PHASE-FIELD MODELLING OF TERNARY EUTETIC SOLIDIFICATION IN HOT DIP GALVANIZATION

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ABSTRACT

Continuous hot dip galvanizing is one of the commercially most important process techniques used for protecting steel sheets against corrosion. Preheated steel sheets are continuously drawn through a pot with a molten zinc alloy. After passing a gas jet that controls the layer thickness multiple cooling units act to cool down the sheet. During passing these aggregates nucleation, dendritic primary solidification and the formation of a binary and ternary eutectic occurs. In the present paper, the coupled modelling of macroscopic heat flow, multiphase thermodynamics and crystal growth during solidification of a Zn-2.5 wt.% Al-1.5 wt.% Mg alloy is presented. The heat flow problem requires a numerical domain in the order of meters, growth of primary Zn-dendrites in the order of several hundred micrometers, and the interdendritic eutectic in the order of several nanometers. For technical alloys like the ternary system considered here, a thermodynamic database has been online linked to a phase-field model to describe phase transformations including all occurring solid/liquid or solid/solid interfaces. Process simulations have been used for getting appropriate thermal boundary conditions for 3D phase field simulations which were performed at three different length-scales. For modelling primary dendritic Zn-a seed density model was used for predicting the grain structure within the Zn layer. At a smaller length-scale, a small part of a Zn-dendrite surface was taken as starting point for simulating the transition between primary binary eutectic and ternary eutectic coupled growth of Zn-rich, Al-rich, and MgZn₂-phases. Finally, the morphology of the ternary eutectic has been evaluated at the smallest length scale. The comparison with real solidification microstructure reveals encouraging agreements.