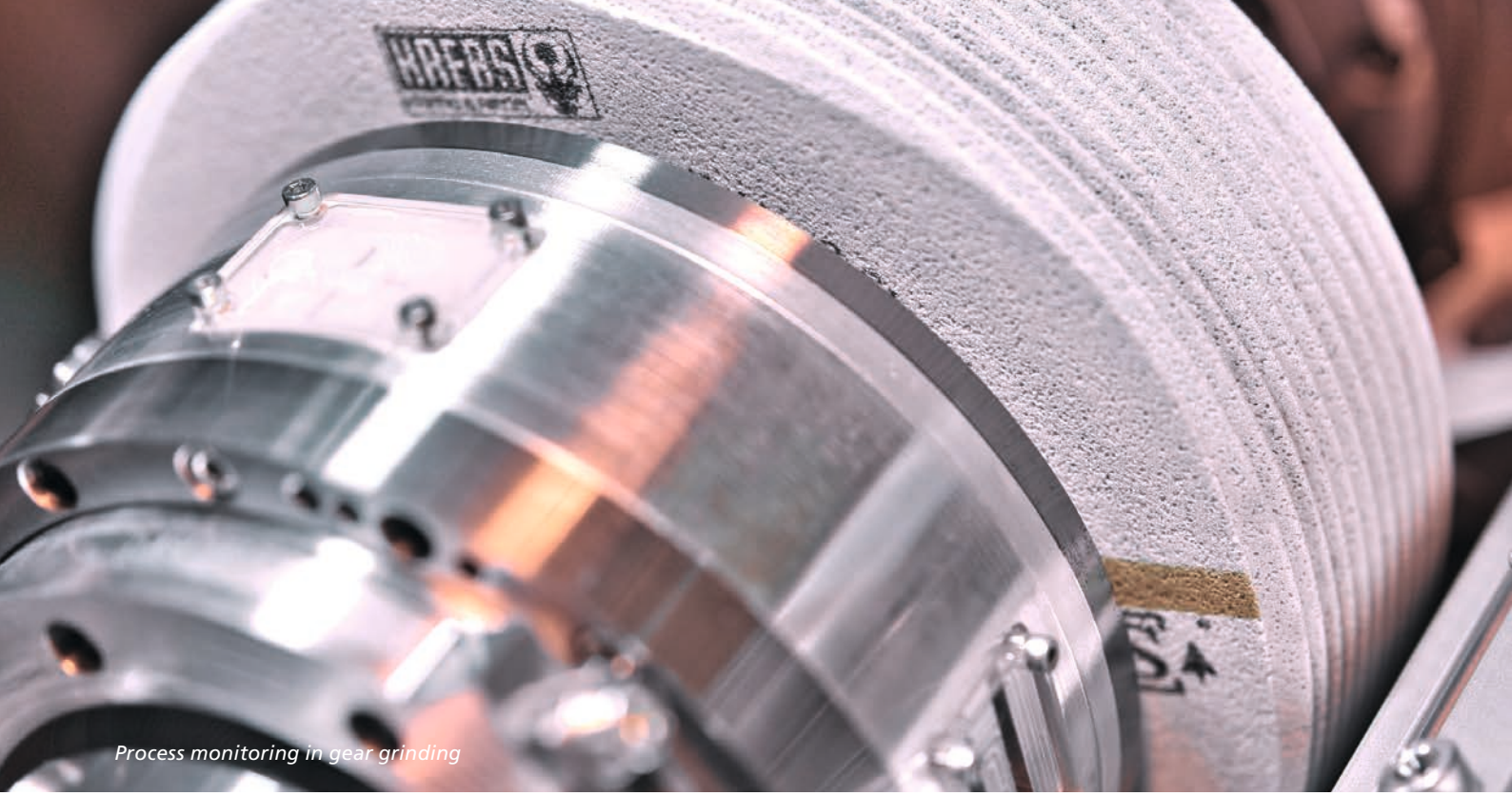

Process monitoring in gear grinding

Cutting technology and surface design

Holistic, production-oriented components and process chains

How can manufacturing technology in cutting and ablative machining processes be further developed. Our cutting technology and surface design business unit is all about this question. Priorities of this business unit are quality, productivity, and competitiveness, followed by resource and energy efficiency for ecologically sustainable production. Our research focuses on developing processes and process chains, particularly in mobility and transportation, production systems, and medical technology. To this end, we cooperate with automotive and aircraft manufacturers, and their suppliers, on environmentally friendly mobility concepts of the future. Relevant research areas are the development and (process) design of weight- and function-optimized powertrain components, medical technology components, and tool and mold-making. We respond to the trend towards increased power density and quality requirements, miniaturization, and functional integration by means of holistic, production-oriented component design and process chain development.

The machining technology department specializes in machining processes with geometrically defined and undefined cutting edges.

In addition to process modeling and simulation, our portfolio comprises experimental investigations, feasibility studies, prototype production, and implementing the developed processes in series production.

Our department for functional surfaces and microfabrication focuses on the simulation, manufacturing, and evaluation of functional surfaces. It develops ablative processes, above all laser-based machining and electrochemical machining, in combination with micro-machining.

Our researchers investigate in resilient, though flexible, production technology. In this understanding, digitization means developing intelligent, adaptive processes and algorithms, including innovative tools using sensor-actuator systems and machine components. On this basis, we can accelerate the commissioning of new processes, reduce safety factors in production, shift process boundaries, minimize downstream measurement and testing efforts, and ultimately significantly improve manufacturing efficiency.

