# Efficient use of resources in manufacture of metal components

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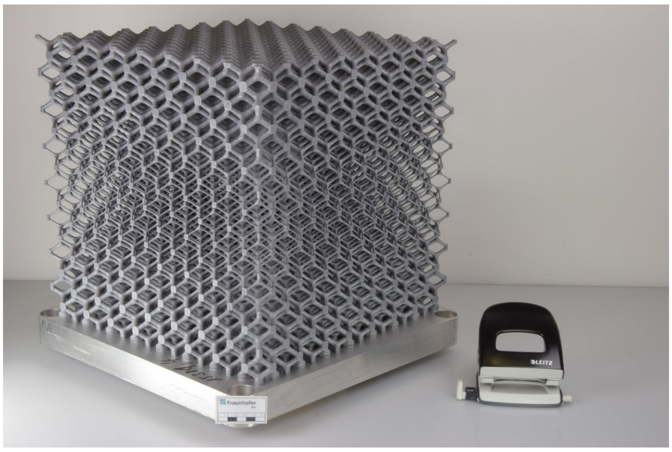
Structurally optimized wheel bearing for an ultralightweight vehicle designed for Additive Manufacturing – made in the 3D-Printing Lab for Metals and Structural Materials at Fraunhofer EMI. Credit: Fraunhofer EMI

Additive Manufacturing has established itself in many industrial sectors as a method for making plastic parts. The 3-D printing of metals is on the road to becoming a similar success story. In the newly opened 3-D-Printing Lab for Metals and Structural Materials at the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI, researchers have investigated how resource-efficient the manufacturing process is when lightweight aluminum components are manufactured using additive methods. They discovered that even marginal reductions in the material and resources used per component yield high cost savings in series manufacturing.

The 3-D-Printing Lab for Metals and Structural Materials at Fraunhofer EMI in Freiburg houses one of the largest commercially available 3-D printers for metal currently in existence. In the research sector, an apparatus of this size is unique. Using the selective laser melting technique (see box "How SLM works"), metal structures with dimensions of up to 40 centimeters can be made by additive manufacturing. 3-D printing offers completely new ways of designing components with highly complex shapes and optimizing their weight.

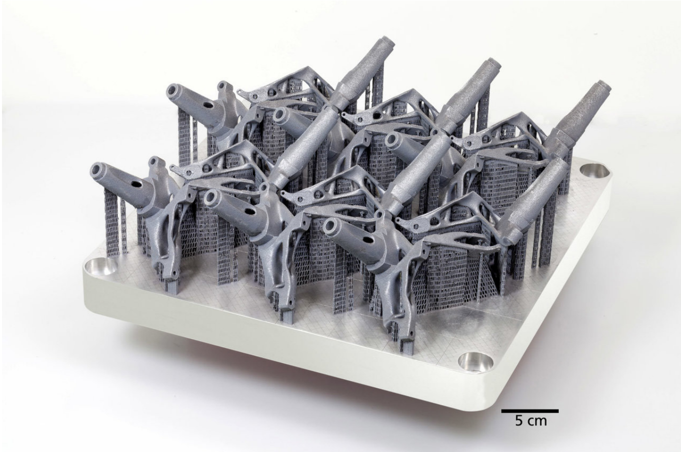
But it is only by combining Additive Manufacturing and intelligent lightweight design that you can maximize resource efficiency in manufacturing. Fraunhofer researchers in the 3-D-Printing Lab have investigated just how economical the manufacturing process is in terms of resources, and whether material and operating costs can be minimized compared to conventional industrial methods. To do this, they took a practical, widespread component for their tests: a wheel carrier such as might be used in a lightweight vehicle. "We were able to quantify the effect lightweight construction – and specifically the use of structural optimization methods – has on the resources used in the SLM manufacturing process," says Klaus Hoschke, scientist and group leader at Fraunhofer EMI. The focus was on energy and material consumption, the manufacturing time and the $CO_2$ emissions that arise during the small-scale production of twelve wheel bearings.



Lattice cube with edge length of 40 centimeters, one of the largest metal structures manufactured using selective laser melting (SLM). Credit: Fraunhofer EMI

## Resource efficiency of a small manufacturing run

After the researchers had used the numerical finite element method (FEM) to simulate and analyze a draft design and determine the right geometric shape with structural optimization methods, they constructed the wheel bearing in an optimized lightweight design. The result was a wheel bearing designed for the defined load scenarios and offering maximum performance. Because of their geometric complexity, structures produced in this way cannot be manufactured by conventional methods such as milling or turning. "With the lighter model, we were able to save hugely on resources during production, as less material has to be produced per component. If you multiply this by the number of units in a small-scale run, then you require less time, material and energy for manufacturing. Reducing volume through the use of higher-strength materials offers the greatest potential for energy savings here," says the researcher. Using the numerically optimized version of the wheel bearing, 15 percent less energy was required for the additive process than for the conventional method: Twelve kilowatt hours of electricity were needed for the conventional design, whereas only ten kilowatt hours were needed for the numerically optimized design. (In each case, the measured value refers to a series-manufactured component.) Manufacturing time was cut by 14 percent and $CO_2$ emissions by 19 percent. And where material consumption was concerned, it could be significantly reduced by 28 percent.

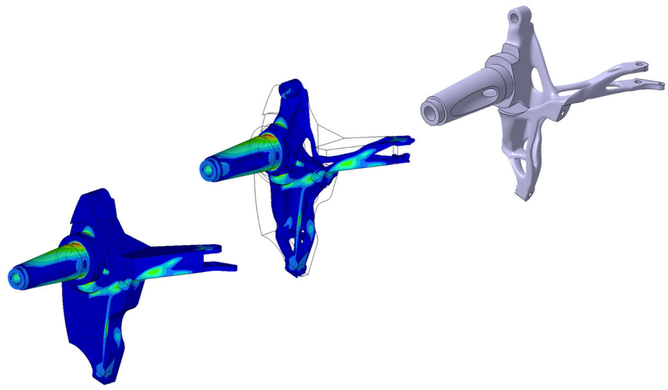



Several structural components arranged on a base plate after a selective laser melting process. Credit: Fraunhofer EMI

## Additive Manufacturing – the method of choice

Although structure-optimizing algorithms and numerical optimization simulations are already being employed in the 3-D printing of components today, they are only used when the component must be extremely lightweight, such as aircraft parts designed to reduce fuel consumption during operation. Components that lack these implications as regards structural optimization are still generally manufactured using conventional industrial methods. The results of the small-scale series production of the wheel bearing suggest that additive manufacturing can also be useful when a component does not have to be structurally optimized as such. "A heat exchanger or a tool mold, for example, do not have to be lightweight to improve their functionality. Nevertheless, it makes sense to design them with reduced weight and volume when manufacturing them additively, because this way you can bring down manufacturing costs," explains Hoschke.

Forecasts on what effect the Additive Manufacturing of metals will have on global production vary widely. But everyone agrees on one thing: for many industries – such as aerospace, automotive engineering, medical engineering and toolmaking – it is a game changer. "Our positive results for resource efficiency in the manufacturing process should reinforce this," says the scientist. In the future, Hoschke and his team want to research the extent to which other design heights, series sizes and materials such as titanium affect the resource efficiency of the manufacturing process.



Finite element analysis of the start design of a wheel bearing technology demonstrator (left); numerical design optimization of the technology demonstrator to reduce the component's mass without impairing functionality (center); and CAD template for manufacturing the 3D metal component (right). Credit: Fraunhofer EMI

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