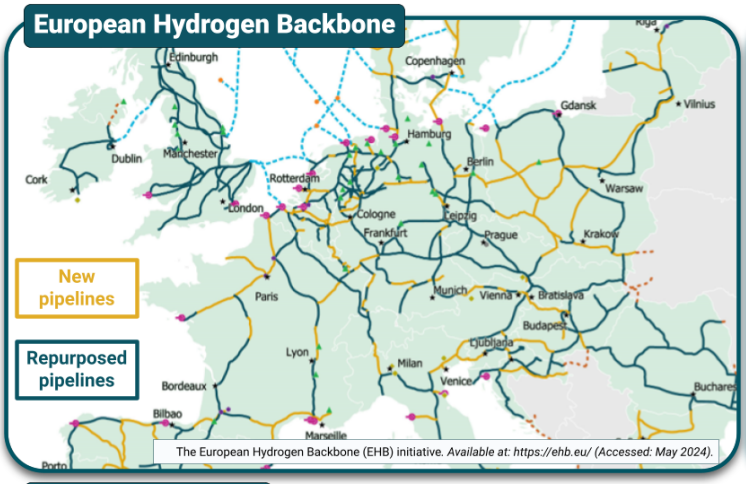
FACULTY OF ENGINEERING AND ARCHITECTURE
DEPARTMENT OF MATERIALS, TEXTILES AND CHEMICAL ENGINEERING
DEPARTMENT OF ELECTROMECHANICAL SYSTEMS AND METAL ENGINEERING
SMS SUSTAINABLE MATERIALS SCIENCE
SOETE LABORATORY

SCREENING THE HYDROGEN COMPATIBILITY OF PIPELINE STEELS AND WELDS

Jubica, Lisa Claeys, Laura De Pue, Julien Schweicher, Wim De Waele, Tom Depover, Kim Verbeken

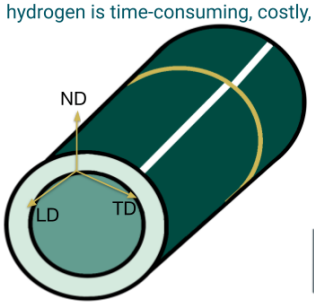
European Hydrogen Backbone



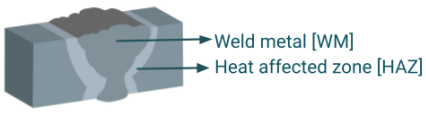
The European Hydrogen Backbone (EHB) initiative. *Available at: https://ehb.eu/ (Accessed: May 2024).*

Objective

Repurposing natural gas pipelines for hydrogen transport is key to **decarbonizing** energy [1]. However, evaluating pipeline steel's fracture toughness and fatigue in high-pressure hydrogen is time-consuming, costly, and demands strict safety measures.



Hence, a **screening methodology** using **quasi-static tensile testing** is considered to assess the susceptibility of **X70 steel base materials and their welds** to hydrogen embrittlement in a relatively fast and less expensive way. **Fractography** analysis remains a crucial tool for interpreting the screening results.

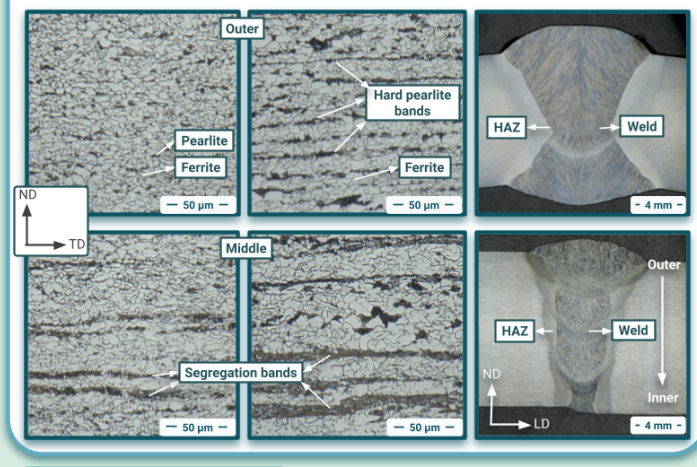


Base material [BM] | Longitudinal Weld [LW] | Girth Weld [GW]

