Microstructure and properties of crystals growing from undercooled Ni-based superalloys

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Predicting the microstructure and distribution of the chemical composition allows us to optimize the mechanical properties of the resulting product. To investigate the process of chemical microsegregation in the Ni-based alloy and to check the possibility of modeling the real alloy with the quantitative phase field model [1-3], experimental studies were carried out to measure the growth rate and analyze the change in the microstructure depending on the melt undercooling. The kinetics of crystal growth was studied using an electromagnetic levitation setup. Chemical composition and microstructure were investigated by Electron Backscatter Diffraction (EBSD) and Energy Dispersive X-ray spectroscopy (EDX). The subsequent comparison of the results of a full-scale experiment with the results of computer simulation of rapidly growing Ni-based crystals has been successfully carried out. In the present study, we apply the phase-field model to simulate the microstructure of growing crystals depending on melt undercooling in quasi-binary approximation. The results of modeling are compared with experimental data obtained on samples of the alloy Inconel 718 processed using the electromagnetic levitation technique. The comparison of model's predictions with experimental data has been made for the quasi-binary approximation of Inconel 718 assuming crystals growing from Ni-Nb alloy's melt.

The microstructures and concentration fields obtained in the phase field modeling can be used as initial parameters for further research, for example, for modeling the formation of secondary phases during heat treatment of crystals. It can be noted that, secondary phase formation between crystalline cellular patterns may occur as Nb-rich regions are expected to transform into Laves phases or γ''-phase during subsequent crystal's growing steps. Modeling of such phase formation is planned as a further development of the phase field model in its chemically multicomponent formulation with application to crystals formation in nickel-based superalloys.

References

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