ZLP

Center for Lightweight-Production-Technology

DLR

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The DLR Center for Lightweight-Production-Technology (Zentrum für Leichtbauproduktionstechnologie; ZLP) has two research sites, which are located in Augsburg and Stade. Its main focus is the automated production of carbon-fibre-reinforced plastic (CFRP) components for the aerospace, transport and energy sectors.

Several DLR institutes work together in the ZLP: the Institute of Structures and Design, the Institute of Composite Structures and Adaptive Systems and the Institute of Robotics and Mechatronics. This enables DLR to reproduce the entire CFRP engineering process chain – from the material to the automated production.

Using one-of-a-kind, multifunctional, large-scale facilities, the ZLP develops strategies for manufacturing large, high-quality CFRP components in a cost-effective manner. To achieve this, every step in the process is studied, integrated and, using the appropriate technical infrastructure, reproduced on an industrial scale. This setup is also available to customers for flexible development and validation in tandem with the DLR production processes according to their requirements.

Research for the aerospace, automotive and wind energy sectors

Carbon-fibre-reinforced plastic is a material used for, among other things, manufacturing next-generation commercial aircraft – lighter, more fuel-efficient and more environment-friendly with regard to pollutant emissions.

CFRP is also increasingly used in the manufacturing of automobiles and rotor blades for wind power generation systems. To meet this growing demand, high quality, cost-effective production methods are needed. The ZLP is conducting research on the industrial scale to be able to respond specifically and flexibly to the particular requirements of the respective industry.

ZLP site at Stade

The research carried out at the ZLP site at Stade focuses on the manufacture of very large, complex components in high-production fibre placement processes and sensor-guided component-specific control of thermally inert curing processes in autoclaves and open moulds. The researchers in Stade are also working on fully automated manufacturing of high-volume components using dry textile semi-finished products in the resin transfer moulding (RTM) process. As well as for the aerospace sector, the processes being developed are also intended for applications in the automotive industry and for the production of rotor blades for wind energy systems.

For these research activities, the ZLP site at Stade has been equipped with the following innovative research facilities:

- a fully-automated RTM process chain
- the largest research autoclave in the world, BALU
- CNC-based multi lay-up facility for automated fibre placement (AFP) and automated tape laying (ATL)
- rotor blade mould (length: 45 meters)

Near-net shape RTM components in large quantities

Short processing times and automated procedures in a quality-assured, robust process are key features for the production line of large quantities of CFRP components. From cutting and handling and draping dry semi-finished products, to consolidating and fine trimming of the pre-form, as well as the automated injection process, tool logistics, the annealing cycle and demoulding – all of the technology needed for manufacturing up to 100,000 pieces per year is represented in this interconnected research facility. The data acquired from the actual equipment is entered into a process simulation in order to be able to draw reliable conclusions about cost-effectiveness and productivity, as well as the expected component costs.

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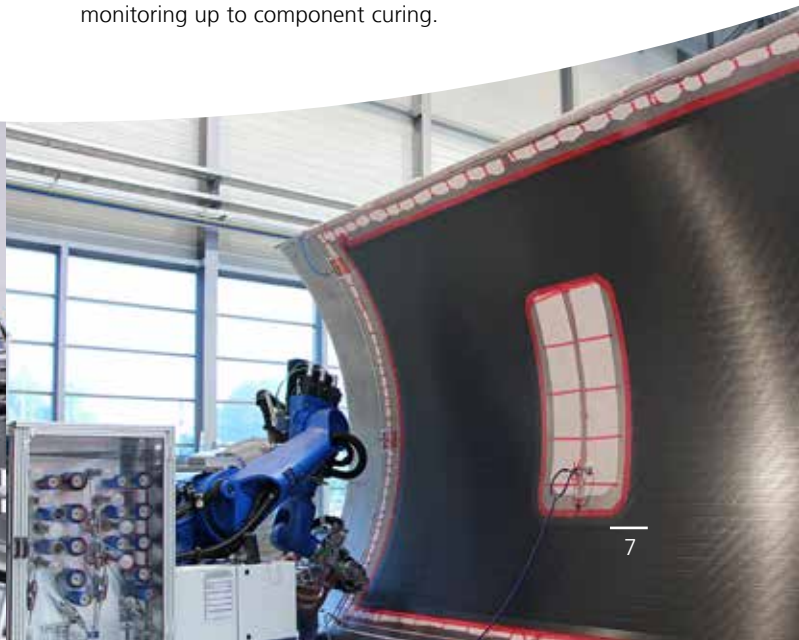
Intelligent autoclave process technology

Autoclaves are an integral part of the production chain for CFRP components. Quality-assured manufacturing in the autoclave is based on research into the processes and their parameters. To do so, the research autoclave at the ZLP site in Stade is equipped with extensive sensor systems, such as a thermal camera and curing sensors, and is simultaneously coupled to a simulation module, the 'virtual autoclave'. This reproduces the entire process with constant comparison to the sensor data in a realistic model, and enables the process to be predicted. The inertia of the autoclave can then be counteracted, allowing for process deviation and exothermic reaction measures to be introduced in a targeted manner. Consequently, the interaction with the autoclave enables productivity-optimised, more energy-efficient autoclave processes to be researched.

