CHARACTERIZATION METHODOLOGY OF PIPELINE WELD JOINTS UNDER HYDROGEN ATMOSPHERE USING MINIATURE SAMPLES

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Context: Towards a European hydrogen ecosystem

✓ Hydrogen's potential is now foremost in everyone's minds: as a direct solution for the decarbonization of industry, a source of reindustrialization and a lever for energy self-sufficiency. It seems to be the ISSUE of climate change.

✓ The European Commission has proposed to produce 10 million tonnes of renewable hydrogen by 2030 and import 10 million tonnes by 2030.

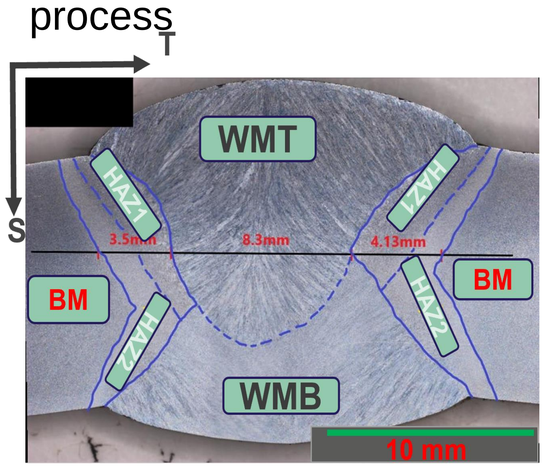
Challenges

✓ The transition of the existing natural gas grid infrastructures is the solution proposed for hydrogen transport and storage.
✓ The natural gas pipelines are made of steel which are not designed for hydrogen transportation and are susceptible to hydrogen embrittlement (degradation of mechanical properties)
✓ To avoid catastrophic failures and ensure pipelines safety, it is of the utmost importance to study the mechanical properties under hydrogen environment.

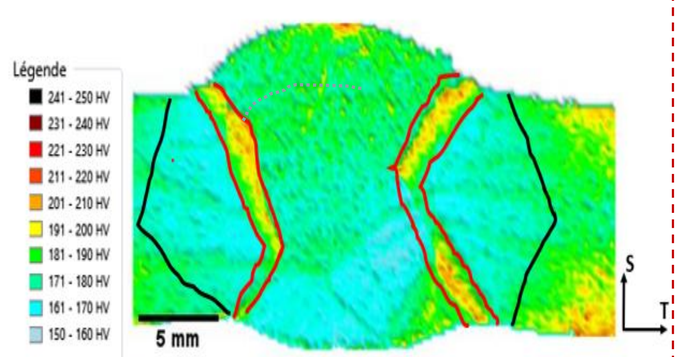
DEVELOPMENT OF NEW METHODOLOGY FOR MECHANICHAL CHARACTERIZATION UNDER HYDROGEGN GAS

Material and Microstructure

- API 5L X52 vintage pipeline steel and their weld joint
- Complex microstructure in weld joint due to the weldment process



Micrography observation of a longitudinal X52 weld joint

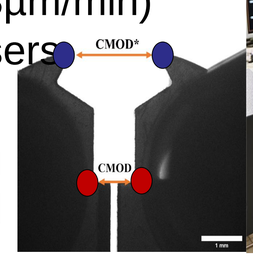


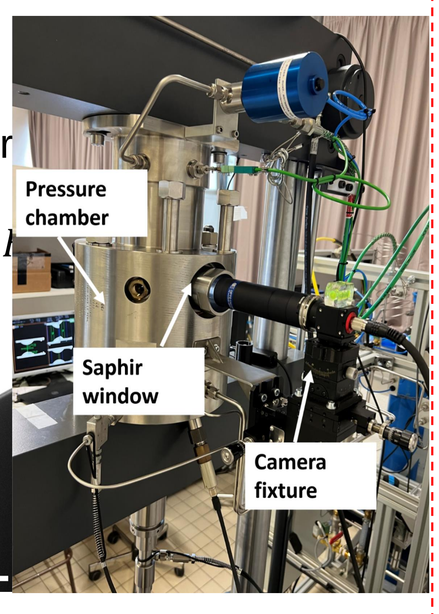
Micro-hardness maping in weld joint

Development of new setup and methodology

❑ ***Experimental setup***

- Servo-hydraulic tensile frame
- Load cell 5kN
- Small pressurized chamber (up to 250 bar
- Four Sapphire windows
- No need for ATEX environment (Low V Vol)
- Small displacement rate (0.3µm/min)
- Oxygen and moisture analysers





