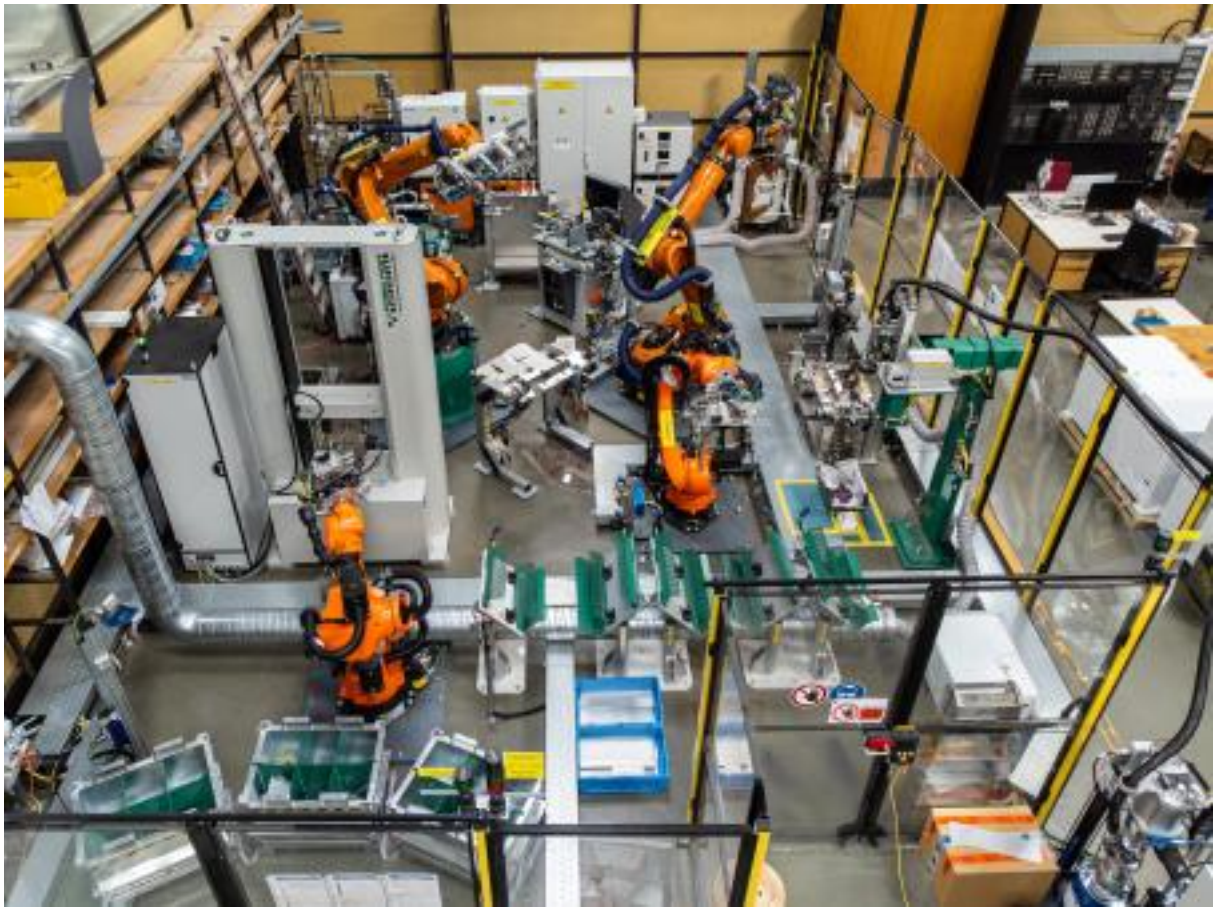
Optimising aluminium spot welding for lightweight car bodies: Big data with robotics

About this project



OptiWAL

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Markets:

Material: Aluminium

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This project is funded by the Technology Transfer Programme Leichtbau (TTP LB) of the Federal Ministry of Economics and Energy.

Technology Transfer Program Leichtbau

Context

Car manufacturers are increasingly turning to high-strength aluminium alloys, often combined with steel, for lighter car bodies. This allows them to reduce vehicle mass and energy consumption - without compromising on safety. In order to fully utilise this lightweight construction potential, the new materials must be able to be joined reliably.

