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Analysis of macrosegregation formation and columnar-to-equiaxed transition during solidification of Al- 4 wt. %Cu ingot using a 5-phase model

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Abstract

A 5-phase mixed columnar-equiaxed solidification model was recently introduced to predict the as-cast structure, and a series of laboratory experiments were performed previously to verify the model. The focus of the current work is to analyze the formation of macrosegregation, which accompanies the formation of the as-cast structure including the columnar-to-equiaxed transition (CET). The as-cast structure and macrosegregation map of a cylindrical Al-4 wt.% Cu ingot poured at 800 °C are used as a reference to validate the calculations. Good agreement between the calculations and the experiment regarding both the macrosegregation and CET is achieved. Thermal-solutal convection and equiaxed crystal sedimentation in such ingot are verified to be key mechanisms governing the formation of macrosegregation. The competitive equiaxed/columnar growth, the soft and hard blocking mechanisms predominate the CET. The numerical study of grid sensitivity indicates that the global segregation pattern and CET are not significantly affected by grid size; however, some fine details of the segregation map which are predicted by fine grid (~0.5 mm) are smeared or locally averaged by the coarse grid (~2 mm). Such details were also not resolved in the measurement. Future investigations are demanding.

Keywords: macrosegregation, sedimentation, CET, as-cast structure, solidification, ingot casting, modeling