A continuum based unified multiaxial low- and high cycle fatigue model

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Abstract

Fatigue of materials under variable loading histories is a complicated physical process which is characterized by nucleation, coalescence and stable growth of cracks. Nucleation of cracks starts from stress concentrations near persistent slip bands, grain boundaries and inclusions. Depending on the intensity of loading two ranges of fatigue lives can be classified, namely the low- and high-cycle regime. However, in recent years, it has been observed that fatigue failures can also occur at very high fatigue lives $10^9 - 10^{10}$, below the previously assumed fatigue limits for infinite life.

In this work, an extension of a previously developed continuum based multiaxial high-cycle fatigue model is enhanced to capture the low-cycle fatigue regime. The high-cycle part of the model is based on the concepts of a moving endurance surface in the stress space with an associated evolving isotropic damage variable. The low-cycle part of the model is formulated as a traditional nonlinear isotropic and kinematic hardening J2-plasticity model. The LCF- and HCF-models are connected via the damage evolution equation. Within this unified approach, there is no need for heuristic cycle-counting approaches. The model parameters are easily calibrated and results from some test cases are shown. Implementation of the model is discussed.