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ABSTRACT

Phase field fracture modelling has emerged as a promising computational method for predicting crack initiation and growth in solids. The model builds upon Griffith's thermodynamics framework and enables predicting complex cracking features such as crack nucleation, branching, kinking or merging in arbitrary geometries and dimensions, on the original finite element mesh, and without convergence problems [1]. The method has very recently been extended to fatigue damage [2, 3], showing that features such as fatigue crack growth rate curves or S-N curves can be predicted without any prior assumption. However, most failures often occur due to the combination of environmental effects and mechanical fatigue loading. One of the most relevant environmental effects is the role of what is generally referred to as hydrogen embrittlement [4]. Hydrogen atoms enter the material, migrate through the crystal lattice, and degrade the mechanical properties of the material, reducing (by up to 90%) the fracture toughness and augmenting fatigue crack growth rates.

In this work, the phase field formulation is extended to predict environmentally assisted fatigue. The modelling framework builds upon the success of recent phase field fracture formulations for environmentally assisted cracking under static loads [5, 6]. Of interest are hydrogenous environments and capturing the synergy between corrosion fatigue and hydrogen embrittlement. The model is first used to gain fundamental insight and provide a mechanistic rationale for the trends observed in the experiments. Secondly, the model is employed to capture fatigue damage in several 2D and 3D case studies of particular technological interest. We show that the modelling framework presented can be used to predict the impact of the environment on fatigue crack growth rate curves and S-N curves, enabling optimising design and maintenance through *Virtual Testing*, as well as planning efficient and targeted experimental campaigns.

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