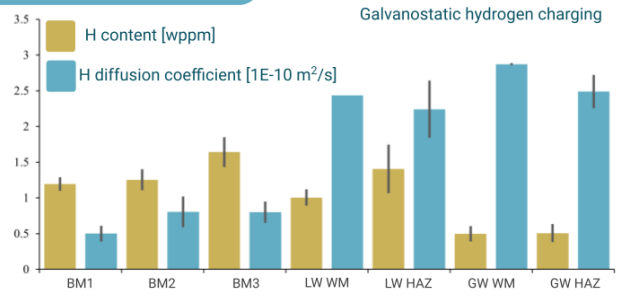
Screening method

1. Microstructural characterization

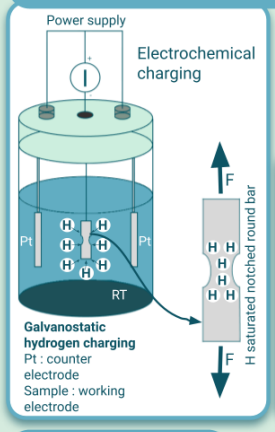
BM1 [In-stock] | BM2 [In-stock] ≈ BM3 [In-service] | LW [top] ; GW [Bottom]



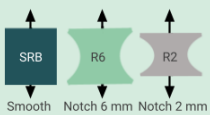
2. Hydrogen characterization



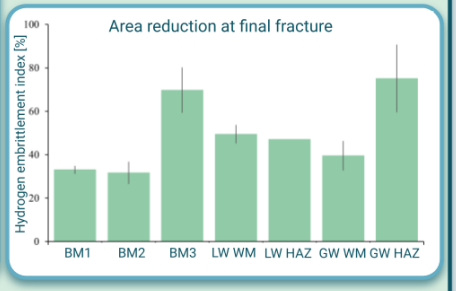
3. Mechanical characterization



Ex-situ quasi static tensile testing



0.5M H_2SO_4 with 1g/l thiourea

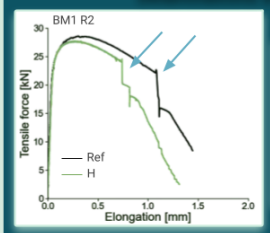


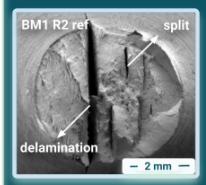
4. Database creation

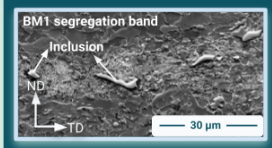
Fractography analysis

General trends

Delaminations & Splits

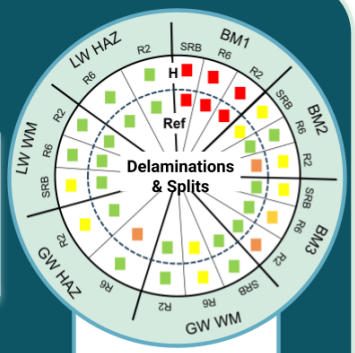






Initiation at microstructural bands in base materials [absent in welds]

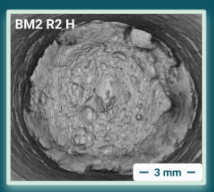
Accelerated by hydrogen surrounding inclusions



Ranking scale for fracture features

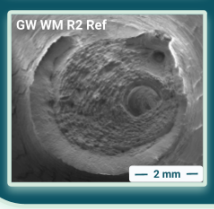
- No defects
- Few defects
- Many defects
- Numerous defects
- Severe defects

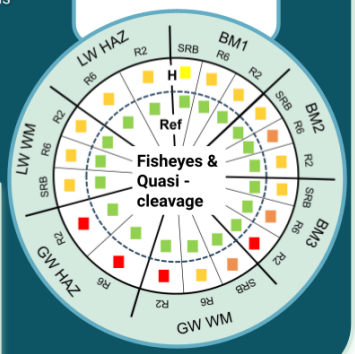
Fisheyes, Quasi - cleavage & Pineapple slices



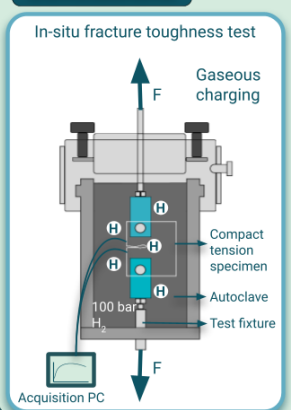
Fisheye initiation at various inclusions: mixed oxides (Si, Al, Mg, Ti, Ca) and sulphides (Ca, Mn)

Pineapple slices at weld flaw





Conclusions



- The natural gas pipeline grid features various pipeline steels and weld microstructures, each of which responds differently to hydrogen exposure.
- Base materials and weld materials must be evaluated separately.
- Emphasis should be placed on identifying trends in the materials' responses across different testing methods.
- Additionally, the applicability of the screening method needs verification against gaseous hydrogen results to determine the most suitable Embrittlement Index.

References

[1] EHB European Hydrogen Backbone, 2021.
URL: https://ehb.eu/page/publications

Contact

jubica.jubica@ugent.be
tom.depover@ugent.be
kim.verbeken@ugent.be

GHENT UNIVERSITY
economie
fluxys