Pre-process calculation to optimize laser parameter in selective laser melting

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INTRODUCTION: Selective Laser Melting (SLM) is an additive manufacturing process, where a laser is used to selectively melt areas in a metallic powder bed. It bears a great potential to produce individual parts of complex geometries, e.g. custom-made implants. To optimize the complex SLM processing throughout the entire component, in-process monitoring and pre-process calculation tools could be used in future. In this work a pre-process calculation was applied to adapt the local laser power during the production of titanium parts.

METHODS: The *RDesigner* Software (DMG MORI) is used to execute the pre-process calculation. The 3D part is sliced into Layer Data and furthermore in cuboid voxels of 100 x 100 x 25 µm^3 (Fig. 1). Based on its topo-logical conditions the algorithm then estimates the thermal connection of each voxel: The laser energy can be absorbed well in red-coloured regions whereas green voxels indicate volumes with low thermal absorption e.g. low heat flow through ambient powder or through the filigree support into the building platform. The aim is to locally reduce the laser energy in these overheated regions according to a predefined function.

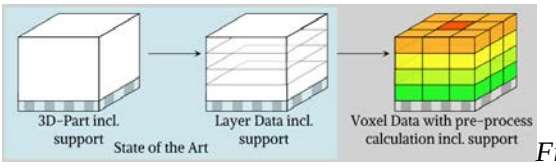

Fig. 1: Estimation of the heat absorption *of each voxel according to its topological situation.*

Mushroom-shaped samples with two different lower cylinder diameter (5 and 10 mm that act as a thermal bottleneck when lasering the massive upper part) were produced out of titanium with the Realizer 125 SLM system (DMG MORI) a) with standard laser parameter (91.5 W) and b) with locally reduced laser energy according to the pre-process calculation.

RESULTS: The results of the pre-process calculation are shown in Fig. 2: Two critical zones were identified and appear green: the connection to the underlying support and the overhanging undersurface. In such overheated areas, the laser power will be dynamically adjusted according to the laser adaption function (Fig. 2c).

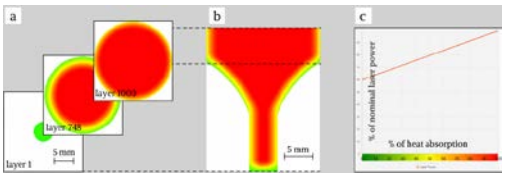

Fig. 2: Result of the pre-process calculation: a) slices at different height, b) frontal plane of the whole sample, c) laser adaption function.

Both parts with 5 mm and 10 mm cylinder diameter could only be completed with the adapted, pre-calculated laser parameter (Fig. 3b). Standard process parameters, however, failed because too much energy was brought in. Therefore, the regions near the overhang superheated because of inadequate heat absorption. Consequently, internal tensions led to deformations. Due to warpage, the building job could not be completed, see Fig. 3a.

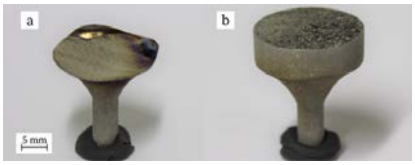

Fig. 3: a) Standard laser parameter: Overheated, incomplete part, b) optimized laser parameter: complete part.

DISCUSSION & CONCLUSIONS: For critical samples with overhangs, thin features such as holes or struts, or large cross-sectional changes, the pre-process calculation can be helpful. The local adjustment of the laser power can increase the quality of the components. However, the definition of the size of the considered topological environment and the precise function of reducing the laser power input remains challenging.

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