Testing in High Pressure, High Temperature Hydrogen - Feasibility of Test Rig

PUBLISHABLE SUMMARY

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Background

Wide utilisation of hydrogen in various fields of engineering requires an in-depth understanding of its influence on materials performance. Deleterious effects of hydrogen on mechanical performance of numerous material classes have been observed over many years, demanding continuous research and material qualification for current and future engineering applications.

Acquisition of materials performance data for components operating in a high pressure gaseous hydrogen environment has proven difficult due to various challenges in performing mechanical testing in this flammable gas. These difficulties are further exacerbated if environmental variables, pressure and temperature, need to match the service conditions of real components. Consequently, only a limited number of laboratory facilities exist which are able to perform testing in high-pressure, high temperature (HPHT) hydrogen atmospheres.

TWI carried out a Joint Industry Project (JIP) to assess the feasibility of creating a facility for mechanical testing in HPHT gaseous hydrogen environments. This feasibility study concentrated on identification of the relevant components of the proposed HPHT hydrogen testing system as well as proposing conceptual designs for the general vessel layout and its supporting experimental apparatus.

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Objective

- To assess the feasibility of designing a testing system that fulfils the following requirements
  - 1100K specimen temperature
  - 1000bar hydrogen gas atmosphere
  - Tensile testing
  - Fatigue crack growth rate testing
  - Strain-controlled 'LCF' testing
  - Testing with a negative load ratio
  - Fracture toughness testing

Project Outcomes

- Identification of the key components of the proposed HPHT hydrogen testing facility and identification of potential equipment for application in the target testing environment
- Definition of the limitations of applicability of various identified system components together with potential solutions to the foreseen issues
- Concepts regarding the vessel arrangement, test control and data acquisition system design
- A model predicting the temperature distribution within the vessel body
- Heater design to achieve steady state temperature in the specimen
- Outline costs for the construction of the facility and key development and operation risks

Benefits

- Knowledge of whether a facility to perform testing under the desired conditions can be built.

Participants

- GKN Aerospace Sweden AB
- ArianeGroup SAS
- TWI Ltd.

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Scope of Work

Pressure Vessel Construction

- Vessel dimensions: design drivers
- Mechanical testing in HPHT hydrogen
- Vessel materials
- Strength considerations

Conceptual designs

- Vessel shape
- Specimen loading

Vessel closure design

- Sealing arrangement

Acquisition of test data

- Electrical feedthroughs
- Load measurement
- Displacement measurement

Management of the test environment

- Pressure control
- Specimen temperature control
- Temperature distribution

Price and Duration

The project had a duration of 1 year and a budget of £80,000. It was funded by 2 Sponsors plus a TWI contribution.

Further Information

For further information on how a Joint Industry Project (JIP) runs please visit:

http://www.twi-global.com/services/research-and-consultancy/joint-industry-projects/

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