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An analytical and numerical approach to multiscale ductility constraint based model to predict uniaxial/multiaxial creep rupture and cracking rates

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ABSTRACT

Uniaxial damage modelling use constituent components of the stress/strain measured data which have inherent scatter. Models developed for this purpose have also attempted to address the issues related to failure mechanisms within a multiaxial stress state context. This paper presents the multiscale approach to constraint by using the relationship between Monkman-Grant (MG) uniform failure strain and local sub-grain stress state to predict creep damage and rupture under uniaxial/multiaxial conditions. In essence, a global geometric constraint and a time-dependent local sub-grain constraint is defined with the latter controlling the failure response of the geometry. The model compliments and is in agreement with the established NSW model is also used to predict the lower/upper bound of cracking rates in crack dominated geometries. The model is employed into a finite element (FE) to assess its capability to numerically predict the rupture of plain and multiaxial notched bar specimens based on appropriate void growth models. For verification, creep constitutive properties of long term data from uniaxial and multiaxial tests on Grade 92 martensitic steels from various databases, where available, are used to establish the procedure. Given the level of scatter in the data and fabrication and testing uncertainties that cannot be accounted for in such databases, it is shown that the model is sufficiently simple and robust to be developed for use in conservatively predicting very long term failure times.

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