SMART FACTORY
Digitalization and Automation
Resource-efficient digital production is the foundation for sustainable increase of the economic and social success of German SMEs in an increasingly globalized future. The division “Smart Factory – Digitalization and Automation” investigates the associated challenges and develops customized industrial solutions.

Together with our partners we develop concepts to integrate business organization, information technology and manufacturing. In this context we focus on the value-adding implementation of these concepts into practical production applications. For many years we have been cooperating with a network of established industry partners, service providers and research organizations – from local SMEs to OEMs. Using our great experience in regional, national and international projects, we accompany our clients starting from the idea all the way up to the operation of our specific developments.

The division focuses its research and development activities on realizing the smart factory on all company levels. We concentrate on designing efficient and ergonomic factories and work environments, using effective production organization and innovative software or automation solutions as a basis for optimizing added value. The cornerstone of our developments consists of managing data and information starting from sensors and reaching all the way up to the employees. Thus, we successfully improve the quality and quantity of production processes, while at the same time creating more transparency in order to increase productivity.

**Guiding topics**

We rely on profound knowledge of methodology, interdisciplinary innovations and advanced technologies in order to guarantee the highest quality of our services and solutions. Our services and main research areas are led by the latest guiding topics of industrial production in Germany and Europe.

- **Resource-efficient factory**
  Energy- and resource-efficient creation of added value as a permanent competitive advantage – supported by individual planning approaches, innovative process control and integrated management

- **Digitalization in production, Industrie 4.0**
  Transparency and controllability of processes, machines and plants through intelligent linking; targeted digitalization and value-driven reorganization of processes

- **Automation and monitoring**
  Zero-defects production: task-related automation of production systems to ensure high throughput while maintaining the required quality, warranted through inline monitoring and control of machines and production processes

- **Integrating humans in modern work environments**
  Efficiency and ergonomics for future work stations through the application of established design methods, lean organization and intuitive mobile assistance systems
Energy efficiency and energy flexibility

Energy efficiency plays an important role in industrial production. The integration of decentralized renewable energy sources as well as the flexibilization of industrial loads gains more and more importance. The questions arise if costs for the procurement of energy can be decreased in the short-term and how can businesses prepare for new energy supply business models? Using energy analyses and best practices, we identify the potentials and for optimizing and leveraging energy supply and energy consumption. To make the best use of future flexibility options on the energy market, we offer our support to companies in identifying potentials and in enabling technical facilities in the factory.

Simulation of material and energy flows

Stochastic influences and complex interactions are prime challenges when it comes to increasing efficiency in production facilities. Even complex manufacturing processes can be represented, investigated and optimized by using material flow simulation and other tools of the digital factory. For this purpose, we have been using the software Siemens Tecnomatix Plant Simulation very successfully in numerous industrial sectors. Moreover, we have developed the extension eniBRIC, which allows for the simultaneous simulation of material and energy flows in production facilities. It enables us to examine the effects of a wide array of individual measures in advance.

Planning and operation of resource-efficient factories

In future production systems, the highest priority will still be placed on the pursuit of goals regarding production logistics, such as minimum processing times and minimum stocks, as well as maximum timeliness. The achievement of these objectives is decisively influenced by the selection of the correct control strategies. Additional goals such as resource efficiency further increase the complexity of the factory. Thus, our current research activities focus on integrating MES, building management systems and energy management systems in order to continuously plan and control material and energy flows efficiently on all distribution levels. Together with our clients, we design and realize concepts for resource-efficient production organization, including the building, infrastructure and processes.

Trends and development

The structural changes in industrial manufacturing become increasingly important for businesses as well as for industrial associations and stakeholders from politics and society. We offer in-depth scientific analyses for decision support in order to exploit innovation potentials early to successfully co-design development processes and to identify promising fields of action. In particular we focus on conveying systematic understanding for complex topics of the future, on assessing potentials and on determining the suitability of sustainable technologies. Furthermore, we analyze and develop management systems in order to increase resource efficiency.
**Digital models and data**

Data is the decisive basis for economic production and the development of new business models. Our research activities focus on new developments that enable acquisition, combination and evaluation of data from various sources. Our services range from setting up digital infrastructures and tapping into data sources to conceptualizing and implementing data architectures up to introducing modular solutions of Industrie 4.0. For this purpose we have developed the Industrie 4.0 stack, a conceptual framework that can be adapted individually to the respective challenges.

