Lattice Boltzmann method for convection and heat transfer in multi-layer metal droplet deposition

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Abstract

Metal Droplet Deposition Manufacture (MDDM), benefited on the advantages including the low material consumption, environment protection and procedure simplification, has gradually become the mainstream in manufacturing industry. The solidifying and remelting in deposition, which are the crucially important parts of MDDM, involve non-linear convection and heat transfer process. Based on the framework of D3Q19 Lattice Boltzmann Method (LBM) for simulating multi-layer deposition process, an element birth and death technology was adopted to realize the loading of droplets. A newly method, coupling of the double distribution function (DDF) and the enthalpy-based model, was constructed to solve the flow and thermal fields and accurately described the phase transform. The macroscopic governing equations can be exactly recovered from the LB equations by the Chapman-Enskog expansion. In such a case, the differences in thermal cycle, a critical character on the molding quality, can be tackled by independently adjusting the relaxation time and the thermal conditions including the temperature of droplets T_D and substrate T_S. Additionally, the visualization of the convection and heat transfer between the new impacting droplet and the previous one revealed the combination process of droplets involved solidifying and remelting, and the deposition error can be controlled by adopting appropriate T_D and T_S. There's a great agreement with the previous experimental and numerical results, demonstrating the present model can provide a computation method for simulating the phase transition problems in the metal droplet deposition manufacture.

Keyword: **Lattice Boltzmann Method; Metal Droplet Deposition Manufacture; Solid-liquid phase change; Double distribution function; Enthalpy-based model**