Joining thermoplastic fibre composites with medium wave infrared: precise heat control

About this project

ReJoin

Joining thermoplastic fibre composites with medium wave infrared: precise heat control

Markets:

Material: Thermoplastics, Glass-fiber reinforced plastics (GFRP), Metal-ceramic composite

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Technology Transfer Program Leichtbau

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Context

Companies use thermoplastic fibre-reinforced composites (FRP) to produce lightweight, heavy-duty components with complex geometries. The companies produce the individual parts using injection moulding. They then join these components together to form assemblies.

Common joining processes such as infrared (IR) and hot gas welding often heat larger areas than necessary, react comparatively slowly and only roughly control the heat input. This increases the energy requirement, favours overheating and makes it difficult to achieve uniform fusion layers. As functional integration increases, so do the requirements: tighter tolerances, shorter cycles, high reproducibility.

Joining technologies that precisely meter heat along the joining contour, control it quickly and actively compensate for tolerances are in demand. Equally important: measurement data for quality and CO# per component. This is where the ReJoin project team comes in - with targeted, spatially resolved heat input and modern control technology to join FRP components efficiently and robustly.

Purpose

In the ReJoin project, the partners are developing processes to make the joining of components made from thermoplastic fibre-reinforced composites (FRP) significantly more energy-efficient, faster and more reliable. The aim is to achieve a homogeneous melt layer with fewer rejects.

To achieve this, the researchers are developing contour-following mid-wave infrared emitters (MW-IR) that precisely dose the heat along the joining contour and quickly reach the target temperature thanks to fast power control. Combined force/displacement control and adaptive distance control between the emitter and the component precisely control the joining process and actively compensate for tolerances.

This reduces the energy requirement - according to current forecasts - by up to 97% compared to established IR and hot gas processes; CO# emissions and operating costs are reduced, the melt layer becomes more homogeneous and rejects decrease. At the same time, the team is establishing integrated quality monitoring with IR measurement technology and a component-related CO# balance.

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Procedure

The project partners first record the geometry and joining contour of the components and define cycle times and target values for the fusion layer and temperature profiles. On this basis, they develop contour-following emitters in mid-wave infrared, which specifically control the heat input along the joining contour. They design the local energy density using the finite element method (FEM) and coupled radiation/flow simulations. An optimised filament mounting reduces heat dissipation and accelerates the response behaviour of the emitters.

The team is developing the control system in parallel: A combined force/displacement control system precisely controls the joining process, while adaptive distance control between the emitter and component compensates for tolerances in real time. The researchers are integrating IR measurement technology into the system for quality monitoring; energy and temperature measurements provide the CO# balance for each component.

The project partners then test the process on complex functional samples, for example on a pressurised air cover. Based on the test results, they optimise the process window and validate the results with the help of a life cycle assessment and a failure mode and effects analysis (FMEA).
In the end, reliable design guidelines and standards for industrial use are created.

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  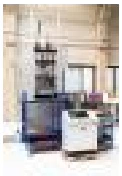 

Funding duration:

Funding sign:	03LB3034	**Funding amount:**	EUR 1.3 million

Final report

Further websites foerderportal.bund.de/foekat/jsp/SucheAction.do?actionMode=view&fkz=03LB3034A - ReJoin in the federal funding catalogue

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Project coordination

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Lightweighting classification

	Realisation
Offer	
Products Parts and components, Machines and plants, Systems and end products, Tools and moulds	✓
Services & consulting Consulting, Testing and trials, Funding, Engineering, Validation, Simulation, Technology transfer	✓
Field of technology	
Design & layout Lightweight manufacturing, Lightweight design, Hybrid structures, Lightweight construction concepts	✓
Functional integration Sensor technology, Thermal activation	✓
Measuring and testing technology Visual analysis (e.g. microscopy, metallography), Materials analysis, Destructive analysis	✓
Modelling and simulation Loads & stress, Life-cycle analysis, Optimisation, Processes, Structural mechanics	✓
Plant construction & automation Automation technology, Handling technology, Robotics	✓
Recycling technologies Recycling	✓

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Lightweighting classification

	Realisation
Manufacturing process	
Additive manufacturing	
Coating (surface engineering)	
Fibre composite technology	
Forming	
Joining Welding	✓
Material property alteration	
Primary forming Injection moulding	✓
Processing and separating	
Textile technology	
Material	
Biogenic materials	
Cellular materials (foam materials)	
Composites Glass-fiber reinforced plastics (GFRP), Metal-ceramic composite	✓
Fibres	
Functional materials	
Metals	
Plastics Thermoplastics	✓
Structural ceramics	
(Technical) textiles	