Contribution ID: **11** Type: **Oral Presentation**

Segregation sensitivity study of Ni-based superalloys for turbine discs application

Monday, 23 September 2024 14:10 (20 minutes)

Ni-based superalloy are sensitive to segregation during solidification and special care must be taken to control final chemistry on billet. Especially, some alloys are very sensitive to the formation of freckle type defect. Thus, the prediction of the evolution of the liquid phase composition and density during solidification is necessary to develop the corresponding melting conditions. Microsegregation of the as cast ingot shall also be reduced by heat treatment. Cycle duration and temperature must be adapted to the as-cast dendrite arm spacing. In this work we investigate the use of DTA sample to study the segregation sensitivity of different Ni-base superalloys. EPMA analyses were used to measure the effective partition coefficient for each alloying element. Some back diffusion is observed for the high segregating alloying elements like Nb and a correction is suggested to predict equilibrium partition coefficient. The correction method is validated for the IN718 alloy by comparison with Thermocalc© Scheil prediction and measured spot segregation. The same methodology was used for high alloyed Ni base superalloys for which the thermodynamic databases are not as accurate. In particular, the partition of W and Al does not match experimental measurements. Freckle sensitivity was investigated based on measured partition coefficients and compared for various superalloys. Finally, the homogenization heat treatment of the as-cast alloy was studied. Diffusion modelling prediction was compared to industrial results. It is concluded that it is necessary to consider the dendrite arm spacing distribution in addition to the average distance to reproduce the experimental results.

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Session Classification: Session 1

Track Classification: Casting and Solidification of Liquid Metals