

Overview of Hydrogen-Related Projects in ENDO Research Group

Durability issues for Hydrogen Storage and Fuel Cells

Involved staff
 Researchers: 12
 Technical staff: 7

pertains to Theme 2
 « Heat and mass transfers »
 3 PhD granted

Durability of high-pressure storage vessels (type IV)

composite / liner hydrogen storage vessels (700 bar) filament winding

- bursting resistance (in sound mode)
- temperature range: -40°C up to +80°C
- cycling resistance (15000 cycles)
- tolerance to superficial damage

Thesis M. Bertin (2010)
 B. Gentilleau (2016)
 T. Pham (2013)
 C. Mercadé (current)
 G. Tantchou (current)

Post-Doc A. Benelfellah (2013-2015)
 J. Pepin (2015-2016)

<h4>thermo-mechanical fatigue</h4> <p>experiments ↔ thermo-mechanical modeling</p> <p>access to local fields to highlight coupling effects on the structure failure mechanisms</p>	<h4>damage bursting prediction</h4> <p>identification of elementary damage modes with fiber orientation</p> <p>damage modeling (initial and induced anisotropy)</p> <p>simulation of damage in the structure</p>	<h4>damage tolerance (shock-induced defects)</h4> <p>defects nucleation (reproducibility and localization)</p> <p>estimation of residual lifetime resistance</p> <p>simulation of defects propagation</p>	<h4>fire resistance</h4> <p>degradation reactions and mechanisms</p> <p>residual properties</p> <p>damage kinetics and heat transfer couplings</p> <p>experiments and modelling</p>	<h4>liner collapse</h4> <p>mechanisms and detrimental factors responsible for the initiation</p> <p>post-collapse cyclic behavior of the liner and residual properties</p> <p>experiments and numerical simulations</p>
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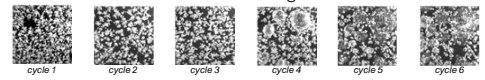
Diffuso-mechanical coupling and damage under decompression in rubbers and thermoplastics

O-ring seals, dispenser plug, receptacle connector of vehicles, hoses

Time-resolved characterization of damage morphology
 optical light transmission, in-situ X-ray tomography

Wide range of mechanical tests in high-pressure hydrogen
 tension, compression, creep, fracture, 3-point bending, fatigue

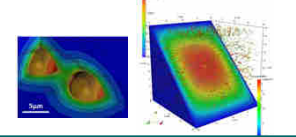
Micromechanisms
 Nucleation, Growth kinetics
 Relationships between microstructure and damage resistance
 Interaction effects between close cavities
 Transition from cavitation to cracking



Modelling routes
 Statistical analysis of cavity fields for variable decompression conditions
 Analysis of a Representative Volume Element for damage modelling
 Numerical simulation of cavity growth (fully-coupled diffuso-mechanics)

Thesis C. Baudet (2006)
 J. Jaravel (2012)
 O. Kane Diallo (2015)
 C. Sanfourche (current)
 M. Fazal (current)

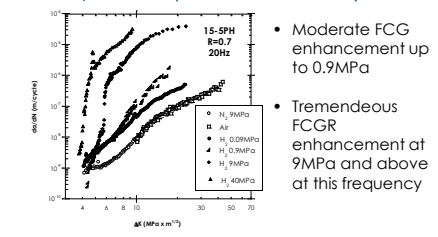
Post-Doc H. Ono (2015)



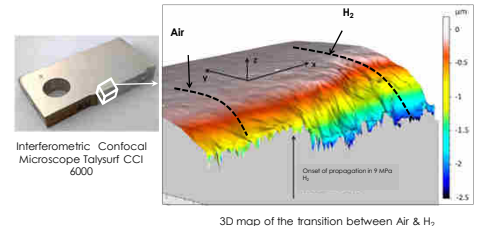
Embrittlement of metals under cyclic loading

- Identification de la cinétique de fissuration en fatigue dans les matériaux métalliques en présence d'hydrogène
- Modélisation par zones cohésives, dans un cadre thermodynamique, du couplage diffusion d'hydrogène / chargements statique, monotone ou cyclique

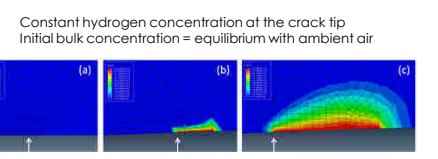
Fatigue crack propagation: influence of pressure (martensitic PH SS)



Hydrogen effect on crack tip plasticity (martensitic PH SS)



Simulation of crack propagation under hydrogen environment

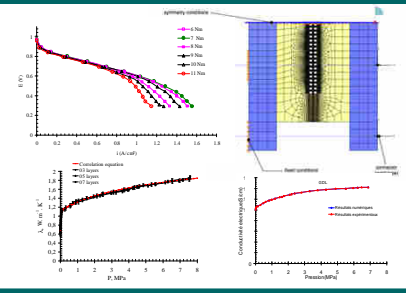


Thesis C. Moriconi (2012)
 G. Bilotta (2016)
 T. Shinko (current)

Post-Doc L. Mansouri (2016-2017)

Durability of PEMFC stacks (collaboration with FTC Department, Pprime)

- Stress state prediction – Relationships to the efficiency
 - Modelling of a cell
 - Electro-thermo-hydro-mechanical couplings
 - Local and global evolution
- Couplings to mechanical pressure
 - Experimental characterization of coupling between pressure and conductivity
 - Phenomenological modelling
- Modélisation complète
 - Prise en compte de tous les couplages
 - Mise en œuvre de caractérisations expérimentales spécifiques
- Stack Fatigue – Extreme conditions
 - Identification of damage kinetics



Thesis M. Hamour (Univ. Tizi-Ouzou) (2013) ...

Post-Doc D. Bograchev (2006) ...

International partners Hydrogenius – University of Kyushu (JAPAN), NTNU Trondheim and SINTEF (NORWAY)

Research Programs OSEO H2E, ANR HIBOU, ANR OSHYRIS IV, ANR TOLEDO, ANR FIRECOMP, ANR COLLINE, GDR HySPàC

Industrial partners Air Liquide, Stelia Aerospace Composites, Hexagon, CEA, IFPEN