FACULTY OF ENGINEERING AND ARCHITECTURE

SOETE LABORATORY – EMSME (EA08)

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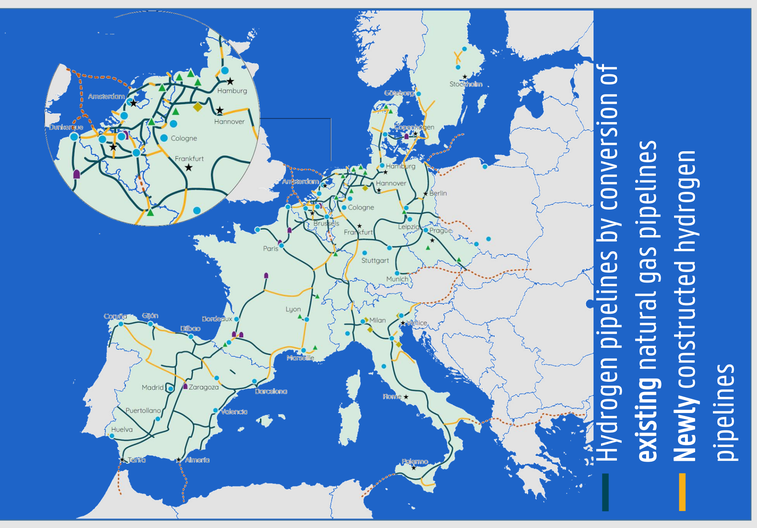
HYDROGEN EMBRITTLEMENT IN PIPELINE STEELS AND WELDS

Introduction

In the energy transition towards a low carbon economy, the EU strives to provide a hydrogen grid of almost 23000 km by 2040. **Reusing existing pipelines** for the transport and storage of hydrogen gas will be necessary to achieve this goal.

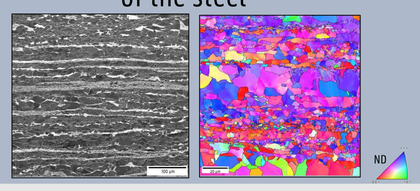
However, steels are prone to **hydrogen embrittlement**: hydrogen reduces their ductility and fracture toughness. The engineering assessment criteria to accept the weld flaws are to a large extent based on those properties. Therefore, **weld imperfections and the heat affected zones** need particular attention in the research on structural integrity of pipelines in the presence of hydrogen.



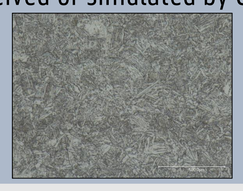
scale

µm

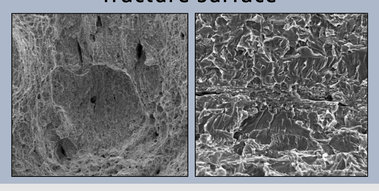
Microstructure & texture of the steel



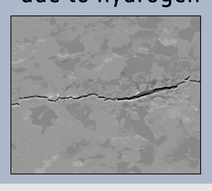
Microstructure of HAZ (as-received or simulated by Gleeble)



