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Multiscale modeling of interfacial flow in particle-solidification front dynamics JUSTIN GARVIN, YI YANG, H.S. UDAYKUMAR, The University of Iowa — Particle-solidification front interactions are important in many applications, such as metal-matrix composite manufacture, frost heaving in soils and cryopreservation. The typical length scale of the particles and the solidification fronts are of the order of microns. However, the force of interaction between the particle and the front typically arises when the gap between them is of the order of tens of nanometers. Thus, a multiscale approach is necessary to analyze particle-front interactions. Solving the Navier-Stokes equations to simulate the dynamics by including the nano-scale gap between the particle and the front would be impossible. Therefore, the microscale dynamics is solved using a level-set based Eulerian technique, while an embedded model is developed for solution in the nano-scale (but continuum) gap region. The embedded model takes the form of a lubrication equation with disjoining pressure acting as a body force and is coupled to the outer solution. A particle is pushed by the front when the disjoining pressure is balanced by the viscous drag. The results obtained show that this balance can only occur when the thermal conductivity ratio of the particle to the melt is less than 1.0. The velocity of the front at which the particle pushing/engulfment transition occurs is predicted. In addition, this novel method allows for an in-depth analysis of the flow physics that cause particle pushing/engulfment.

Justin Garvin
The University of Iowa

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