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Abstract

We present a phase field modeling framework for hydrogen assisted cracking. The model builds upon a coupled mechanical and hydrogen diffusion response, driven by chemical potential gradients, and a hydrogen-dependent fracture energy degradation law grounded on first principles calculations. The coupled problem is solved in an implicit time integration scheme, where displacements, phase field order parameter and hydrogen concentration are the primary variables. We show that phase field formulations for fracture are particularly suitable to capture material degradation due to hydrogen. Specifically, we model (i) unstable crack growth in the presence of hydrogen, (ii) failure stress sensitivity to hydrogen content in notched specimens, (iii) cracking thresholds under constant load, (iv) internal hydrogen assisted fracture in cracked specimens, and (v) complex crack paths arising from corrosion pits. Computations reveal a good agreement with experiments, highlighting the predictive capabilities of the present scheme. The work could have important implications for the prediction and prevention of catastrophic failures in corrosive environments. The finite element code developed can be downloaded from www.empaneda.com/codes

Keywords:
Phase field, Hydrogen embrittlement, Stress-assisted diffusion, Finite element analysis, Fracture

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