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Measurements and modelling of dendritic growth velocities of pure Fe with thermoelectric magnetohydrodynamics convection

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Abstract

Dendritic growth velocities of pure Fe under static magnetic fields of intensity ranging from B = 0 T to B = 6 T were measured using a high speed camera. The data measured at undercoolings up to ΔT = 190 K show a depression followed by a recovery of the growth velocities as the magnetic field intensity increased from a low range, B = 1 ~ 3 T to a high range, B = 4 ~ 6 T. These magnetic field effects are similar to those previously observed for pure Ni and can be attributed to competing thermoelectric magnetohydrodynamic (TEMHD) convection patterns in the local liquid. The experimental measurements for the two metals were modelled using a three-dimensional dendritic growth theory taking into account convection to estimate the effective flow velocities in the tip growth direction. The calculated effective flow velocities identify two undercooling dependences and a distinct type of magnetic field intensity dependence in common for the two metals. In comparison, the calculated effective flow velocities for pure Fe are generally smaller in magnitude. This difference between the two metals can be related to their differences in material-dependent properties as is revealed by a simple model proposed for a transverse TEMHD flow.