Institut für Werkstoffkunde, Fügetechnik und Umformtechnik
Kopernikusgasse 24/I, 8010 Graz

Announcement of a Master's Thesis, 26th November 2025

Evaluation of Hydrogen Assisted Cracking Susceptibility of Recycled Pressure Vessel Steel P460NL1 by in-situ electrochemical charging

Introduction

From the point of The European Green Deal steel producers face two issues, which are -

- Increasing the recycling share to reduce CO_2 emissions, i.e. use up to 100% scrap
- higher hydrogen load on steel infrastructure, like tubes or vessels for energy supply, i.e. transport and production of hydrogen (gas or liquid solutions)

In difference to conventional steel making from ore (Blast furnace and Linz-Donawitz Oxygen converter / BOF) the recycled steel is produced from scrap, remelted in the Electric Arc Furnace (EAF), where also the metallurgical deoxidation is performed, afterwards going directly to the continuous casting and the hot-rolling mill for producing sheets. By this recycling procedure the CO_2-emission is reduced from 2.3 t (BOF) to 0.7 t (EAF) per ton raw steel.

A higher susceptibility for Hydrogen Embrittlement (HE) or, more specific, Hydrogen Assisted Cracking (HAC) due to the higher amount of Non-Metallic-Inclusions (NMI) of a Recycled Steel (RSt) in comparison to Conventional Steel (CSt) should be expectable. Here especially sulfide inclusions are to be mentioned, as they form segregation sites for hydrogen and can induce cracks.

Hydrogen Assisted Cracking of a tensile specimen from P460NL1 recycled steel in SSRT with electrochemical H-charging

The H-absorption depends on the microstructural features of the steel, such as grain size, grain boundaries, dislocations, interstitial lattice sites, defects etc., which also depends on the production processes. HAC refers to the loss of ductility in metals caused by hydrogen absorption into the crystal lattice. The diffusion and concentration of atomic hydrogen around zones of high triaxiality promote local embrittlement mechanisms. Transport of hydrogen through the metal is determined by diffusion between interstitial lattice sites and trapping of hydrogen at microstructural sites such as grain boundaries, dislocations, carbides, inclusions and precipitate particles.[1]

Working packages

- Literature study on HE of welded & unwelded P460NL1, conventional (CSt) & recycled steel (RSt)
- Welding of CSt and RSt by Manual Metal Arc (MMA)
- Metallographic characterization (phases, grain size and inclusions) and hardness test of conventional (CSt) and recycled (RSt) P460NL1 and weldments.
- Potentiodynamic measurement and evaluation of the current density - potential curves and selection of cathodic polarization for the Slow Strain Rate Tests (SSRT)
- Manufacturing of tensile specimens for SSRT
- Performing SSRT (10-5 and 10-6/s) with in-situ electrochemical hydrogen charging and analyzing the fracture surface by SEM
- Evaluation of HE susceptibility and writing the master's thesis report

[1] Walder, T. et al. (2025): HYDROGEN EMBRITTLEMENT OF RECYCLED PRESSURE VESSEL STEEL P460NL1: COMPARISON BETWEEN RECYCLED (RSt) AND CONVENTIONAL STEEL (CSt); ICPES 2025, Niš/Serbia; https://doi.org/10.46793/ICPES25.145W

Organisation: https://www.tugraz.at/institute/imat/teaching/master-theses

Supervisor: Dr. Rudolf Vallant / IMAT TUG, rudolf.vallant@tugraz.at

Start/Duration: as of now / at least 6 month, depending on commitment

Working place: IMAT TUG, 8010 Graz

Remuneration: -