Developing a recyclable high-entropy alloy: Lightweight construction in casting and laser melting

About this project

LHEA

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Markets:

Material: Others (Structural materials, heat-stressed materials), Aluminium, Intermetallic alloys, Magnesium, Others (Copper, tin, etc.)

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

In lightweight construction, metal alloys for load-bearing components have to fulfil several requirements at the same time: They need to save weight and at the same time absorb high loads while remaining sufficiently malleable and functioning reliably even under corrosive conditions. This combination is often a conflict of objectives. If the strength increases, the ductility often decreases, or the corrosion resistance is not sufficient.

Processing also has a strong influence on the properties: if brittle components or inhomogeneities form in the microstructure, this weakens the component's reliability and can make it more difficult to return it to the cycle.

High entropy alloys offer a solution to this problem. As alloys with several main components, they open up scope for the targeted adjustment of material properties via the composition. The prerequisite is to design the alloy and process control in such a way that a homogeneous structure without brittle components is created and the material can be returned to the cycle after use.

At the same time, production should be material-efficient. Processes such as casting and laser-based additive manufacturing produce components largely in their final form. This results in fewer chips and rejects, which supports resource-saving recycling.

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Purpose

In the LHEA project, the team is developing a high-entropy, low-density alloy based on several metals such as aluminium, magnesium, copper and tin. The project partners are defining composition ranges and process windows in such a way that the material can be processed as a casting material and is suitable as a starting material for powder production and selective laser melting.

The researchers demonstrate key mechanical properties, including yield strength, tensile strength and elongation at break. They also achieve a high component density in the additive structure and demonstrate corrosion resistance at the level of conventional aluminium casting alloys.

The project team is testing the results on demonstrators: a bionically designed rudder blade holder, which the participants are producing additively and as a cast structure, and an impact absorber mount as a cast component. The participants are also investigating whether the material can be returned to the cycle by remelting.

Procedure

The researchers first determine alloy variants and narrow down suitable compositions with the help of computers. In this way, they avoid brittle components and ensure density as well as melting and solidification behaviour. To do this, they use CALPHAD simulations in particular, which can be used to estimate phase formation and material properties even before experimental tests. The participants also take into account the criteria that apply to high and medium entropy alloys.

The project team then develops casting routes, produces samples and casting demonstrators and evaluates the melt and cast part using testing and analysis methods. On this basis, the participants produce primary material for powder production and provide powders with suitable particle size distribution and reproducible quality.

The team then develops a process route for selective laser melting, manufactures test specimens and transfers the parameters to the bionically optimised demonstrator. Along the process chain, the researchers test the microstructure, porosity, mechanical properties and corrosion behaviour. From the results, they derive adjustments to the alloy and heat treatment and thus ensure the transfer to industrial applications.

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Funding duration:

Funding sign:	03LB2063	**Funding amount:**	EUR 1.6 million

Final report

Further websites

foerderportal.bund.de/foekat/jsp/SucheAction.do?actionMode=view&fkz=03LB2063A - LHEA in the federal funding catalogue

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Project coordination

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English (EN){{ Projektpartner }}

Fraunhofer IAPT

Lightweighting classification

	Realisation
Offer	
Products Materials	✓
Services & consulting Validation, Simulation	✓

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Lightweighting classification

	Realisation
Field of technology	
Design & layout Lightweight material construction	✓
Functional integration	
Measuring and testing technology Visual analysis (e.g. microscopy, metallography), Materials analysis	✓
Modelling and simulation 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 Casting, Others (Laser Powder Bed Fusion (LPBF))	✓
Processing and separating	
Textile technology	

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Lightweighting classification

	Realisation
Material	
Biogenic materials	
Cellular materials (foam materials)	
Composites	
Fibres	
Functional materials Others (Structural materials, heat-stressed materials)	✓
Metals Aluminium, Intermetallic alloys, Magnesium, Others (Copper, tin, etc.)	✓
Plastics	
Structural ceramics	
(Technical) textiles	