



Phase field Modelling of Environmentally Assisted Fatigue

Golahmar, Alireza; Martínez Pañeda, Emilio; Niordson, Christian F.

Publication date:
2021

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Golahmar, A., Martínez Pañeda, E., & Niordson, C. F. (2021). *Phase field Modelling of Environmentally Assisted Fatigue*. Abstract from COMPLAS 2021, Barcelona, Spain.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Phase field Modelling of Environmentally Assisted Fatigue

Alireza Golahmar^{*}, Emilio Martínez-Pañeda² and Christian F. Niordson¹

^{*}¹Department of Mechanical Engineering, Technical University of Denmark
Kgs. Lyngby DK-2800, Denmark
e-mail: ^{*}aligo@mek.dtu.dk, ¹cn@mek.dtu.dk

²Department of Civil and Environmental Engineering, Imperial College London
London SW7 2AZ, UK
e-mail: e.martinez-paneda@imperial.ac.uk

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.

REFERENCES

- [1] B. Bourdin, G. A. Francfort, and J.-J. Marigo, "The Variational Approach to Fracture", *J. Elast.*, **91**, 5–148 (2008).
- [2] P. Carrara, M. Ambati, R. Alessi, and L. De Lorenzis, "A framework to model the fatigue behavior of brittle materials based on a variational phase-field approach", *Comput. Methods Appl. Mech. Eng.*, **361**, 112731 (2020).
- [3] P. K. Kristensen and E. Martínez-Pañeda, "Phase field fracture modelling using quasi-Newton methods and a new adaptive step scheme", *Theor. Appl. Fract. Mech.*, 102446 (2019).
- [4] R. P. Gangloff, "Hydrogen assisted cracking of high strength alloys", *Compr. Struct. Integr.*, **6**, 31–101 (2003).
- [5] E. Martínez-Pañeda, A. Golahmar, and C. F. Niordson, "A phase field formulation for hydrogen assisted cracking", *Comput. Methods Appl. Mech. Eng.*, **342**, 742–761 (2018).
- [6] P. K. Kristensen, C. F. Niordson, and E. Martínez-Pañeda, "A phase field model for elastic-gradient-plastic solids undergoing hydrogen embrittlement", *J. Mech. Phys. Solids*, **143**, 104093 (2020).