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Anisotropic creep damage and fracture mechanism of nickel-base single crystal superalloy under multiaxial stress

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Abstract

The influence of orientation on the creep rupture properties of a single crystal superalloy DD6 under multiaxial stress was carried out at 980 °C and 400 MPa. A circumferential V-type notched specimen has been designed to investigate the effect of multiaxial stress state on the creep behavior. It is found that the creep lifetime of the [111] oriented notched specimen are slightly longer than that of the [011] orientation and 1.36 times longer than that of the [001] orientation. The computational results show that the strain and damage distribution revealed fourfold symmetry, double symmetry and threefold symmetry for [001], [011] and [111] orientation respectively, which was confirmed by experimental observation. At high temperature the creep anisotropy in three different orientations exhibited mainly in primary and secondary creep stages. Through the study of notched specimens by SEM, the morphology evolution of γ'-phase proved that the directional coarsening was strongly dependent on the local effective stress and the direction of the local max principal stress with respect to loading axis. Fracture morphology displayed uneven cleavage configuration with multi-level feature, and the cleavage planes parallels (001), (011) and (111) crystal plane for [001], [011] and [111] orientation, respectively. The cleavage plane, which is attributed to the cracks propagated along the interfaces of γ/γ' phases, displayed square-like, rhombus-like and hexagon-like feature for [001], [011] and [111] orientation, respectively. Due to the higher density in dislocations of {111} planes, it is more easily as the secondary crack when the crack reach the {111} planes, which is thought to be the main reason of forming different feature on primary cleavage plane.