Robot-based, highly-productive fibre placement technology

To increase the production rates of very large, shell-like components manufactured from fibre composite materials in an automated fibre placement process, and to reduce manufacturing costs, the ZLP has developed a system in which up to eight robot units lay up simultaneously and in a coordinated manner on a double-sided moulding tool. As well as the robot platform, the technology in the facility comprises a new generation of fibre placement and tape-laying heads that, for the first time, work simultaneously on a single component. The basis for an efficient, productive, quality-assured and stable production process is established through the development of continuous simulation software, the integration of real-time sensor systems, the investigation and impact of material-optimised process parameters, and comprehensive process monitoring up to component curing.



ZLP site at Augsburg

At its Augsburg site, the ZLP focuses on thermoset matrix composite materials made of dry fibre semi-finished products, infusion resin systems, as well as thermoplastic matrix composites. Other key areas are production-integrated quality assurance and the corresponding mechatronics and robotics. The Multifunctional Cell robotic research platform (Multifunktionale Zelle; MFZ), the only one of its kind in Europe, enables research to be carried out on an industrial scale.

The ZLP site at Augsburg is equipped with the following research infrastructure:

- MFZ - multifunctional robotic workcell with five robots (total size roughly 15 x 30 x 7 metres)
- Technology experiment cell (Technologieerprobungszelle - TEZ) with two robots
- Thermoplastic processing with robotic workcell
- Quality assurance laboratory
- Thermoplastic furnace (200°C) and duromer furnace
- Waterjet cutting system

Processes and automation

To be able to manufacture components cost-effectively in large quantities, the ZLP site at Augsburg is working on shorter cycle times for textile and infusion technology as well as for thermoplastic processing. This is done throughout the entire process chain.

In the textile and infusion technology area, the ZLP is developing automated gripping systems for textile semi-finished products for pre-form production. The aim is to achieve placement rates of over 100 kilograms per hour and guarantee damage-free handling of the products in the process. Furthermore, the ZLP is working on an automated vacuum system for resin infiltration and subsequent curing without the use of an autoclave.

With its short cycle times, thermoplastic processing offers great potential for automation - from placement to shaping and consolidation. The ZLP is developing processes for manufacturing near-net shape contour components with reproducible results and short cycle times.

Robotics and mechatronics

The high requirements of production technology in the aerospace sector demand innovative robotic and mechatronic solutions. At the core of the facilities at the ZLP Augsburg site is a robot-assisted research platform (the Multifunctional robotic workcell - Multifunktionale Zelle; MFZ), which is used for investigating and subsequently validating the potential of a wide range of production processes for automation. Robots working independently or together can handle even large components

Assembly and consolidation technology

The current state of technology in the aerospace sector for bonding structures is to use rivets or bolts and, increasingly, adhesives as well. In this research area, the ZLP develops processes for integrally producing or automatically adding fibre composite structures in future. Due to size and enormous flexibility of the MFZ, scenarios that have been investigated in digital models can be validated on demonstrators with realistic dimensions.

Produktion-integrated quality assurance

The automated production of aircraft and other lightweight structures requires fast, cost-effective, integrated quality assurance that detects errors during the actual production of components and corrects them if necessary.

To do this, the ZLP is developing quality assurance strategies and suitable end effectors from established processes for non-destructive testing, such as thermography or ultrasound. These are being integrated into the robotic facilities accordingly. New methods for automated assessment of the data are being used to ensure that constant, reliable quality assurance is provided throughout the production process, to enable efficient manufacturing of high-quality lightweight structures.

DLR at a glance

DLR is the national aeronautics and space research centre of the Federal Republic of Germany. Its extensive research and development work in aeronautics, space, energy, transport and security is integrated into national and international cooperative ventures. In addition to its own research, as Germany's space agency, DLR has been given responsibility by the federal government for the planning and implementation of the German space programme. DLR is also the umbrella organisation for the nation's largest project management agency.

DLR has approximately 8000 employees at 16 locations in Germany: Cologne (headquarters), Augsburg, Berlin, Bonn, Braunschweig, Bremen, Goettingen, Hamburg, Juelich, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stade, Stuttgart, Trauen, and Weilheim. DLR also has offices in Brussels, Paris, Tokyo and Washington D.C.

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