**Software development**

Modern software solutions for planning, controlling and optimizing production plants are an essential part of smart factories. The focus lies on the entire life cycle of software systems – ranging from task analysis to architectural design, development and up to software installation and maintenance. By following concepts of Industrie 4.0, suitable databases, software libraries and application frameworks are brought together in particular. In this context we create innovative solutions for planning and monitoring processes for the intelligent control of production systems as well as the acquisition and evaluation of production data.

**Virtual und augmented reality**

Virtual technologies are applied more and more in industrial environments. Our services of research and development range from design reviews assisted by virtual reality (VR) to presentations using a mobile VR system, up to complex augmented reality solutions in the context of Industrie 4.0.

**Human-robot interaction and assistance**

In future production, human creativity and flexibility are decisive competitive factors. In order to provide the best possible support in this area, we develop innovative concepts of interaction, methods of modularization and interface concepts for intelligent assistance solutions in production environments. The effects of such systems include, among other things, the reduction of set-up times and maintenance times.

**Data science**

Big data analyses and the application of machine learning approaches become more and more important to achieve the optimal design and control of production systems. We realize editing, analysis and modeling for machine data and business data. For this purpose we combine visual methods of analysis with tools for statistical evaluations in order to derive knowledge from collected data, which we then implement into software modules for automated analyses and prognoses.

**DIGITALIZATION IN PRODUCTION**
Automation and control technology

When manufacturing processes are automated, electric and hydraulic axle drives are used with digital position control and force control in order to realize innovative machine concepts such as parallel kinematics, hydraulic die cushions or hybrid drive systems. In addition to creating concepts for drives and controls, our core competences mainly comprise simulation, programming, implementation and commissioning of new automation and control algorithms. We introduce new technologies by adding new NC-core applications or HMI applications to existing machine functions of industrial PLCs, MCs and CNCs (e.g. by Siemens, Rexroth, Andron, PA, Beckhoff) or by transferring new functions to specialized decentralized controls (microprocessors).

Inspection technology

One challenge of industrial inline quality inspection often lies in the fact that component properties to be monitored are not or only partially accessible during production. Based on our long-term experience, we support you in selecting the required sensors to ensure continuous secure quality inspection. In this context, we apply solutions for multi-sensor processing (sensor fusion), thus increasing the spectrum of detectable defects and significantly raising the reliability of assessment. The implementation of inspection systems in industrial applications is executed by utilizing the Xeidana® software, which has been developed by us.

Measurement technology

Experimental analyses of machines and production plants contribute to determining their static, dynamic, thermal and kinematic properties. On this basis we derive conclusions for the design as well as the comparison of calculation models and the operation of the machines. By applying smart sensors and by developing intelligent evaluation algorithms, we facilitate the calibration of machines as well as gapless process monitoring in order to guarantee the required quality of the manufactured workpieces.

Condition monitoring

The availability of machines and production plants plays a significant role in the production process. In order to raise this availability, condition monitoring systems that access measurement data from controls, drives and additional sensors are increasingly used. By applying our modular condition monitoring system, essential machine assemblies can be monitored on the basis of measured values so that alerts can be sent when limiting values are exceeded, and suitable maintenance measures can be taken. Moreover, task-oriented intelligent algorithms are developed for identifying damage and prospectively for predicting lifetime as well. Therefore unexpected failures can be avoided, repairs can be planned better and in the end cost can be saved.
**Design of workplaces**

Despite the increasing use of automated machines, humans will remain an integral part of production in the future. Under this premise we investigate innovative approaches for designing manual or partly automated workplaces and work processes. Already in the planning stage we use methods and software like the editor of human work (ema) to think ahead for creating ergonomic, economic and humane working conditions. We integrate intuitive, manageable IT solutions into our approaches in order to provide an optimum supply of information for the employees of production facilities. Our interdisciplinary team, the certified training of our experts in MTM and REFA and our insight into various companies allow us to create progressive ideas for our clients and to develop them to application maturity.

**Process organization**

Successful management systems are characterized by clear structures and process orientation. They enable businesses to validate and continuously increase their competences regarding quality, environmental impact, energy consumption, etc. Applying our profound methodical knowledge, we support our clients with analyses, concept development and implementation of measures for optimum employee involvement while considering current standards.

**Workload and order planning**

Adequate dimensioning of the production capacities and control of orders are imperative for successful production operations. Based on our extensive practical experience, we design individualized planning solutions for the spatial structure of factories and process organization. We include our clients in this planning process. Thus, we apply established methods of factory planning, lean management and production planning and control.

