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Welding of Single Crystal Nickel-Base Superalloys*

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While it is very desirable to be able to weld single crystal nickel-base superalloys, two main obstacles exist to successful welding of these materials. On the one hand, new grain formation (stray grain formation) during weld solidification destroys the single crystal nature of the base material, and compromises the properties that result from the single crystal microstructure. On the other hand, these materials are very prone to hot cracking. This paper will examine the former, stray grain formation, in detail. Experimental results as well as modeling work will be presented to provide a better understanding of the mechanisms of stray grain formation and the possible means for avoiding it during welding. Several different modeling approaches have been used to investigate the phenomenon in detail and to obtain a thorough understanding of the process. A geometrical model is used to describe the selected dendrite growth directions as a function of position in the weld pool. A finite element code for heat flow was used to identify the weld pool shape. Computational thermodynamics and interface response function models have been used to calculate the extent of constitutional supercooling and the effect of weld metal composition. These models have been combined to evaluate the extent of stray grain formation as a function of weld conditions and crystallographic orientation of the base metal. The model predictions are compared to a series of experimental welds made under different weld conditions. Finally, the relationship of stray grain formation to hot cracking tendencies will be discussed.

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