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GENERATION OF POROUS STRUCTURES WITH LASER POWDER BUILDUP WELDING

THE TASK

The aerospace, energy, medical device and automotive industry sectors all have an enormous innovation potential from lightweight and load-adapted components, which are designed to exactly meet the requirements of their application.

Manufacturing such structures with conventional methods often requires substantial efforts or is not even possible. Generative processes promise an enormous freedom of design. Additive manufacturing methods can build up complex freeform bodies by sequentially depositing the material. Examples of such methods are the generative laser powder buildup welding and laser beam welding in powder beds.

A lightweight materials example from nature is the bone in the (human) body. Bones have a branched internal structure with open and closed cavities that are enveloped by a dense bone skin.

This design principle has great potential for numerous technical applications if it is possible to build separated cavities free of powder. Additive manufacturing is an advantageous method for this task as it creates near-net-shape structures without using more material than needed.

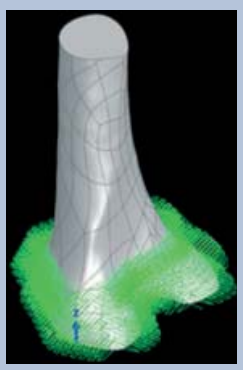
OUR SOLUTION

Bonelike structures are fabricated at the Fraunhofer IWS Dresden using laser powder buildup welding technology with coaxial powder nozzles (Fig. 1). A cavity-forming agent is added in-situ to the raw powder material to froth it up. The delivery and mixing of metal powder and cavity-forming agent occurs via two separated and completely automated delivery channels. The composition of both components can be continuously adjusted, which allows for the local variation of the cavity density and thus the adaptation of the structure to match the needs of the designated application.

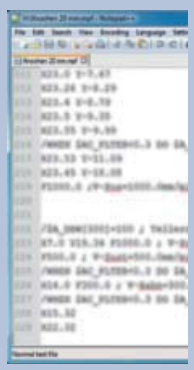
The cavities are directly produced during the fabrication of the part. A fast solidification is typical for the laser powder buildup welding process, which prevents the process gas from escaping. Thus closed cell structures can be produced.

Planning of the buildup strategy and obtaining the NC code

CAD data



slicing of the data file



NC program

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RESULTS

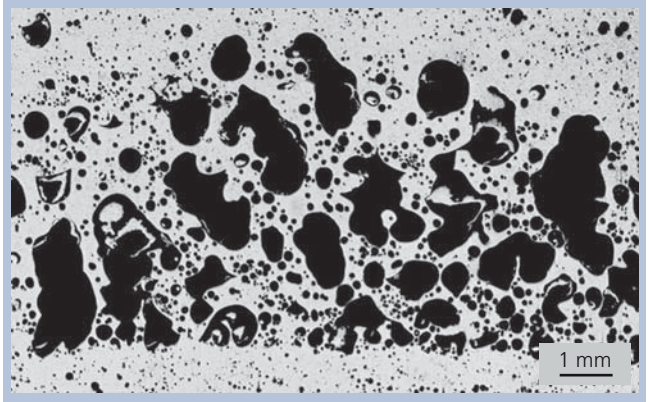
The generative fabrication approach builds up the component layer by layer. This makes it possible to build inner structures with powders. So far we were able to produce cavity-to-material ratios of about 1:1.

But the process is capable of much more than just simply producing porous materials. It is possible to spatially alternate between porous and dense structures, to create density gradients and, thereby, to vary local mechanical properties.

The systems are very much automated so that such alternating density and cavity structures can be readily adapted to the requirements of different applications (Fig. 4). This way it is possible to create steep as well as gradient density transitions (Fig. 5).

This technique adds design possibilities to typical hybrid processes, which combine generating and finishing steps. This in turn leads to new applications of the technology. Lightweight manufacturing is one application area, but new functionalities can be developed such as hidden breaking points or regions with large surface areas to enhance biocompatibility for example.

Polished cross section of a solid body with local variation of the pore density



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1 Process picture of generating the bone structure

3 Bone section generated with laser powder buildup welding process

4 Cut of a bone section with porous inner structure and dense skin

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