Hydrodynamic model based on extended Discontinuous Galerkin method for powder-bed fusion numerical simulation

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ABSTRACT

Powder-bed fusion during additive manufacturing processes leads to microscopic defects which originate from molten pool instabilities. To address this issue, a numerical model focused on laser/matter interaction, packed particles melting, melt pool formation and thermodynamics effects is developed.

The approach assumes an incompressible Newtonian laminar flow of the melt pool and uses an enthalpy-porosity method to model the solid/liquid metal transition. The jump conditions at the liquid-solid interface for the energy equation are included through the modification of the enthalpy which encorporates the latent heat of fusion. A Carman-Kozeny porosity method is implemented in the momentum equation to penalize the flow in the solid phase. Molten flows are driven by natural and thermocapillary convection which are modelled using Boussinesq approximation and Marangoni free-surface stresses respectively. This numerical model is implemented within a Discontinuous Galerkin (DG) finite element formulation which ensures high order convergence on unstructured mesh [1].

The complex geometry of packed particles within the powder bed leads us to consider an appropriate embedded method to ensure accuracy in the vicinity of the particles surface. In this work, a sharp interface method is integrated into the three dimensional high-orderDG code Argo [2]. This method allows to keep the high-order of convergence of the DG scheme even near the interface not conforming with the mesh. This is essential to capture the thermo-hydrodynamics phenomena during powder-bed fusion with accuracy.

Preliminary results have been produced in the framework of the AM-Bench 2018 for hydrodynamic simulations. The comparison with experimental data provided will be compared in this work. Current work is dedicated to investigate the occurrence of discontinuities in fused powder tracks depending on material properties and process parameters. Future work will be devoted to upgrade the model to account for normal surface tension effect and recoil pressure associated with vaporization. This will require a robust numerical method adapted for high-order schemes.

REFERENCES

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