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Numerical Simulation of Laser Fusion Additive Manufacturing Processes using the SPH Method

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Abstract

In this work, the Smooth Particle Hydrodynamics (SPH) method, a Lagrangian mesh-free numerical scheme, is adapted for the first time to resolve thermal-mechanical-material fields in a range of Laser Fusion Additive Manufacturing processes. The method is capable of simulating large-deformation, free-surface melting, flow, and re-solidification of metallic materials with complex physics and material geometries. A novel SPH formulation for modeling isothermally-incompressible fluids, which allows for the accurate simulation of thermally-driven, liquid-phase metal expansion/contraction, is presented and verified. Fundamental validation of the methodology is performed via comparison with spot laser welding experiments. The methodology is then used to investigate the the specific Additive Manufacturing process of the Selective Laser Melting of Metallic, micro-scale particle beds. The physics of a track deposition process is explored through numerical experiments, and the influence of processing parameters on the quality of the finished melt-track is investigated. The unique abilities of using a Lagrangian mesh-free method, as opposed to mesh-based numerical schemes, to model this process is highlighted. The SPH method is found to be a viable and promising numerical tool for simulating laser fusion driven Additive Manufacturing processes.

Keywords: SPH, Selective Laser Melting, Additive Manufacturing, Computer Simulations, Heat Flow, Laser powder bed fusion

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