

PhD research vacancy

Development of a micromechanics based damage law for the hydrogen induced failure of notched high-strength low alloy steel components

Contract	4 years
Degree	Master of Science degree in mechanical engineering is required
Occupancy rate	100%
Vacancy type	Research staff; aimed towards obtaining a PhD in mechanical engineering

Project description

High-strength low alloy (HSLA) steel structures are often exposed to hydrogen due to cathodic protection towards corrosion (e.g. in offshore conditions). The structural integrity of these structures is degraded as hydrogen reduces material ductility and toughness. The effects of hydrogen on HSLA steels are not yet fully understood. There is a lack in fundamental understanding of both the material (microstructural) properties contributing to degradation sensitivity, and the numerical techniques to model the process of material degradation.

Ghent University has acquired funding from FWO Vlaanderen (Research Foundation Flanders) for a four-year project investigating the hydrogen assisted degradation of HSLA steels (commonly used in welded structures such as offshore, transmission pipelines, etc.). This project looks at the hydrogen based degradation of HSLA steels in a combined and synergetic experimental and numeric study, and aims to acquire fundamental understanding in the form of a mechanics based damage law for hydrogen induced failure. This damage law will be calibrated on the basis of microstructural and micromechanical measurements, and validated by means of fracture toughness tests of both ex-situ and in-situ hydrogen charged specimens. Particular attention is given to the coupled dynamics of hydrogen diffusion and stress (re)distribution as a crack initiates and grows, and the effect of specimen size in these dynamics. Chosen as a toughness test configuration is the single-edge notched tension (SENT) test. This test procedure has been extensively investigated and optimized during the last decade, given its close relation to the toughness behaviour of thin-walled structures, many of which are exposed to hydrogen.

Two PhD researchers will be working on a full time basis on this project. There will a strong collaboration between both researchers, and sharing of information will be required in both directions. One researcher (a materials engineer who has already been selected) will focus on experimental material characterisation in terms of microstructural, micromechanical, toughness and hydrogen degradation properties. **This vacancy relates to a second PhD researcher, whose focus will be on the development, calibration and validation of a numerical multiphysics (mechanical and diffusion) material model that simultaneously comprises hydrogen diffusion, material degradation due to hydrogen, and damage arising under mechanical load due to this degradation (crack initiation and growth).**

The envisaged work for the current vacancy will start with an extensive literature review and is further subdivided into four distinct tasks:

- 1) Supporting the other PhD researcher in the mechanical material characterisations (micromechanical tests for damage model calibration; procedure development for SENT tests of ex-situ and in-situ hydrogen charged specimens;
- 2) Development of decoupled models for hydrogen diffusion on the one hand, and ductile crack growth assisted by hydrogen induced material degradation;

- 3) Development of a fully coupled, dynamic model that simultaneously describes hydrogen diffusion, material degradation, ductile crack growth and the resulting hydrogen and stress redistribution. To this purpose, a user material subroutine will be developed within the FE software package ABAQUS®.
- 4) Calibration and validation of the models, based on experimental test results, followed by a numerical parametric study comprising material and geometrical effects. Particular attention will be given to size effects on the structural response of hydrogen charged HSLA steel components.

Profile of the candidate

- you possess a Master of Science degree in mechanical engineering
- you have a strong motivation for (and preferably a history of) conducting scientific research and working with complex questions;
- your expertise resides in mechanical engineering, but you additionally have experience and interest in material science.
- you possess structured and creative problem-solving abilities;
- you possess strong analytical and technical skills and take responsibility for the development of your work;
- you can work independently as well as in team;
- you have excellent English communication skills (written and presentation);
- experience with computational mechanics and programming is a prerequisite;
- knowledge of damage and fracture mechanics is an advantage;
- experience with user material subroutine programming in ABAQUS is an advantage;
- experience with experimental work is an advantage;
- knowledge of Dutch is a plus.

Approval and Enrolment

The scholarships for the PhD degree are subject to academic approval. The successful candidate will be enrolled in the doctoral program of Ghent University¹.

Salary and appointment terms

- The salary and appointment terms are consistent with the current rules for PhD degree students.
- A starting PhD student (unmarried) has a **monthly net salary of around 2000€**.
- The duration of the project is **four years**. The research progress is subject to a yearly evaluation.
- The expected starting date is between **April and July 2019**.

How to apply

The application form² should be sent in pdf format to Prof. Stijn Hertelé (stijn.hertele@ugent.be), including:

- CV;
- an official record of transcripts (bachelor and master are required) and a copy of degree certificates;
- a brief motivation letter, showing why the applicant wishes to engage in the scientific research;
- two or more references.

Incomplete applications will not be considered in the selection process.

For further information on the vacancy and/or how to apply, contact Prof. Stijn Hertelé (stijn.hertele@ugent.be).

¹ For more information, see <http://www.ugent.be/doctoralschools/en>

² See <https://www.ugent.be/ea/eemmeecs/en/research/soete/vacancies>