INHOMOGENEITY OF MICROSTRUCTURE AMD PLASTIC DEFORMATION IN CAST SUPERALLOY IN738 FRICTION STIR WELD

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FSW is applicable to different metal based alloys, amorphous materials and ceramics. In the same time while the FSP joining of light and plastic alloys already has practical application, but FSP of the materials with high melting temperature is still on the stage of development and solving some very important problems. As the principal possibility to apply FSP for join of such materials still has not been proved.

By means of optical and electron microscopy, and synchrotron diffraction, the peculiarities of plastic deformation and microstructural changes in Ni-based superalloy IN738 cast after friction stir welding (FSW) were studied. The combined influence of temperature and plastic deformation resulted in considerable changes in the alloy – the typically stable cast dendrite microstructure of the base metal (BM) is replaced by fine grained structure in the stir zone. The size of these grains depends on the distance from the surface of the weld. Simultaneously dissolution and reprecipitation of the disperse γ'-phase particles of submicron size takes place. In the stir zone, layered and deformed grain structure is formed with a high density of geometrically necessary dislocations. This results in the drastic increase in hardness (up to 650Hv), as compared to 410Hv average in the base metal. The recrystallization coupled with the extensive plastic deformation initiates the formation of certain amount of large grains with low dislocation density (close to that typical of the BM). Both the synchrotron and electron microscopy analyses revealed that plastic deformation is highly localized microscopically, as well as macroscopically different in various locations in the weld. The deformation, as indicated by the dislocation density from synchrotron data, is more pronounced on the advancing side and less pronounced on the retreating side. The bottom region has intermediate amount of the plastic deformation. The size of the thermal-mechanically affected zone varies considerably in different region of the weld.

Results

Extensive plastic deformation with essential mass transport takes place during FSW of cast IN738 which is not typical for this alloy. This is possible due to simultaneous occurrence of several processes coupled with plastic deformation. In particular recrystallization and dissolution at high temperatures strengthening γ'-phase particles. Kinetic phenomena taking place during FSP transform the initial dendrite cast microstructure to highly inhomogeneous microstructure and localized regions of plastic deformation.

Conclusions

1.Application of FSW to cast superalloy IN738 results in a highly localized plastic deformation in the stir zone and the resulting inhomogeneous recrystalllization at both the macro- and micro scales.
2.The stir zone is not homogeneous and consists of deformed small grain matrix with randomly distributed large grains.
3.Grain size in the matrix correlates with their distance from the surface in the central part of the stir zone.