MEASUREMENT OF ABSORPTION IN THE SLM PROCESS

Task

Selective Laser Melting (SLM), also known as Laser Beam Melting or Laser Powder Bed Fusion (LPBF), is a relatively new technology whose physical sub-processes have not been fully explored and understood. One such sub-process is the absorption of laser radiation during the LPBF process. For it, different process regimes (heat conduction or keyhole regimes) and different material states (absorption of the laser radiation in the substrate, component, in the powder layer and melt) must be considered. This results in different relevant and effective absorptance for the LPBF process, depending on the materials phase.

Method

The core of the experimental set-up is an integrating sphere placed in an industrial LPBF system, which allows experimental measurements of the diffuse and directed reflection for the different material (Ti6Al4V) states as well as for the overall process. Since this method has not been tested for the LPBF process, the measurement accuracy of the system was first examined. The measured values for substrates and powder layers were determined experimentally with the integrating sphere and compared with existing literature values. After the experimental setup was validated, the absorption behavior during the LPBF process was analyzed.

Results

The experimentally determined absorptance for the substrate and the powder layer are consistent with comparable calorimeter-based results from the literature and have a relative error of less than 3.2 percent. The measuring method was then used to determine the absorption of the laser radiation in the liquid phase $A_{liq} \approx 63$ percent as well as for the overall LPBF process. In addition, it was determined that the absorptance correlated with the process regimes Keyhole $A_{Keyhole}$ to ≈ 70 to 80 percent and with heat conduction A_{heat} to ≈ 50 percent. Since the design limits the maximum usable laser power (about 30 to 50 percent of the power commonly used) and the process-relevant inert gas flow, the results cannot be transferred to the LPBF process until confirmed by further investigations.

Applications

The experiments determined effective absorptance of the various process regimes and material states as well as the overall process, all of which are relevant input variables for simulations of the LPBF process. In addition, these measurements serve to expand the general understanding of the process.

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3 Long exposure photograph of the LPBF process.