

A. Structure and Defects in Single Crystal Ni-Base Superalloy Welds

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Weld repair of single crystal nickel base superalloys is a crucial technology needed for economical reuse and repair of used and defective turbine components. The final performance of these welds is closely related to microstructure evolution in both heat-affected-zone and weld metal regions. In this research, microstructure evolution in the HAZ and in the FZ regions was investigated with Laue X-ray microdiffraction with synchrotron radiation, optical and scanning electron microscopy.

Two single crystal alloys, Rene N5 and CMSX-4, in standard heat treated condition and two different crystallographic orientations were investigated. Autogenous welds were made on thin sheets (70mmX50mmX0.8mm). A 1.5 kw continuous wave Nd-YAG laser was used with Ar gas shielding. Different processing conditions were used (power(w) - from 300 to 850; velocity (mm/s) – from 2.1 to 21.2). The top surfaces of the welds were polished and etched. The dendritic orientations were identified from micrographs of sections of the welds and from X-ray microdiffraction.

Weld metal cracks, microporosity and stray grains are typical defects found in the weld joints in the Ni-base alloys. The conditions of the formation of each of these defects were analyzed. Formation of microporosity is due to liquation processes taking place in the peripheral regions of growing dendrites. Micro pores were observed in the interdendritic regions where $\gamma+\gamma'$ eutectic forms during solidification. Under thermal stresses these pores initiate cracks. All cracks may be classified into two kinds. First kind of crack is solidification crack. They are mostly in the central part of the weld.

The second kind of cracks is nucleated near the fusion line into the FZ and then propagates along the interdendritic regions. The second kind of crack depends on the presence of high thermal stresses near the fusion line.

It was shown that it is very difficult to avoid the formation of the stray grains. It was found that stray grains usually nucleate at the fusion line.

The formation of a perfect single crystalline structure without cracks or stray grains was established in the weld joints of these alloys.

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