

A. Stray Grain Formation during Welding of Single Crystals

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Introduction

With the expanded use of single crystals in turbine engines, especially for future generations of large land-based turbines, weld repair of damaged or worn components becomes more and more desirable. Welds of nickel-base single crystal superalloys are vulnerable to stray grain formation, where new grains are nucleated during solidification and the single crystal nature of the base material is lost. A study was undertaken to understand the mechanism of stray grain formation.

Technical Approach

The work was carried out with the use of model Fe-Cr-Ni alloys and commercial nickel-based alloys. Alloy composition was varied, and laser and electron beam welds were made under different welding conditions. The resultant microstructures were evaluated by optical metallography. The tendency to form stray grains was analyzed as a function of alloy composition and welding conditions. Comparison welds on nickel superalloys were also made and evaluated.

Results/Discussion

It was found that stray grain formation can be explained by the extent to which constitutional supercooling (CS) exists ahead of the growing dendrites. As the degree of CS increases, the tendency to nucleate new grains also increases. Results will be presented that support CS as the underlying mechanism of stray grain formation, both in the model alloys as well as in commercial nickel-based superalloys. Finally, projections as to how to minimize stray grain formation tendencies will be provided

Conclusions

The results show that CS is the mechanism for stray grain formation during welding of single crystals. The results also show procedures and alloy modifications that may minimize or eliminate stray grain formation during welding. This information is critical for the successful weld repair of single crystal nickel-base superalloys turbine engine components.

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