ABSTRACT

Numerical investigations on the effects of natural convection induced due to temperature and concentration gradients during melting and solidification of pure metals and binary alloys have been carried out.

The fixed grid enthalpy-porosity method has been adopted for modeling phase change of pure metals. The coupled differential equations are discretized using the control volume based finite difference scheme. SIMPLER algorithm is adopted for solution of the flow field. The energy equation is iterated during an overall iteration loop, to first obtain a convergence in the nodal liquid fraction value which proved to be time efficient. The capability of the enthalpy-porosity method is demonstrated by solving melting and solidification problems. The enthalpy-porosity formulation has been adopted to study the effects of liquid superheat and solid subcooling during solidification and melting of pure metals.

Studies on solidification of binary alloys are based on the continuum model. The strongly coupled elliptic partial differential equations have been solved using the finite difference control volume approach with SIMPLER algorithm. The model is validated by comparison with the available numerical and experimental results for NH_4CL-H_2O binary system available in the literature.

The continuum formulation has also been employed to study thermosolutal convection and macrosegregation during solidification of hypereutectic and hypoeutectic NH_4CL-H_2O binary system in trapezoidal side chilled ingots. Magnetic field effects have been included in the continuum formulation to investigate the influence of magnetic field strength and direction during solidification of a binary metal alloy (Pb-Sn) in a statically cast rectangular ingot. In an attempt to account for the solid motion and anisotropic permeability behavior during solidification of binary metal alloys within the framework of the continuum formulation, a porous-viscous model has been developed which treats the mushy zone as a porous medium or a viscous fluid with an effective viscosity depending on a critical solid fraction.