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Increasing the robustness of the laser powder bed fusion by integrating diffractive optical elements

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Additive manufacturing by laser powder bed fusion (L-PBF) is gaining more and more importance for production. Due to its high design-freedom almost any geometrical structure can be manufactured. An essential requirement for industrial products is to ensure the final part quality, as defects such as pores or unmolten powder decrease the mechanical properties. To overcome these needs a fundamental process understanding is necessary. Therefore, current research uses advanced methods like high speed optical [1] or x-ray imaging [2]. It was found that high process dynamics is related to spatter formation and imperfection of the L-PBF part.
An approach for influencing the process dynamics is modifying the laser beam profile. This can be achieved by integration of a diffractive optical element in the laser beam path. This study investigates the influence of three different customized beam profiles on the resulting process window for heat conduction welding and spatters formation in comparison to unshaped beam profiles with laser powers up to 3.2 kW. In comparative experiments between bead-on-plated weld without and with a single powder layer the process dynamics are analysed using high-speed cameras. It is demonstrated that the molten volume and therefore the process dynamics in both setups are in the same order of magnitude. It was found that for complex beam profiles the rule of thumb high peak intensity equals high process dynamics is not valid anymore. It seems to be much more important to take the real intensity distribution into consideration. By using shaped beam profiles the process regime for heat conduction mode welding could be enlarged compared to a multimode laser spot defocussed to the same spot size. It could also be shown that lower process dynamics are reflected in the amount of spatter formation. This demonstrates that the use of beam shaping in L-PBF on is a promising approach for increasing the final part quality by the creation of a more stable melt pool with less spatter formation.

Literature

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