MECHANISTIC MODEL FOR HYDROGEN ACCELERATED FATIGUE CRACK GROWTH IN A LOW CARBON STEEL

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Fatigue crack growth in the presence of hydrogen is a severe mode of environmental failure. Although this failure mode has been the subject of intense investigation over several decades, a mechanistic model is still lacking. In this study, we present a model for fatigue crack propagation induced by alternating crack tip plastic blunting and re-sharpening and in which crack growth is governed solely by the plastic dissipation ahead of the propagating crack. The Chaboche constitutive model which is a nonlinear kinematic hardening model capable of capturing many features of material behavior under cyclic loading is used for the calculation of the stress and strain fields. The model is calibrated using a sequence of experimental data from uniaxial strain-controlled cyclic loading tests and uniaxial stress-controlled ratcheting tests of a low carbon steel, JIS SM490YB, in the absence and presence of hydrogen. The numerical simulation results indicate that the proposed crack propagation model can predict Paris law behavior in the absence and presence of hydrogen, and it can successfully demonstrate acceleration of fatigue crack growth in the presence of hydrogen. Significantly, the profiles of the steady-state opening stress and strain ahead of the fatigue crack tip in a C(T) specimen were found to have sections over which they vary as ln(1/r) with distance r from the crack tip.