Development and adjustment of a CFD-based model for the prediction of laser operating windows for SLM of metallic powders

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ABSTRACT

The rapid ascending trend of additive manufacturing techniques requires a parallel tailoring and further developing of already existing models applied to industrial solidification processes. Modeling tools of friendly use can be a valid aid in setting optimal operating parameters ranges for extending those modeling technologies to already existing or innovative alloys.

A modelling approach is described simulating the generation of single tracks scanned over the powder bed in a selective laser melting process, attaining track geometry as function of alloy thermo-physical properties, laser speed and power, and powder bed thickness. Post-processing the model results allows for the derivation of the porosity of the printed part, due to lack of fusion, and to yield condition for the formation of porosities due to keyhole formation.

The approach followed is based on a simplified representation of the physical aspects. Main simplifying assumptions concern: the laser energy input, modelling the formation of the pool cavity and the powder bed thermo-physical properties. In the model, the effective laser absorptivity increases with rising the specific energy accounted at the onset of evaporation, to attain the real trend of pool volume increase, the subsequent pool cavity deepening and laser rays' interceptions.

Modeling the effective laser absorption variation has been validated using literature experimental data relating to laser welding tests performed on 316L discs [1].

The model has been adjusted using literature data providing measures of track width and depth and relative density of printed parts, relating to different alloys: Ti6Al4V, Inconel625, Al7050, 316L and pure copper [2-5]. Few adjusting parameters are employed, namely: liquid pool effective thermal conductivity, slope of the effective laser absorptivity curve vs specific energy, slope of laser energy application depth vs specific energy.

Other checks on different alloys are needed to refine the adjustment. The results show good chances about the future possibility of using the model for achieving operating windows for alloys other than the tested ones, avoiding the need of providing experimental data, specific for each alloy.

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