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Cracking Behavior in Nickel-Based Single Crystal Superalloy Welds

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Laser welding using a powder deposition process was carried out on a commercial nickel-based single crystal superalloy (Rene N5). Two different weld geometries were used. In the first, new material was laid down on top of a slab of the single crystal, simulating a cladding geometry. In the second configuration, a groove was machined in the single crystal sample and laser powder deposition was used to fill the groove. Three different filler metals were used in the investigation: IN625, representing a solid solution filler metal, IN738, representing a γ' strengthened filler metal with modest γ' levels, and MarM247, representing a γ' strengthened filler metal with high γ' levels. The welds were examined metallographically, both in the transverse and longitudinal orientations, to assess the extent of cracking in the welds. The results will be presented. Cracking was found in the fusion zone only, with no cracks in the heat-affected zone. Most cracks were transverse in nature, although some longitudinal cracking was found in a few cases. It was found that the number and size of cracks increased with increasing amounts of γ' in the filler metal. It was also found that cracking was much more prevalent in the groove geometry than in the cladding configuration. In most cases, the cracking was found to take place along stray grain boundaries. These stray grains are solidified weld metal that did not form epitaxially on the base metal, and therefore they represent newly nucleated grains formed during solidification. Their presence also indicates that the base metal single crystal structure is lost in the weld metal. The extent of stray grain formation paralleled the extent of cracking found in the welds. The results indicate that the cracking behavior is strongly dependant upon the presence of stray grains in the welded fusion zone. The dominance of transverse cracks fits agrees with limited stress analyses that indicated longitudinal stresses are the dominant stresses formed during welding in the configurations examined in this work.

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