**Production assistance**

Information editing and information provision gain more and more importance in addition to data analysis and the generation of information that is relevant for production. Context-based concepts ensure that employees receive all the information required to fulfill their tasks. Both in data analysis and in providing information it is required to possess knowledge regarding the respective process. Therefore it remains imperative to actively involve humans as creative problem solvers and to adequately consider their natural competences such as intelligence and creativity. In order to accomplish this, we work with advanced web technologies and platform-independent solutions that can be integrated optimally into existing business networks.
When talking about the contribution of cars towards climate protection, fuel consumption is the first thing that comes to mind. Not least, fuel consumption depends on the weight of the carbody. However, huge saving potentials and potentials for increasing efficiency exist already during manufacturing. After all, a fourth of the total energy requirements in the lifecycle of a car is associated with its production, of which a considerable portion is allotted to carbody manufacturing.

How can products be manufactured in a resource-efficient manner? Which new manufacturing processes are required to save material and energy? These questions were investigated by the innovation alliance Green Carbody Technologies (InnoCaT®), funded by the Federal Ministry for Education and Research (BMBF) and coordinated by Fraunhofer IWU and its industrial partner Volkswagen. Over 60 partners from industry and research developed solutions for automobile production in 30 sub-projects, using a total investment volume of approx. 100 million euros.

The content of the joint research ranged from tool making to press plants, carbody construction and painting. The same challenge applied for all these areas: improving the degree of material utilization and the energy efficiency. It was not only a matter of adjusting the individual parameters in the production process, but it also involved considering manufacturing as a whole. For this reason a major assignment consisted in establishing continuous planning for energy- and resource-efficient processes across the trades, i.e. individual process steps and complete process chains.

In order to demonstrate the individual results and the approaches, including detailed verification, a concept was developed and used for a reference carbody manufactured in an adequate reference factory. The novelty of this reference carbody is its use as a benchmark independent from any companies and specific cars. Thus, the achievable savings potentials are illustrated as one entity for the first time. In addition, they serve as reference values for more energy- and resource-efficient automobile production when it comes to the implementation of new technological concepts, enhanced manufacturing technologies and extended planning tools.

**ADVANTAGE**

<table>
<thead>
<tr>
<th>Savings of primary energy at an output quantity of 250,000 carbodies:</th>
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<tr>
<td>- Press plant 8.1%</td>
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<tr>
<td>- Tool making 1.4%</td>
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<tr>
<td>- Carbody construction 16.5%</td>
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<tr>
<td>- Painting 6.7%</td>
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Future potentials are considerably higher.
PROJECT EXAMPLE
DIGITALIZATION IN PRODUCTION, INDUSTRIE 4.0
Production technology is increasingly penetrated by modern components of information and communication technology. That is why today a large amount of heterogeneous data is available with a direct or indirect connection to production processes. Thus, acquisition and processing of this data is possible. As a consequence, “data” continuously gains more and more importance as a resource. How can this data be processed and how can it be supplied as supporting information in more and more complex production scenarios?

It is decisive that this information is available at the right time and place. This is the only way to ensure flexible and resource-efficient production along the entire process chain. The organization of these production processes is the purpose of the “Linked Factory”, a data hub developed at Fraunhofer IWU. At our research institute it is used as a software platform in the E³-Forschungsfabrik [E³ research factory], among other things.

The “Linked Factory” is fed by various IT systems of the factory, for example, data are collected from individual machines, characteristic values from the building technology, logistics and the related essential economical parameters to form a virtual image of the factory. By linking most diverse data, new information is generated in real-time. This new information does not just remain somewhere, but it is forwarded fast and to a specific target.

When large amounts of data are processed to information which is then made available, it is important to dispense the data volume in a manner assisting employees in their assignments rather than additionally burdening them. Therefore context based provision is the keyword. A production manager needs different information than an operator or a maintenance worker. Thus, every employee is supplied with information depending on his or her area of responsibility. It is unimportant which terminal is used for human-machine interaction. The entire spectrum of mobile hardware is possible – ranging from laptops to tablets and smartphones.

**ADVANTAGES**

- Smart connections between devices, controls and applications
- High data acquisition speed; easily expandable for data analysis
- Derivation of previously hidden relationships used as a basis for increasing productivity
- Faster reaction times of the workers due to supply of context-based information
PROJECT EXAMPLE
AUTOMATION AND MONITORING
Often operatives in a press plant perform a visual inspection at the outfeed conveyor belt to check whether the quality of the pressed component is correct. This task is exhausting for the operative and the quality inspection is often not a hundred percent accurate. Using the XEIDANA® software, quality control can be conducted considerably more efficiently and precisely.

