Modelling heat transfer and phase change in SLM Additive Manufacturing Process

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Abstract

The numerical analysis of phase change problem has been an interesting problem for several years [1]. The phase change takes place in many technological process including solidification and freezing and industrial processes like casting and welding where the analysis of the location of liquid and solid temperature is important. The numerical approaches which have been proposed to model phase change are mainly divided into two classes; the front-tracking methods and the fixed-grid enthalpy methods [2]. Enthalpy method treats the enthalpy as a dependent variable and hence can write a single energy equation for the whole domain in different phases. The evolution of latent heat is accounted for by the definition of enthalpy so the numerical solution is calculated on a fixed grid.

Selective laser melting (SLM) is an additive manufacturing process for production of metallic structural components. In SLM process, the energy of the laser beam is transfered from the top surface to the bottom surface through various physical phenomena such as heat transfer, phase change, fluid flow within the molten pool, and chemical reactions [3]. The thermal history during the SLM process can determine the resulting micro-structure and material properties. Hence, thermal modelling of SLM will help to achieve process and product optimization.

We present a model to study transient temperature evolution using heat transfer equation coupled with the phase function. The model describes the multiple phase change while balancing the thermal energy. We use the enthalpy method to differentiate the powder phase, melting liquid phase, dense solid phase and vaporized gas phase. The model is solved numerically by finite difference method and consider the temperature dependent material properties. We present the simulations that show the temperature evolution during SLM process.

Keywords— Heat transfer, Enthalpy method, Finite difference method, Selective laser melting

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