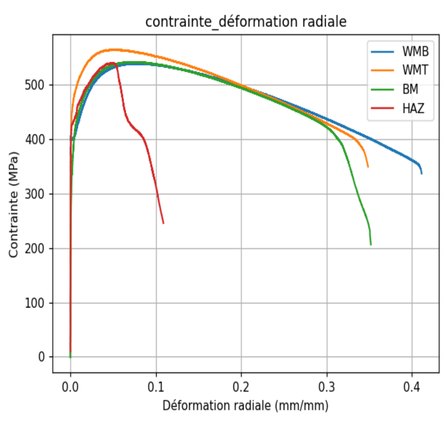
❑ ***Testing methodology***

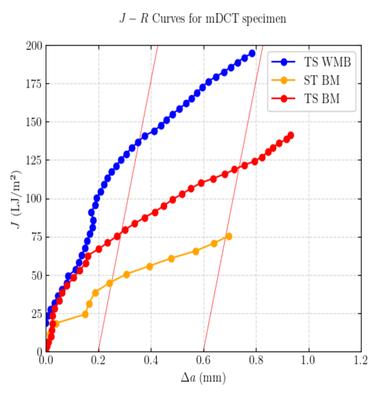
- Optical extensometers using Edge Tracing (ET) are used to control testing machine.

MECHANICAL CHARACTERIZATION OF PIPELINE STEELS AND THEIR WELDS USING SUB-SIZE SPECIMENS

Use of sub-size specimens for mechanical testing

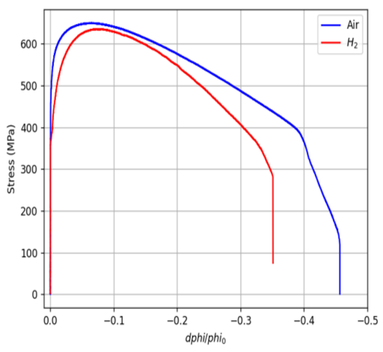
- Tensile testing : mST and mNT specimens
- Fracture toughness testing : mDCT specimens
- All specimens were machined from BM, WM and HAZ

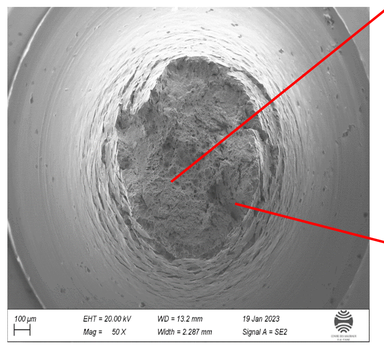


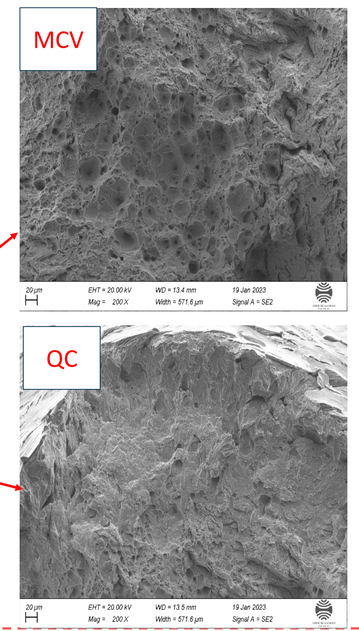


Application to study Hydrogen embrittlement

- Application of the new setup and methodology to hydrogen embrittlement under 200 bar of hydrogen gas.
- Results obtained on mNT show the effect of hydrogen of mechanical tensile properties (loss of ductility and apparition of QC surface)







CONCLUSIONS

- The edge tracing technique applied on sub-size specimens was successfully achieved under air: tensile and fracture resistance tests were successfully performed without mechanical extensometer
- The tensile tests performed on base metal show a a mechanical behavior differences between the core and the surfaces
- Tensile tests under gaseous hydrogen using miniature specimen show a loss in ductility and the apparition of QC surface (hydrogen embrittlement).

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