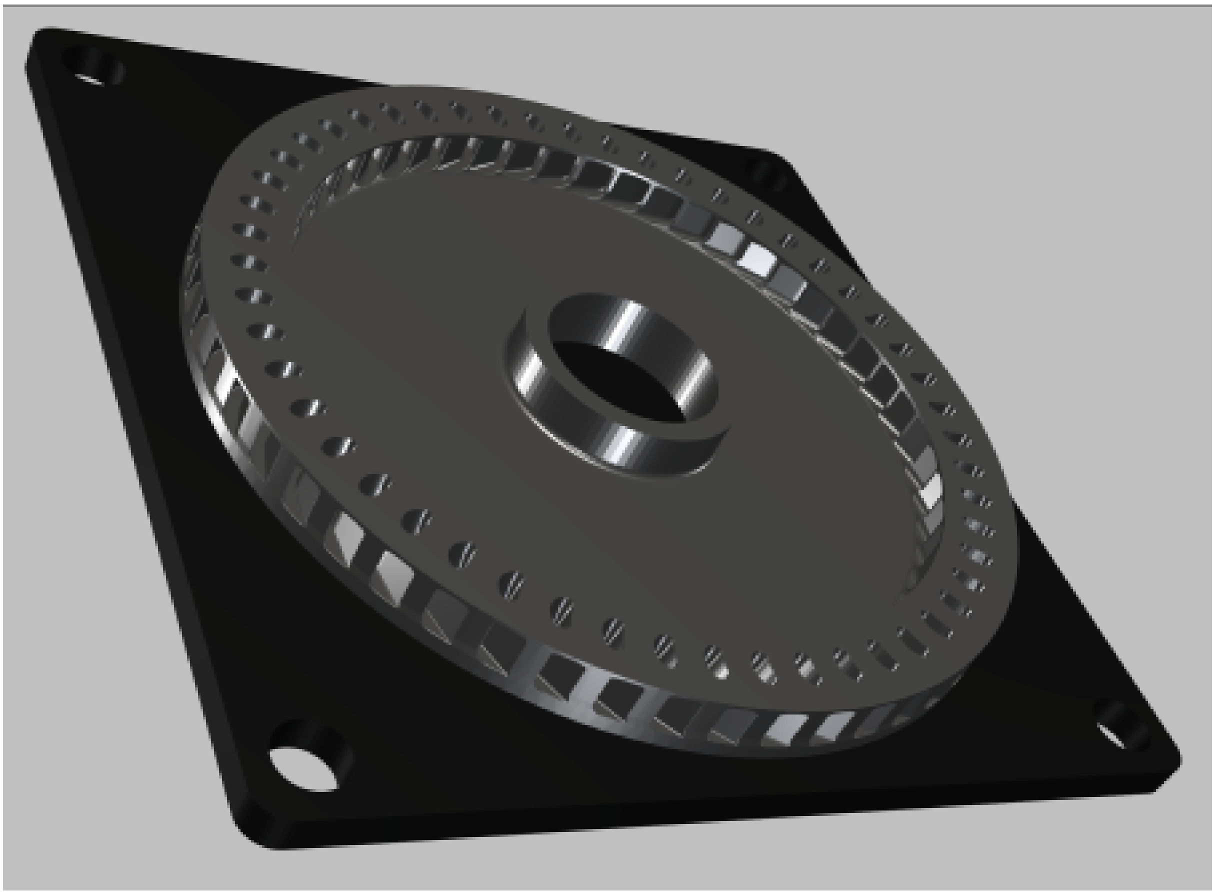
Selective laser beam melting: Optimising heat distribution and reducing stresses

About this project



Opti-Add

Selective laser beam melting: Optimising heat distribution and reducing stresses

Markets:

Material: Steel

Selective laser beam melting: Optimising heat distribution and reducing stresses

About this project

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

Technology Transfer Program Leichtbau

Context

Selective laser melting (SLM) is a key technology for lightweight construction, as it enables the production of complex, load-optimised components. In this process, metal powder is melted layer by layer with a laser to produce high-strength structures. A key problem with this process is residual stresses caused by uneven heat input. These stresses can lead to component distortion or microcracks and have a negative impact on the mechanical properties.

However, safety-critical applications, such as in the aerospace and automotive industries, require precisely manufactured, resilient components. In addition, process control has so far often been carried out without detailed adaptation to the respective component geometry or load. Standardised exposure strategies such as parallel scan paths or checkerboard patterns do not take into account how heat is distributed in the component. This results in stress maxima that lead to quality defects. Adaptive process control is required to control the mechanical properties of additively manufactured components in a targeted manner and to make the use of materials more efficient.

Purpose

In the Opti-Add research project, the project team aims to reduce the residual stresses in the SLM process through an optimised exposure strategy and specifically adapt the component properties. To this end, the researchers are developing an intelligent control system that adapts the process parameters - in particular laser power, scanning speed and scanning strategy - to the geometry and thermal situation of the component. In this way, the scientists hope to reduce component distortion, minimise susceptibility to cracking and improve fatigue strength. This is particularly important for lightweight structures that are exposed to high dynamic loads.

The project team also wants to use targeted heat control to influence the microstructure of the materials so that they last longer. The researchers also want to increase resource efficiency: By controlling the melting bath more precisely, material consumption should be lowered and waste reduced.

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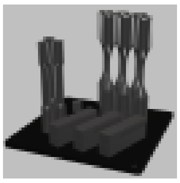
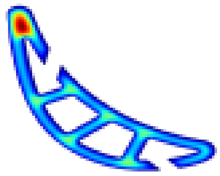
Procedure

In order to improve process control, the researchers are developing a build processor that optimises the exposure strategy based on the component geometry and thermal simulations. Using temperature field analyses, they identify critical areas where stresses are particularly high. Based on this, the project team is testing alternative scanning strategies such as the pilgrim step method, in which the laser varies the exposure sequence so that heat is distributed more evenly. The researchers are also using a thermographic detector system that records the temperature curves during the printing process in real time.

This data is fed into the build processor for path planning in order to specifically adjust the laser power and scan patterns. After production, the researchers analyse the components using methods for residual stress analysis and optical distortion measurement. These show that the checkerboard pattern scanning strategy results in less warpage in direct comparison to linear scanning strategies, but that the residual stresses are influenced more by the temperature of the build platform, the laser power and the laser speed than by the scanning strategy. The residual stresses decrease with increasing temperature of the build platform and increase with increasing laser power and laser speed.



Funding duration:

Funding sign:	03LB2038	**Funding amount:**	EUR 1.2 million

Further websites foerderportal.bund.de/foekat/jsp/SucheAction.do?actionMode=view&fkz=03LB2038A - Opti-Add 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 Machines and plants, Software & databases, Materials	✓
Services & consulting Testing and trials, Prototyping, Validation	✓
Field of technology	
Design & layout Lightweight manufacturing	✓
Functional integration	
Measuring and testing technology Visual analysis (e.g. microscopy, metallography), Materials analysis, Destructive analysis	✓
Modelling and simulation Optimisation, Processes, Materials	✓
Plant construction & automation	
Recycling technologies	
Manufacturing process	
Additive manufacturing Selective laser melting (SLM, LPBF, ...)	✓
Coating (surface engineering)	
Fibre composite technology	
Forming	
Joining	
Material property alteration	
Primary forming	
Processing and separating	
Textile technology	

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Lightweighting classification

	Realisation
Material	
Biogenic materials	
Cellular materials (foam materials)	
Composites	
Fibres	
Functional materials	
Metals Steel	✓
Plastics	
Structural ceramics	
(Technical) textiles	