Dual-time stepping method for modelling of transient multiphase dynamics in laser metal additive manufactures (Sim-AM 2019)

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Understanding the dynamics and interactions of the solid-liquid-vapour multiphase thermal flow is necessary to understand the bead shape and quality in laser metal additive manufacturing. Modelling the transient multiphase dynamical behaviours are very time-consuming due to the sub-microsecond (about 10^{-7}~10^{-8} s) dynamic time-scale of the laser-induced vapour behaviour. In this paper, we proposed a dual-time stepping method: using a short time-scale (sub-microsecond) to calculate the vapour dynamics and a long time-scale (about 10^{-5}~10^{-6} s) to calculate the molten pool dynamics separately. Then, we use a ghost-fluid-based two-way coupling boundary condition to couple the vapour and molten pool dynamics. The weld pool shape, fluid flow pattern, keyhole oscillation behaviour and the vapour flow behaviour are consistent with experimental and literature data. The computational speed is accelerated by more than 30 times. Therefore, our proposed method could be used to efficiently understand the underlying mechanisms in laser metal additive manufacturing.