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Comparative study of the segregation behavior and crystallographic orientation in a nickel-based single-crystal superalloy

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Abstract:

The segregation behavior and crystallographic orientation of a nickel-based single-crystal CMSX-6 superalloy produced by the downward directional solidification process have been investigated. The results were compared with those in the Bridgman process. In comparison to the Bridgman process, the fluctuations in the concentrations of Al, Ti, Ta, Co, Mo and Cr became smaller along the path from the dendrite lobe through the interdendritic region to the adjacent dendrite lobe. This suggests that the degree of the segregation of these alloying elements was reduced by using the DWDS process. In addition to this, the angle between the dendrites' preferred growth direction and the heat flow direction in the DWDS cast samples, and the splaying region were smaller than those in the Bridgman solidified samples. This indicates that better crystal orientation can be obtained in nickel-based single-crystal superalloy components by using the downward directional solidification process.

Keywords: Alloys; Crystal growth; Solidification; Electron probe

1. Introduction

Nickel-based single-crystal superalloys are widely used in turbine blades where high temperature strength and creep resistance are required [1]. The performance of these single-crystal superalloy blades can be improved by either optimizing their composition [2-7] or their solidification process. Nowadays, the major directional solidification processes (DS) are the Bridgman process [8], the liquid metal cooling process (LMC) [9-11] and the gas cooling casting process (GCC) [12]. However, these processes exhibited some disadvantages when they are industrially used to produce highly-efficient single-crystal turbine blades, especially for large industrial gas turbine blades (IGB) [13]. In the Bridgman process, the thermal

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