A Pragmatic Multiphysics Numerical Model for Melt Hydrodynamics in Selective Laser Melting

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Abstract

This study explores the significance of the recoil pressure, Marangoni convection and surface tension effects in selective laser melting of Ti-6Al-4V. A pragmatic two dimensional model with appropriate powder distribution over a substrate of finite thickness has been developed in COMSOL Multiphysics®; the model reveals complex time-varying flow patterns having strong susceptibility towards process parameter selection. The mechanisms associated with SLM, such as balling effect, the formation of humps, entrainment of pores, the transition from conduction to keyhole regime and formation of spatters have been elucidated. The possible rectification of aforementioned defects is discussed. Further, sensitivity analysis has been employed to obtain process maps for better optimization of the SLM process.

Figures used in the abstract

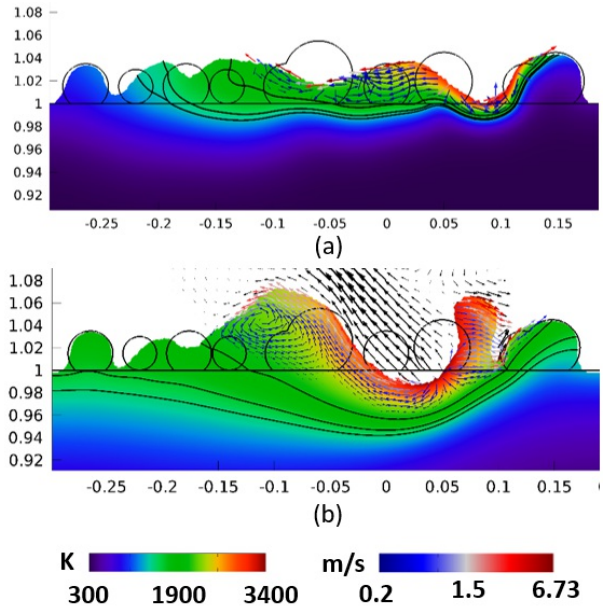

Figure 1: Figure: Melt hydrodynamics along the longitudinal section, with laser moving to the right. The liquid melt pool is confined within the region T>1900K. The melt pool away from the laser irradiance region showcases strong backward melt flow patterns owing to Marangoni convection and surface tension leading to the formation of balling and humps along the surface. In the laser irradiance region melt, depression along with the formation of spatter can be observed due to the presence of recoil pressure. Temperature Surface plot and arrow velocity plot cross section for different process parameters. (a) P=400W, scan speed=4 m/s (b) P=100W scan speed=0.4 m/s. The black colored arrow represents vapor flow from gas-liquid interface with the velocity in the order of 10 m/s.