Our services

- High-performance machining
  - Machining of new, high-strength materials and wear-resistant coatings
  - Development of hybrid processes through the use of media and motion superpositions
- Grinding and honing technologies
  - In-process evaluation of component and tool conditions based on novel sensor and intelligent evaluation technologies
  - Mold honing using adaptronics
  - Surface design by finishing and smooth rolling
- Development of adaptive machining strategies
  - Design and implementation of strategies for process monitoring, process control, and process management
  - Integration of AI/ML techniques
- Gear cutting technology
  - Development of technologies, tools, and machine components
  - Modeling and simulation of hob peeling as well as hob and profile grinding
- Functional surfaces
  - Simulation, manufacturing, and evaluation of functional surface structures, in particular for tribological applications and the reduction of contact resistances of electrical systems
- Micromanufacturing
  - Process development for laser machining, electro-chemical machining and spark erosion in combination with micro-machining and micro-forming
  - Development of process chains for diagnostic microfluidic systems, microstructured components, and tool and mold making

Highlight from our research

Technologies for future-proof point-of-care diagnostics

Point-of-care (PoC) diagnostics aims at decentralized on-site analytics that can also be applied outside of a laboratory infrastructure and can save time, especially when decisions need to be made immediately or in the case of (life-sustaining) measures. Interdisciplinary collaboration between diagnostics and production engineering is crucial for the development and translation of highly integrated PoC test systems.

With the WIR! alliance "DIANA – Technologies for future-proof point-of-care diagnostics based on microstructured manufacturing processes and sustainable materials", we want to work together with the Fraunhofer IZI and SensLab GmbH to develop the region between Leipzig and Chemnitz into a key region for medical diagnostics.

Manager

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Forming technology

Preserving resources, energy efficiency, digitization
In this business area, we are committed to solutions that benefit climate protection, transition to renewable energies, resource-saving use of materials, and electromobility. We are intensifying efforts to increase the efficiency of energy-intensive forming processes such as press hardening and forging and are stepping up activities in electric drive technology. The high degree of material utilization is an asset of forming technologies.

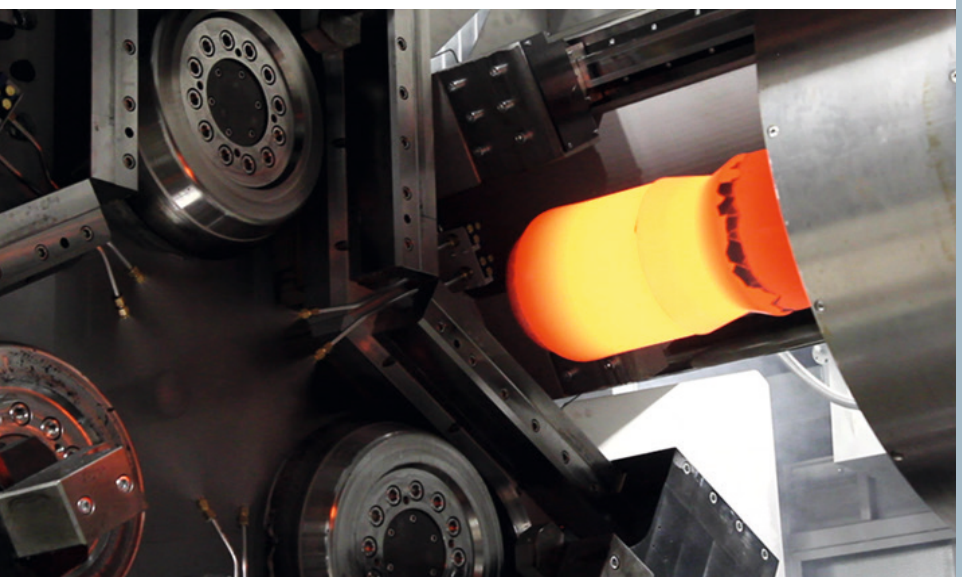
Hollow embossing rolling of a bipolar plate

Therefore, with our industrial and research activities, we aim to develop integrated energy- and resource-saving process chains in sheet metal and bulk metal forming. Seen from the perspective of batch size flexibility, relevant factors are the maximum utilization of the forming capacity of the materials, their recyclability, and the reusability of products manufactured via forming technology, including the tools required for this. In sheet metal forming and solid forming the integrated numerical simulation of processes and process chains has become a standard. This way, effects resulting from batch fluctuations of semi-finished products, or the targeted variation of tool and process parameters can be identified – at an early stage. These effects allow for the optimization of existing forming operations and the design of new ones.

Modified test methods, stress-based determination of characteristic values, and extensive use of sensors and actuators in forming tools lay the foundation for stable processes and reproducibility of formed parts. The combination of data from the material, components, tools, and processes, and their processing using artificial intelligence, will significantly increase the efficiency of forming processes and the predictability of forming results.

Our services

- Temperature-assisted forming processes
- High-speed technologies for forming, cutting and joining
- Flexible forming processes in sheet metal and solid forming
- Lightweight construction concepts: hybrid processes and materials
- Extended process-specific characteristic value determination
- Optimization of material flow through active process control
- Digitalization, like complete digitalization in the mold design process
- Tribology optimization through structuring of mold surfaces
- Closed-loop value creation



Highlight from our research

MarGet – Large gear shafts for gearboxes through resource- and environmentally friendly forming production strategies

With the further development of the spin extrusion process and the associated plant technology, we created the technological basis for the realization of a flexible production technique for the energy- and material-efficient manufacture of hollow large gear shafts for the first time.

The forming plant specially developed for this purpose (still under construction in the top picture but operative in the meantime) is a novelty with a total pressing force of 900 tons and a forming torque of 20,000 newton meters. It is suitable for the hot forming of components with a maximum weight of three tons and a diameter of up to 600 millimeters. It sets entirely new standards, compared to the previously known state of research.

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