The Dislocation Behaviour and GND Development in Nickel Based Superalloys during Creep

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Abstract

Creep tests of the polycrystalline nickel-based superalloy (RR1000 and Waspaloy) have been conducted at varying stress conditions at 700°C. Investigation through the use of Transmission Electron Microscopy and high resolution EBSD has examined the dislocation networks formed under these conditions, notably those with stresses above and below the yield stress. This study highlights how the dislocation structures vary throughout creep deformation stages and proposes a dislocation mechanism theory for creep in nickel-based superalloys. In particular, the roles of recovery, tertiary gamma prime particles and dislocation foresting are examined, and related back to observations from the Wilshire equation fits. The virgin (untested) material has been forged and heat treated, containing some recrystallised material together with areas of more heavily deformed and recovered material clustered around the grain boundaries. Observations from tests below the 0.2% proof stress show relatively low dislocation densities away from grain boundaries and dislocation movement can be seen to be governed by interactions with the γ precipitates. In contrast, above the 0.2% proof, EBSD and TEM observations show a substantially greater density of dislocations. The increased dislocation density provides an increment of strength through forest hardening. At stresses above the original yield point, determined by the precipitate effects, the creep rate is controlled by interaction with the dislocation forest and results in an apparent activation energy change.

Keywords: Dislocation, GND, nickel superalloy, Creep, EBSD

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