Numerical Modeling of Solid Movement in Phase Change Processes

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Abstract: In the modeling of liquid to solid phase change processes the movement of the solid phase (e.g., the grains that form when solidifying an alloy) can have a significant impact on the timing and pattern of the process. While a number of solidification models account for the movement of the solid phase, additional analysis is needed to fully understand the phenomena and guide in the selection of appropriate numerical technologies for its resolution. Towards this end, here, we introduce a reduced complexity model (RCM) to describe the solidification of an initially liquid binary material flowing between two parallel cooled plates from the location x = 0. We write the 2-D governing equations in a dimensionless form for this set up, introducing into the model a single parameter that controls the flow velocity of the solid (VS) between the limit values of 0 (fixed) and (VL) (the fluid phase velocity). We construct and solve a 2-D numerical solution for this coupled heat/flow model. Further we show that, with appropriate choices of the Peclet and Biot numbers, our numerical predictions are in an agreement with a closed form analytical solution. Results from the model clearly demonstrated that the rate of solidification is delayed when the solid moves and that the point where full solidification between the plates occurs is further down stream of the entrance at x = 0.

Keywords: Two phase model; enthalpy equation; solidification; solid movement.