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Segregation and microstructure heterogeneity of single crystal nickel based superalloy ŽS 26

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Abstract

Microstructural heterogeneity was examined in the as-cast microstructure of directionally solidified ZS 26 nickel based superalloy. The distribution of elements in primary and secondary dendrite growth direction was determined by quantitative EDX analysis. Measurements of elemental partitioning show apparent segregation behaviour of Al, Ti, W, and Ni during solidification. The series of one stage solution were used to homogenize samples microstructure of samples and simultaneously to study the solutes redistribution.

The elemental segregation that accompanies the solidification process affects the as-cast microstructure of nickel base superalloys produced by DS technique. Therefore in order to understand, and as well, to modify the structure heterogeneity of castings it is necessary to investigate the segregation behavior of alloying elements.

The samples in the form of rods 80 mm long and 12 mm in diameter were produced by a directional solidification technique. As-cast sample microstructure was single crystal, consisting of the individual well aligned columnar dendrites which passed through the length of the sample. These were generally oriented with $\langle 001 \rangle$ crystallographic direction parallel to the sample growth direction. No differences in microstructure were observed along the longitudinal axis of samples (bottom, mid, and top). A detailed study of microstructure by SEM and TEM revealed changes in size and shape of gamma prime particles inside columnar dendrites and in interdendritic regions. A high temperature single stage annealing was applied to find out the possibility of redistributing the solutes and so homogenize the as-cast microstructure.

Solute profiles for all major alloying elements (except C) in dendritic single crystal samples and in the annealed structure were obtained for primary and secondary dendrite growth directions on longitudinal and transverse sample cross sections. Alloying element distribution coefficients representative of the initial solidification were calculated as the ratio of dendrite core composition to the bulk alloy composition. Calculated values for the distribution coefficients are in good agreement with those stated in [1] [2] for binary alloys. Measurements of element partitioning showed that during the DS processing of alloy ŽS 26, Ti and Al were found to segregate to the liquid and V segregates to the solid. Cr, Co and Ni did not segregate consistently to one phase during solidification. The elemental segregation can be eliminated, as the results showed, by a single stage high temperature annealing treatment.

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Fig.1 Microstructure of casting longitudinal section, x75

Fig.2 Microstructure of casting, transverse section, x75

Fig.3 Morphology of gamma prime particles with size heterogeneity

Fig.4 Microstructure of solution treated samples

Fig.5 Dependence of eutectic volume fraction and solution temperature

Fig.6 Morphology of gamma prime particles corresponding to central part of dendrite

Fig.7 Irregular morphology of gamma prime particles at interdendritic areas

Fig.8 Cuboidal morphology of gamma prime particles after solutionizing

Fig.9 Element concentration profiles along primary dendrite growth and intercellular interface

Fig.10 Element concentration profiles after solutionizing

Fig.11 Measured concentration of solutes corresponding as-cast conditions

Fig.12 Measured concentration of solutes corresponding solution treatment