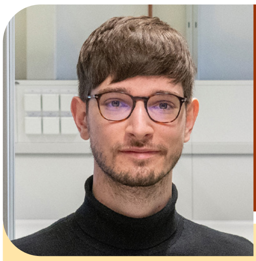

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ABSTRACT

PRESENTATION

PAPER

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FUNDAMENTALS OF QUANTITATIVE TEMPERATURE DETERMINATION DURING LASER POWDER BED FUSION OF METALS (PBF-LB/M) VIA HYPERSPECTRAL THERMOGRAPHY

Additive manufacturing (AM, also known as 3D printing) of metals is becoming increasingly important in industrial applications. Reasons for this include the ability to realize complex component designs and the use of novel materials. This distinguishes AM from conventional manufacturing methods such as subtractive manufacturing (turning, milling, etc.). The most widely used AM process for metals is laser powder bed fusion (PBF LB/M, also known as selective laser melting SLM). Currently, it has the highest degree of industrialization and the largest number of machines in use. In PBF LB/M, the feedstock is present as metal powder in an inert gas atmosphere inside a process chamber where a laser melts it locally. By repeatedly lowering the build platform, applying a new layer of powder, and then selectively melting it with the laser, a component is built up layer by layer. The local temperature distributions that occur during this process determine not only the properties of the finished component, but also the possible formation of defects such as pores and cracks. Due to the high relevance of the thermal history for precise geometries and defect formation, a temporally and spatially resolved measurement of quantitative (or real/actual) temperatures would be optimal. Quantitative values would ensure comparability and repeatability of the AM process which would also positively affect the quality and safety of the manufactured component. Furthermore, it would also contribute to the validation of simulations and to a deeper understanding of the manufacturing process itself.

At present, however, only qualitative monitoring of the thermal radiation is performed (e.g., by monitoring the melt pool using a photodiode), and safety-relevant components must be inspected ex situ afterwards which is time-consuming and costly. A reason for the lack of quantitative temperature data from the process are the challenging conditions of the PBF LB/M process with high scanning speeds and a small laser spot diameter. Furthermore, the emissivity of the surface changes at high dynamics (temporally/spatially) as well as with temperature and wavelength. This specifically makes contactless temperature determination based on emitted infrared radiation challenging for PBF LB/M. Although classical thermography offers very good qualitative insights, it is not sufficient for a reliable quantitative temperature determination without a complex temperature calibration including image segmentation and assignment of previously determined emissivities.

For this reason, this publication presents the hyperspectral thermography approach for the PBF LB/M process: The emitted infrared radiation is measured simultaneously at many adjacent wavelengths. In this study, this is realized via a fast hyperspectral line camera that operates in the short-wave infrared range. The thermal radiation of a line on the target is spectrally dispersed and detected to measure the radiant exitance along that line. If the melt pool of the PBF LB/M process moves through this line at a sufficient frame rate, a spatial reconstruction of an effective melt pool is possible.