Thermal simulation of scanning paths in LBM additive manufacturing

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ABSTRACT

The Laser Beam Melting (LBM) process is a technique of direct manufacturing that uses a laser with a high power to melt the powder, according to scanning paths. During this process, the achieved temperatures in local areas could generate significant thermal gradients. These gradients lead to the apparition of residual stresses that affect the mechanical characteristics of the part and may cause deformations, as well as micro and macro cracks due to the cooling of the part [1]. In this context, scanning paths play a major role in the fusion and solidification of the material and therefore of the part. For that reason, it is necessary to validate the generation of trajectories considering the thermal behaviour induced by this process.

This work is between macroscopic simulations that consider a set of layers or groups of layers [2] and simulations at the scale of the melt pool [3]. The purpose of this communication is to define and use an analytical thermal 2D model that allows the analysis of the laser trajectories in each layer, in an efficient way.

The proposed approach consists, first, in applying impulsive thermal excitations along the scanning path and then, in summing the thermal conduction effects in the material in order to calculate the distribution of the temperature field over the whole surface, at each time step. Therefore, the main thermal transfer, considered in this simulation, is the conduction. Radiative and convection losses are supposed to be negligible. Indeed, the simulation method is based on a heat conduction model in an semi-infinite environment. The analytical resolution of this model allows the use of an elementary temperature field in the powder. The local effect of the energy deposition is simulated in a simple way, and then cumulated on the surface, according to a predefined trajectory, to obtain a complete cartography of the thermal field. The reduction of the interest area close to the thermal source, while controlling the simulation error, reduces the calculation time as well as the memory space.

The developed model was validated in the case of the Ti6Al4V alloy through a comparison with a finite element thermal simulation of industrial software. The proposed method was then implemented to analyze trajectories commonly used in the literature and industry.

The thermal simulation model will be used to synthesize the scanning paths in the future.

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