The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

Single-edge notched tension testing for assessing hydrogen embrittlement: a numerical study of test parameter influences

Robin Depraetere[1], Margo Cauwels[2], Wim De Waele[1], Tom Depover[2], Kim Verbeken[2], Stijn Hertelé[1]

[1] Ghent University, Department of Electromechanical, Systems and Metal Engineering, Soete Laboratory, Technologiepark-Zwijnaarde 46, 9052 Zwijnaarde, Belgium, robidpra.Depraetere@ugent.be

[2] Ghent University, Department of Materials, Textiles and Chemical Engineering, Sustainable Materials Science, Technologiepark-Zwijnaarde 46, 9052 Zwijnaarde, Belgium

Key Words: *Hydrogen Embrittlement, Fracture Toughness Testing, Finite Element Method, Continuum Damage Modelling, Diffusion*

Hydrogen will play a key role in the future low-carbon society. In order to ensure the safe transport and storage of hydrogen gas, the phenomenon of hydrogen assisted degradation of steel used in the pipeline grid has to be examined. A finite element based framework developed for describing this phenomenon at the continuum scale is used to assist in the design and analysis of experimental characterisation of tearing resistance. The framework is based on the complete Gurson model for ductile damage and takes into account damage acceleration due to the local hydrogen concentration, and the diffusion of hydrogen. Simulations representing single-edge notched tension (SENT) fracture toughness tests of an API 5L X70 grade steel are performed and results are discussed in terms of crack growth resistance curves. Side grooves are included in the geometry of the SENT model to promote crack growth uniformity. Different boundary conditions are employed, simulating ex-situ and in-situ hydrogen charging of specimens. Moreover, the effect of the applied deformation rate on the dynamics of hydrogen diffusion and the resulting toughness values is investigated. Finally, the effect of the geometry of side grooves on the resistance curves is studied. Accordingly, guidance regarding experimental SENT testing for hydrogen assisted tearing resistance degradation is provided, in terms of test conditions (in-situ/ex-situ), displacement speed and specimen geometry. In future work, the numerically observed effects will also be correlated with experimental tests.