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Experimental And Numerical Modelling of Cyclic Softening and Damage Behaviors for a Turbine Rotor Material at Elevated Temperature

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ABSTRACT

In order to better understand the physical process of deformation and cyclic softening a 12% Cr martensitic stainless steel FV566 has been cyclically tested at high temperature in strain control. Increase in temperature was found to increase the cyclic life, softening rate and viscous stress magnitude. An increase in the dwell time led to the acceleration of the material degradation. The microstructure changes and dominating deformation mechanisms were investigated by means of scanning electron microscopy, electron backscatter diffraction and transmission electron microscopy. The results have revealed a gradual sub-grain coarsening, transformation of lath structure into fine equiaxed sub-grains, and misorientation angle development in blocks and packets until material failure. Further, a unified viscoplastic constitutive model coupled with a physically-based damage variable, is proposed to capture the cyclic mechanical behavior and microstructural evolution of the material at elevated temperature. The mechanical strength can be reduced by the decrease in the dislocation density, the coarsening of the martensitic lath and the loss of the martensitic structure under cyclic loading. The proposed physically-based damage variable is driven by the evolutions of dislocation density and martensitic lath width. The good comparisons with test results mean that the proposed model can reasonably model the cyclic elastic-viscoplastic constitutive behavior of the material at high temperature.

KEYWORDS

High temperature fatigue; cyclic softening damage mechanics; dislocation density; martensitic lath

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Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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