Realising innovative lightweight construction: powder bed-based melting of metal using lasers

About this project

addLight

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Markets:

Material: Aluminium, Steel

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

Powder bed-based melting of metal using a laser beam (PBF-LB/M technology) builds up components layer by layer by melting metallic powder with pinpoint accuracy using a laser. In this way, elements with complex internal structures can be created that are light yet stable. Engineers use computer-aided design (CAD) to design these components. They often save the designs in STL format (Standard Triangle Language). STL files describe surfaces as small triangles.

This method works well for simple geometries, but quickly reaches its limits with complex, internally optimised structures, such as lattice or topology-optimised components. The file sizes become enormous and errors in the triangular mesh can impair the quality and simulation of the components. When modelling the melting process, classic, phenomenological models do not provide sufficient detail to capture the interactions between laser power, layer thickness, cooling rates and the resulting microstructure. Therefore, integrated simulation methods and data-based approaches are needed to better understand local material changes.

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Purpose

In the addLight research project, the project team aims to demonstrate the industrial use of additively manufactured lightweight structures. The researchers are developing components made from aluminium alloys that can withstand static, dynamic and cyclical loads. They are creating specific design rules for lattice structures and topology-optimised components, i.e. components that only use material where it is necessary for load-bearing capacity.

To do this, the project team combines physical models - which theoretically depict the PBF-LB/M process - with data-driven machine learning methods. These so-called grey box models link simulation and experimental data in order to predict local material properties and fatigue reactions almost in real time. In addition, the researchers describe process anomalies using data-driven models and compensate for them through local process adaptation. With the resulting reproducible manufacturing processes and precisely determined material parameters, the researchers hope to pave the way for the series production of safety-relevant lightweight components.

The partners also want to enable the efficient exchange of complex geometries such as lattice structures between different software components (CAD, simulation, data preparation) without any loss of information.

Procedure

The researchers select components with high lightweight construction potential and pursue two development paths. On the one hand, they optimise lattice structures in which an inner mesh saves material, and on the other hand, they develop fully solid, topology-optimised components. They adapt the PBF-LB/M process by making local changes to the process parameters in order to achieve consistent surface quality and controlled microstructures. Modern monitoring systems record important parameters such as laser parameters, position data and melt pool radiation in parallel with the process. The researchers are developing methods that use this data to predict defects in the component and calculate local process adjustments to improve the homogeneity and reproducibility of the melting process.
The researchers also test the components using tensile, compressive and cyclic loads. The data obtained is incorporated into grey box models that combine physical simulations with data-based machine learning methods. Finally, the team uses computer-aided engineering (CAE) to validate the models and derive specific design guidelines for series production.
The researchers are investigating suitable geometry representations for lattice structures in order to derive an efficient file format. This will be proposed for standardisation in an industry consortium in order to enable interoperability between software products from different manufacturers.

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Funding duration:			
Funding sign:	03LB2009	**Funding amount:**	EUR 2 million

Final report

Further websites

foerderportal.bund.de/foekat/jsp/SucheAction.do?actionMode=view&fkz=03LB2009A - addLight in the federal funding catalogue

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Project coordination

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English (EN){{ Projektpartner }}

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Lightweighting classification

	Realisation
Offer	
Products Parts and components, Software & databases, Materials	✓
Services & consulting Training, Testing and trials, Engineering, Standardisation, Prototyping, Simulation, Technology transfer, Approval	✓
Field of technology	
Design & layout Lightweight manufacturing, Hybrid structures, Lightweight construction concepts	✓
Functional integration	
Measuring and testing technology Component and part analysis, Materials analysis, Destructive analysis, Non-destructive analysis	✓
Modelling and simulation Crash behaviour, Loads & stress, Optimisation, Processes, Structural mechanics, Materials, Reliability validation	✓
Plant construction & automation	
Recycling technologies	

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Lightweighting classification

	Realisation
Manufacturing process	
Additive manufacturing 3D printing, Selective laser melting (SLM, LPBF, ...)	✓
Coating (surface engineering)	
Fibre composite technology	
Forming	
Joining	
Material property alteration Heat treatment	✓
Primary forming	
Processing and separating Turning, Milling, Sawing, Grinding	✓
Textile technology	
Material	
Biogenic materials	
Cellular materials (foam materials)	
Composites	
Fibres	
Functional materials	
Metals Aluminium, Steel	✓
Plastics	
Structural ceramics	
(Technical) textiles	