Proposition of Post-Doc position at LITEN/CEA Grenoble and LaSIE CNRS UMR 7356 / La Rochelle university, France.

Establishment of the pressure equivalence between gaseous and electrochemical hydrogen under mechanical testing for a low carbon steel

Context:

Today, hydrogen presents a major challenge for energy and environmental transition. In this context, GRTgaz aims to set up a plan for the deployment and transport of hydrogen (H2) using its natural gas (NG) pipeline network. The perspective of this plan is to increase the part of hydrogen injected into the network while ensuring the safety and durability of infrastructure. It will, therefore, be crucial to assess the impact of the hydrogen injected and the transport conditions (pressure, H2 / GN mixture) on the mechanical properties of the steels constituting the pipes. However, this qualification requires the development of the testing infrastructures more expensive and with a high level of restrictive in terms of security conditions. To overcome these limitations, GRTgaz RICE, and the laboratories LaSIE at La Rochelle University and LITEN at the CEA of Grenoble have joined forces to propose a new project allowing to establish equivalence, in terms of sensitivity to embrittlement by hydrogen, between gaseous hydrogen (H2) and electrochemical hydrogen (Had) under mechanical testing for a low carbon steel.

Work description:

The study will be carried out on a low carbon steel of ferrite-pearlite structure, and will consist in first on performing tensile tests under gaseous hydrogen (mixture H2/NG) according to different conditions of pressure and strain rate, then analyze the damage modes by SEM-EBSD, and measure the hydrogen concentrations by thermal desorption spectroscopy (TDS). In parallel, we will establish the hydrogen solubility in steel as a function of the pressure and mixing conditions (H2/NG). This approach will enable the establishment of a mapping reflecting the relationship between the H2-charging conditions, the mechanical characteristics, and the states of hydrogen in steel.

In the second phase of this study, electrochemical hydrogen charging and TDS tests will be performed on control samples under different conditions (medium, current densities) in order to evaluate the maximum of hydrogen solubility (Had) in the studied steel, and established an “equivalence” with hydrogen gas charging without mechanical solicitation. Then, a tensile test coupled to an electrochemical cell will be developed in order to carry out tensile tests on axisymmetric specimens under electrochemical hydrogen charging (Had) according to different conditions (current density) and strain rate. Following the same approach as for the gaseous part, post-test analyzes by SEM-EBSD and

TDS will be carried out in order to establish a relationship between the states of hydrogen (Had) and the mechanical characteristics.

In addition to this work and in order to identify the impact of hydrogen (H2 and Had) on local mechanical characteristics, a local approach of fracture will be performed under specific conditions of H2 and Had on notched test specimens.

Note that the impact of surface phenomena on the equivalence conditions will also be questioned.

Using the results obtained under electrochemical and gaseous hydrogen conditions, we will establish a theoretical approach with a thermo-kinetic formalism associating the partial pressure of hydrogen (in electrochemistry) to the applied pressure of the H2 / GN mixture (in gaseous).

Work progress:

This study will start at the end of 2020 and will last 24 months. The first year will be done in the LITEN laboratory at CEA in Grenoble for the gaseous hydrogen part, then the second year will be carried out at LaSIE UMR 7356 laboratory in La Rochelle University for the electrochemical part.

Required profile:

Holder of Ph.D. in materials science in materials science, the candidate with experimental sensitivity, must have solid knowledge in metallurgy and mechanical behavior of metals and alloys (from plasticity to damage). Interest for theoretical approaches and finite element modeling (FEM) will be highly appreciated.

Application conditions:

Detailed curriculum vitae with list of publications / conferences, and a cover letter

Laboratories and contacts:

- Laboratoire Composants et Assemblages, Liten, CEA/Grenoble
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