APCOM & ISCM
11-14th December, 2013, Singapore

Numerical Simulation of Containerless Solidification

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We present a front-tracking/finite difference method for simulation of containerless solidification, where the melt is confined by its own surface tension. The problem includes temporal evolution of three interfaces, i.e. solid–liquid, solid–air, and liquid–air, that are explicitly tracked under the assumption of axisymmetry. The solid–liquid interface is propagated with a normal velocity that is calculated from the normal temperature gradient across the front and the latent heat. The liquid–air front is advected by the velocity interpolated from nearest bulk fluid flow velocities. Method validation is carried out by comparing computational results with exact solutions for two-dimensional Stefan problems. We also verify the numerical method by studying the case of equal densities of the solid and liquid. As an application of the method to a practical problem, we use the method to investigate a droplet solidifying on a cold plate in which there exists volume expansion.

Keywords: Containerless solidification, Front-tracking, Droplet, Surface tension