Aluminium presents manufacturers with particular challenges in resistance spot welding: high electrical and thermal conductivity, oxide layers and heavy electrode wear lead to fluctuating spot diameters, high testing costs and limit the use of higher-strength alloys. At the same time, the requirements for digitalised, data-based development processes with shorter cycles and transferable process models are increasing. This is where the OptiWAL project comes in.

The project team aims to design the resistance spot welding of high-strength aluminium alloys in such a way that spot welds achieve the highest possible strength. This allows for thinner sheet thicknesses, which reduces the weight of the car body and lowers energy and CO# emissions.

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Purpose

The researchers are optimising resistance spot welding of high-strength aluminium alloys for lightweight automotive construction - supported by AI and simulation. The project team is developing an intelligent system that combines expert knowledge, physical process models and machine learning in a digital tool for AI-based test planning and process optimisation.

To this end, the researchers are recording relevant process parameters, material properties, adhesive systems and system configurations in a standardised system and mapping them in digital twins of the welding process. These digital twins enable the project team to evaluate weldability, spot geometry and strength with foresight.

To ensure a broad and reliable database, the participants use a robot-supported test system with automated sample tests and data acquisition. This enables the project team to systematically carry out automated tests with different process parameters. The AI uses the resulting data to build models, select new tests in a targeted manner and continuously improve the prediction quality. In this way, OptiWAL significantly reduces the experimental effort and creates the basis for robust, transferable and industrial lightweight solutions.

Procedure

The project team operates a highly automated welding and testing cell under near-series conditions. The researchers systematically record welding parameters, sensor values and quality indicators through tests. Optical 3D measurements of the welding points and electrode impressions as well as automated mechanical tests provide a comprehensive characterisation of the joints. All data is fed into a database with clearly described meaning models via clearly defined interfaces.

Building on this, the project partners develop simulation-based models based on the finite element method and AI models that work together as hybrid models. They use an interactive system to test hypotheses, select models and compare simulations directly with measurement data. In this way, their understanding of physics flows directly into the analysis.

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Funding duration:

Funding sign:	03LB1009	**Funding amount:**	EUR 3.1 million

Final report

Further websites

foerderportal.bund.de/foekat/jsp/SucheAction.do?actionMode=view&fkz=03LB1009A - OptiWAL in the federal funding catalogue

youtu.be/IuhrjaRjpKc?si=R7y-IA-EyRq7HeU1 - OptiWAL project video on YouTube

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Project coordination

Contact:

Mr Andreas Fezer

+49 0711 685-63582

andreas.fezer@mpa.uni-stuttgart.de

Organisation:

Materials Testing Institute University of Stuttgart

Pfaffenwaldring 32
70569 Stuttgart Vaihingen
Baden-Württemberg
Germany

www.mpa.uni-stuttgart.de

English (EN){{ Projektpartner }}

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Lightweighting classification

	Realisation
Offer	
Products Machines and plants, Software & databases, Materials, Tools and moulds	✓
Services & consulting Testing and trials, Engineering, Validation, Simulation	✓
Field of technology	
Design & layout Lightweight manufacturing, Lightweight material construction	✓
Functional integration Actuator technology, Media conductivity, Sensor technology, Thermal activation	✓
Measuring and testing technology Visual analysis (e.g. microscopy, metallography), Materials analysis, Destructive analysis, Non-destructive analysis	✓
Modelling and simulation Processes, Materials	✓
Plant construction & automation Plant construction, Automation technology, Handling technology, Robotics	✓
Recycling technologies	

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Lightweighting classification

	Realisation
Manufacturing process	
Additive manufacturing	
Coating (surface engineering)	
Fibre composite technology	
Forming	
Joining Welding, Others (Resistance spot welding)	✓
Material property alteration	
Primary forming	
Processing and separating Milling, Sawing	✓
Textile technology	
Material	
Biogenic materials	
Cellular materials (foam materials)	
Composites	
Fibres	
Functional materials	
Metals Aluminium	✓
Plastics	
Structural ceramics	
(Technical) textiles	