

COMPARISON OF THE PHASE COMPOSITIONS IN ALLOY 718 MEASURED BY ATOM PROBE TOMOGRAPHY AND PREDICTED BY THERMODYNAMIC CALCULATIONS

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The design of new or modified superalloys is an extremely expensive process. Therefore, thermodynamic calculations are being used to reduce these costs. However, little experimental data are available on the effectiveness of these predictive tools. In this study, thermodynamic predictions have been compared to the measured compositions of the phases formed in Alloy 718 at various annealing temperatures.

The equilibrium compositions and amounts of phases present in Alloy 718 at different temperatures were calculated with the use of Thermocalc™ version M and a commercial 12 element Ni-Fe database. The phases considered in the calculation were face centered cubic γ , L1₂-ordered γ' , DO₂₂-ordered γ'' , δ , Laves, MC, M₆C, M₂₃C₆, M₇C₃ and liquid. It was necessary to suppress the orthorhombic Ni₃Nb η phase from the calculations due to interference with the γ'' phase.

The microstructure of this commercial niobium-containing Alloy 718 was characterized with a combination of atom probe tomography and analytical electron microscopy. The microstructural characterizations were performed with an energy-compensated optical position-sensitive atom probe (ECOPoSAP) and Philips EM400T and CM12 analytical electron microscopes equipped with Link LZ5 EDS/AN10/85S analyzers. Atom probe tomography has revealed the intragranular microstructure consists of a γ matrix with lenticular γ'' precipitates and secondary or fine precipitates consisting of regions of γ'' and γ' phases. Transmission electron microscopy of this alloy has revealed the presence of needle-like and globular γ'' precipitates, coarse disc-shaped and fine lenticular γ'' precipitates, and fine γ' precipitates throughout the matrix. In addition, some isolated MC carbides and Laves phases were observed at the grain boundaries. However, no η phase was observed.

The results of this study indicate that caution should be taken in the application of the Ni-Fe database/Thermocalc™ to superalloys because some of the predicted phases may not correspond to actual microstructure of commercial alloys. When microstructural information is taken into account and absent phases are suppressed in the calculations, reasonable agreement between the atom probe data and the thermodynamic predictions may be achieved. These results also indicate that microstructural characterization is an essential component in the alloy design process.

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