INFRARED POWDER BED HEATING UNDER HIGH PURITY ATMOSPHERE (InfraPur)

A promising remedy to avoid undesired macro-cracking of hard to weld materials during SLM processing is a build chamber pre-heating system. The increased powder bed temperature reduces cooling rates as well as residual stresses. In this project, a in-house developed build chamber pre-heating system is utilized to process the titanium alloy Ti64 and the titanium-aluminide alloy Ti-48Al-2Cr-2Nb. In addition to the high proceseing temperatures up to 800°C, a gas purification system will be integrated in the SLM Solutions 280 machine in order to reduce residual oxygen content.

PROJECT OVERVIEW

DURATION

05/2020 – 05/2021

PARTNER

Industrial Consortium of DMRC

FUNDED BY

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Motivation and objective

In general, selective laser melting (SLM) enables the production of highly complex geometries based on a layer-by-layer material deposition. This process can be used to produce parts and components from materials that are good to weld. However, the defect-free processing of metallic materials that are hard to weld is quite limited. During SLM processing, residual stresses are generated by the laser source imposing rapid heating and cooling in the melt track as well as in the heat-affected zone can result in undesirable micro- or macro-cracks. Ultimately, these crack-affected components cannot be used in practice.

One promising remedy for a crack-free SLM production of materials that are difficult to weld can be identified by increasing the powder-bed temperature. So far, in commercially available SLM machines, a baseplate pre-heating systems up to 500 °C, is considered state of the art. Just by heating the baseplate leads to a significant temperature gradient in the built direction so that after a few millimeters, the preheating is no longer effective.

Based on the latter, a build chamber pre-heating system was developed at the chair of materials science and the chair of automotive lightweight design, in which a homogeneous heat input of the process wall up to approximately 800 °C is feasible (Figure 1). The deposited metal powder, as well as the components, are homogeneously heated in the z-direction, reducing the temperature gradient significantly.

Additionally, the project addresses the effect of residual oxygen during SLM processing on the powder material and the components built. It will be investigated if oxygen contamination occurs, which may lead to reduced powder reusability and deteriorating mechanical performance of the parts manufactured via SLM. A schematic illustration of the gas purification system employed is revealed in Figure 2.

Preliminary investigations have revealed a pronounced oxygen pick-up of the metal powder at higher pre-heating temperatures.

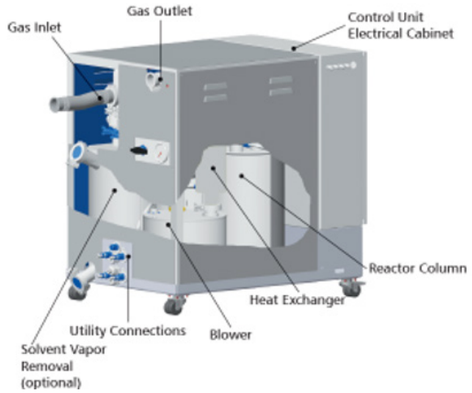

FIGURE 1: Schematic illustration of the MB10 H2O and O2 gas purification system from MBraun, which was integrated into the gas circuit of the SLM system.

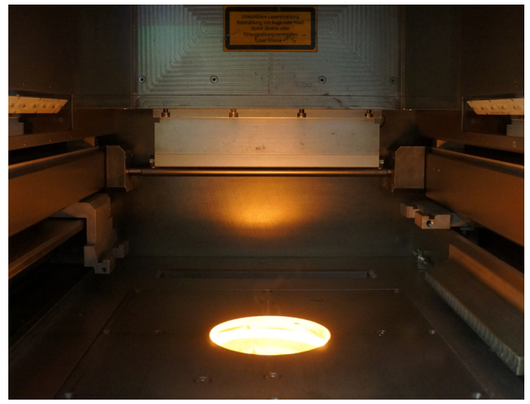

FIGURE 2: Installation of the IR build room heater in the SLM Solutions 280 HL.

Thus, the combination of the pre-heating system with a gas-purification system is highly interesting. A commercially available gas purification system will be integrated into the SLM machine. Regarding the materials, investigated, the titanium alloy Ti64 and the titanium-aluminide alloy Ti-48Al-2Cr-2Nb will be analyzed. Both materials are highly affine to oxygen. Furthermore, the TiAl-alloy has to be processed at elevated temperatures. These alloys are, thus, excellent candidates to demonstrate the effect of the build-chamber pre-heating system and the gas purification system.

Approach

First, the build-chamber pre-heating system and the gas purification system are integrated into the SLM Solutions 280 1.0 machine. After the machine modification, SLM processing parameters are generated at high pre-heating temperatures to achieve crack-free and bulk specimens. During each build-job, a metal powder will be extracted an analyzed concerning an oxygen pick-up. The specimens printed are then microstructurally and mechanically analyzed to determine the effect of the elevated processing temperatures and the oxygen content in the build chamber. Finally, a prototype is fabricated consisting of Ti-48Al-2Cr-2Nb.