Hydrogen-induced features on fracture surface



Internal cracking due to hydrogen



Microstructural investigation

Microstructural effects

Macromechanical effects

mm

cm

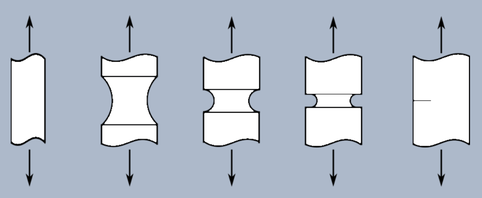
dm

m

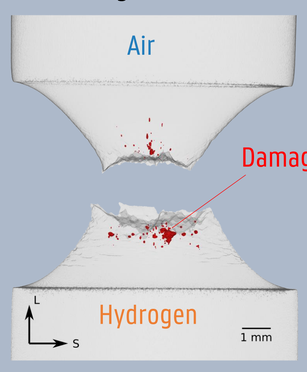
Mechanical testing

Small scale tests: tensile and fracture toughness tests

Effect of different stress states

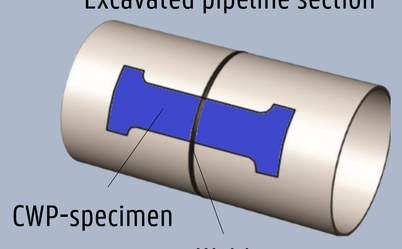


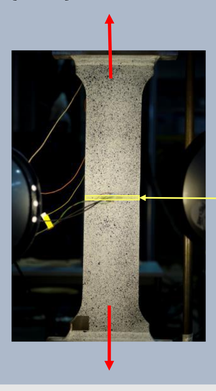
µCT scanning of fractured samples



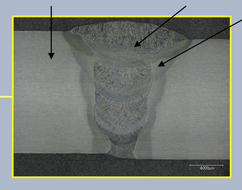
Component scale test: Curved wide plate (CWP) tests

Excavated pipeline section





Base material Weld HAZ

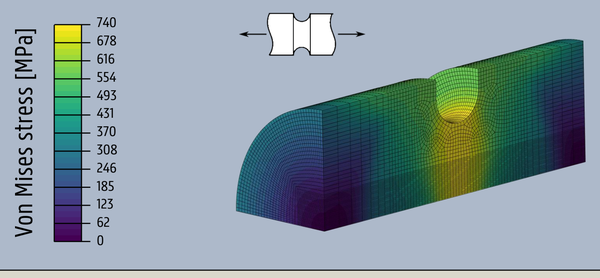


Calibration

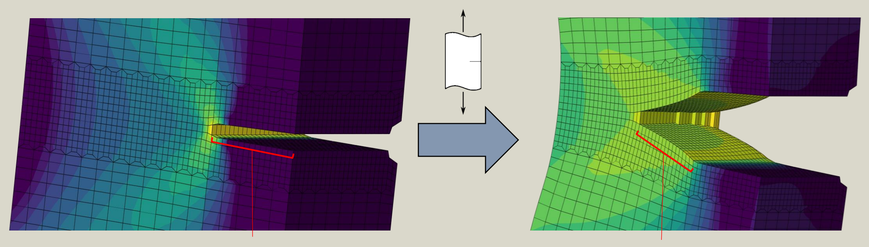
Validation

Numerical simulation

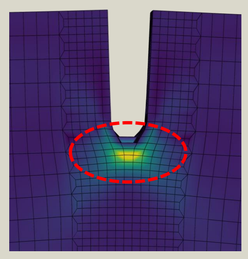
FE model of (notched) tensile test



Stable crack growth

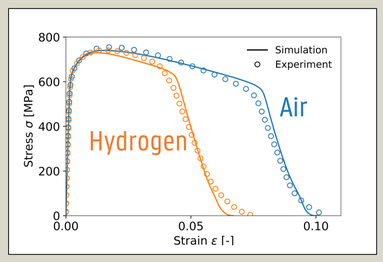


Diffusion of Hydrogen

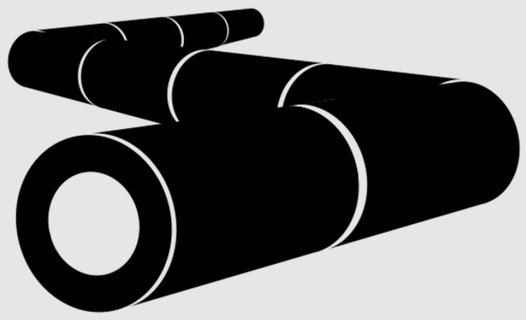


Increased hydrogen near stress concentrations

Degradation of properties



Calibration model parameters



Prediction of fitness for service of pipelines transporting hydrogen gas

Objectives

Develop and perform devoted **tensile and fracture toughness** tests on welded samples with and without hydrogen charging.
Investigate **scale effects** by up-scaling experiments.
Validation and calibration of numerical **diffusion-degradation-damage model** with welded parts.
Define **acceptability** of (girth weld) flaws in the presence of hydrogen.

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