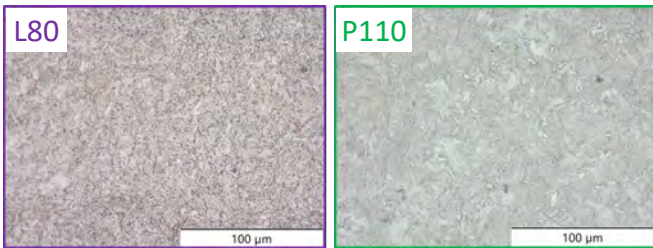


Introduction

Hydrogen is nowadays maybe the most promising energy source for the replacement of fossil energy carriers in industry. To provide the energy needed for this transition hydrogen must be stored and transported under high pressures. The majority of the steels used for pipelines and tanks are carbon steels which are prone to hydrogen embrittlement. Therefore, it is of crucial importance to know how much hydrogen is uptaken under highest pressures and if this contents can cause material deterioration.

Experimental

In the scope of this work the two commercial steel grades **L80** and **P110** which are commonly used for line pipe applications were investigated. To analyse the hydrogen uptake of the steels as function of H₂ partial pressure and temperature a new high pressure high temperature autoclave test bench, with an operation range up to 1000 bar and 200 °C was installed. One advantage of the new device is that it is also possible to conduct constant load tests (CLT) under high pressure gas atmosphere. In the present study all CLTs were conducted under 90 % of the materials yield strength. Additionally the effective diffusion coefficients of both steels were determined by electrochemical permeation measurements. This diffusion coefficients were further used for the numerical simulation of diffusion profiles.



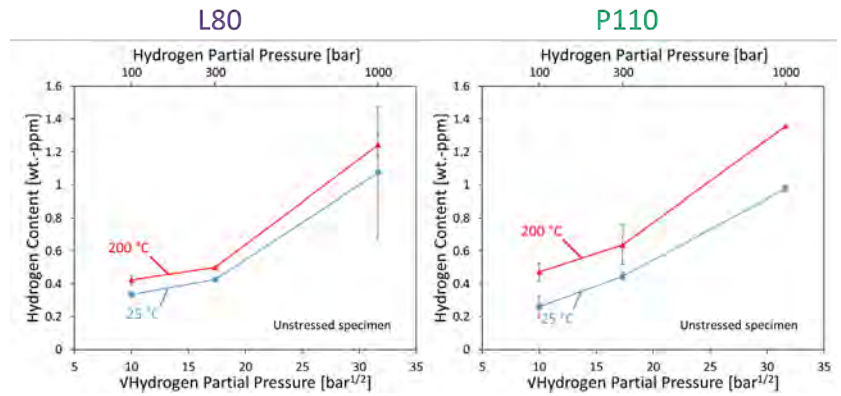
Material	Chemical Composition [%]					
	C	Si	Mn	P	S	Cr
L80	0.32	0.20	1.34	0.018	0.007	0.24
P110	0.31	0.21	1.36	0.011	0.007	0.24

For the examination of the critical hydrogen content in-situ tensile testing, electrochemical permeation and fractographic analyses were combined with numerical simulation.

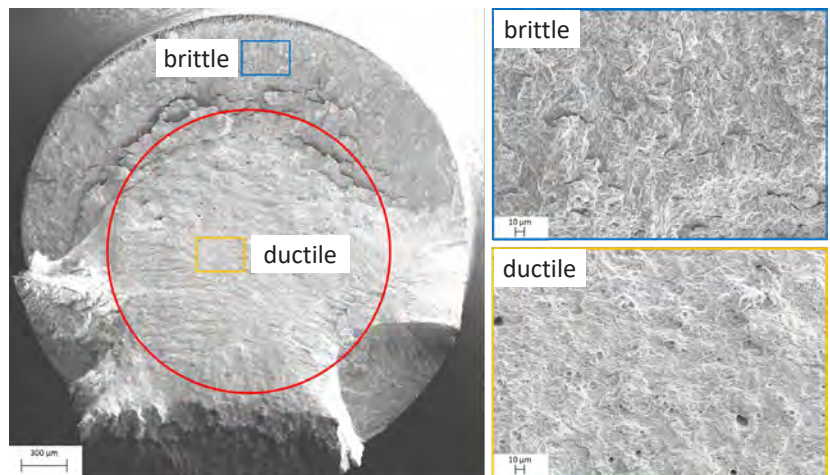


Results

Hydrogen uptake as function of pressure and temperature



Fracture surface and range of embrittlement of in-situ charged tensile specimen



Conclusions

- Characterization of **L80's** and **P110's** hydrogen uptake as function of pressure and temperature:
 - Highest hydrogen contents of **L80**:
 - Unstressed condition:** 1.1 wt.-ppm at 25 °C and 1.2 wt.-ppm at 200 °C
 - 90 % Yield Strength:** 1.1 wt.-ppm at 25 °C and 1.2 wt.-ppm at 200 °C
 - Highest hydrogen contents of **P110**:
 - Unstressed condition:** 1.0 wt.-ppm at 25 °C and 1.4 wt.-ppm at 200 °C
 - 90 % Yield Strength:** 1.2 wt.-ppm at 25 °C and 1.3 wt.-ppm at 200 °C
- No fracture occurred in CLT at 90 % Yield Strength
- The critical hydrogen content for **L80** is 1.7 wt.-ppm and for **P110** 1.0 wt.-ppm respectively