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Growth Morphology of Crystals from Undercooled Melt with Strong Liquid Convection

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Abstract

This paper carried out both experimental and theoretical researches on the formation mechanism of the globular microstructure formed during semi-solid processing of a binary alloy, with focus on the strong convection effect induced by the forced stirring during the processing. Direct observation of the crystal growth of a transparent model alloy, succinonitrile-5 at%water, during semi-solid processing with a self-made experimental device indicates that strong melt convection induced by forced stirring during semi-solid processing will change the crystal growth morphology from dendritical to spherical shape. This morphology change does not originate from dendrite arm fragmentation, instead from the increase of the interfacial morphological stability. The convection effect on the interfacial morphological stability was mainly referred to that strong convection will influence the solute transfer. The convection effect on the solute transfer was accounted for through added a convective loss of solute term in the solute transfer equation. The equation was numerically resolved, and the result indicates that, when the convective loss of solute induced by the tangential flow in front of a spherical crystal is taken consideration in the solute transfer equation, the concentration gradient at the solid/liquid interface decrease. And this leads to an increase in the interfacial morphological stability. The theoretical and experimental results of convection effect on the interfacial morphological stability indicates the same tendency, but the theoretical value is remarkably smaller than the experimental value. The future improvement of theoretical modeling should consider at least two factors: (a) more accurate description of convection effect on the solute transfer, (b) multi-particle effect on the decrease of the melt undercooling.