The program was developed at Fraunhofer IWU and can combine numerous inspections and measurements in one system, where they are evaluated automatically. It is based on various sensors with high resolutions, which control lengths, diameters or volumes. In addition, such sensors check whether assemblies are complete, whether surface damage can be detected; they can even check for internal defects. Large amounts of data flow during these processes.

XEIDANA® was developed particularly for fulfilling these requirements. The software detects and analyzes infrared images and optical live videos, e.g. together with information from ultrasound systems. The data can be evaluated live or archived for later analyses. The program works best with computer systems that have processors with several cores. This ensures that the required computing power is achieved.

Another characteristic of XEIDANA® is the extandable framework. It enables the user to independently add efficient extensions to the software. This allows access to numerous hardware components. At this point the human quality inspector is involved again. With this flexible framework measured results are provided to the quality inspector via tablet or a pair of data goggles. Thus, the tedious visual control at the press output can be eliminated. Moreover, 100% defect detection is accelerated.

**Advantages**

- Highest flexibility due to user-specific expandability
- 100% inspection possible
- Time savings due to faster quality control

**XEIDANA® – One System for Many Sensors**
The joint research project SynErgie, funded by the Federal Ministry for Education and Research (BMBF), develops solutions for enabling energy-intensive key production processes to operate with a more and more volatile energy supply. Using modern approaches of information and communication technology, the energy distribution between various sectors shall be controlled to consider the fluctuating supply of renewable energies.

In REEMAIN, a project of a European network of partners, funded by the European Commission, we investigate implementable solutions for the energy-efficient operation of factories. The results comprise innovative solutions in the field of renewable energies. Moreover, tools and methods are developed for identifying, quantifying, virtually securing and also implementing potentials of energy efficiency in companies.

The project WindNode deals with the development of transferable, scalable and industry-oriented solutions for synchronizing energy producers and industrial loads. In order to apply these partial solutions, a software-based energy management system for synchronizing energy supply and energy demand is implemented as a flexibly expandable hardware and software solution. The E³-Forschungsfabrik [E³-research factory] at Fraunhofer IWU demonstrates solutions of industrial production for supporting the energy turnaround. The focus lies on direct utilization of renewable energies, active energy and load management and on applying energy storage systems in production processes.

Germany is the world-wide leader for production and production technologies of innovative materials. In order to illustrate the potential of this position, Fraunhofer IWU designed and developed the Leichtbauatlas [atlas of lightweight construction] as an innovative system for researching competences. The interactive portal can be used by organizations to present their processes and activities. Furthermore, companies and research institutions can utilize it to look for customized competences in lightweight construction in local areas. Thus, this portal supports the networking of companies and research institutions.
CyProAssist

This project has the objective of implementing the modular system of production assistance, called “FriendlyImprover”, for the acquisition, analysis and interaction of data. An open concept of architecture and interfaces is developed for integrating modules of diverse solutions providers. On this basis the assistance system can provide required data and functions from ERP, SCADA or MES solutions to stationary or mobile terminals by using an adaptive user interface for novel human-machine interaction. A modular system is developed which facilitates the implementation of new assistance solutions considerably and ensures the transferability to various application cases and sectors due to its open interface concept.

www.cyproassist.de

SmARPro

The joint research project, which is funded by the Federal Ministry for Education and Research (BMBF), aims at developing mobile assistance systems based on augmented reality for setting up and operating intelligent production and logistics systems. These assistance systems shall improve the integration of humans as intelligent problem solvers in production systems.

www.smarpro.de

RANGE OF SERVICES

We offer numerous types of collaboration:
– Contract research
– Engineering services
– Joint research/prospective research
– Consultations, studies and workshops

Our competences are reflected in the following topics:

Department Resource-Efficient Factory
– Simulation of material flow and analyses of value streams
– Planning of logistics/production/assembly systems
– Energy- and resource-efficient production
– Design of energy-efficient processes and development of energy supply concepts
– Studies on ergonomics and time management (MTM, REFA)

Department Digitalization in Production
– Digital models and data
– Data science
– Virtual and augmented reality
– Human-machine interaction and assistance
– Software engineering and development

Department Automation and Monitoring
– Concept development for controls and drives
– Development of inline inspection systems
– Property analyses for production machines
– Condition monitoring systems
– Development of assistance systems for production machines