Impact of tensile specimen properties on hydrogen embrittlement testing using hollow specimens

Peter Oberreiter[1*] (P. Oberreiter), **Gerhard Winter**[1] (G. Winter), **Florian Grün**[1] (F. Grün), **Andreas Drexler**[2] (A. Drexler)

[1] Chair of Mechanical Engineering, Department Product Engineering, Montanuniversität Leoben, Franz Josef-Strasse 18, Leoben, 8700, Austria,
[2] voestalpine BÖHLER Edelstahl GmbH & Co KG, Mariazeller Straße 25, 8605 Kapfenberg, Austria

*peter.oberreiter@unileoben.ac.at

This study investigates the influence of the bore-to-nominal diameter ratio (d_0/D_0) on hydrogen embrittlement in a martensitic stainless-steel alloy through tensile testing of hollow specimens. Various geometries were tested, including one designed according to ISO 7039:2024 [1] standard. A conventional test at ambient pressure in air was used as a baseline for comparison. The primary aim was to assess how different d_0/D_0 -ratios affect the mechanical properties and susceptibility to hydrogen embrittlement. In order to check the quality of the b ore hole of the tensile tests, surface roughness measurements were conducted, as surface irregularities can significantly impact hydrogen-induced cracking.

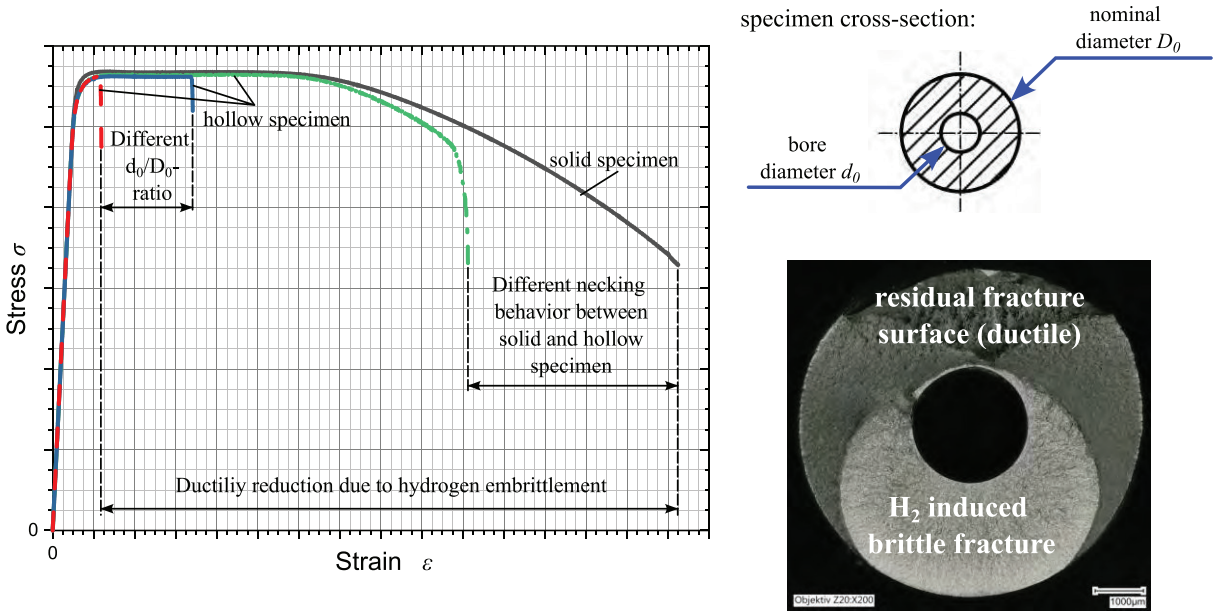

Figure 1. Overview of tensile tests with different d_0/D_0 − ratios, compared to the standard test, along with a corresponding fracture surface.

The results indicate a strong correlation between the d_0/D_0 -ratio and the onset of hydrogen-induced fracture. Hollow specimens with higher d_0/D_0-ratios depicted premature failure compared to those with lower ratios. A comparison of fracture behavior between solid and hollow specimens, tested in inert and ambient atmospheres, highlighted significant differences in the fracture mechanisms. Notably, the yielding strengths and ultimate tensile strength remained comparable and independent of the d_0/D_0-ratio and environment (Air, H2, and Ar). These findings suggest that a higher d_0/D_0 -ratio not only affects the stress distribution in tensile test specimens but also impacts the embrittlement process. The study offers a valuable contribution for optimizing the design of test specimens for hydrogen embrittlement testing.

References

[1] ISO 7039:2024, Metallic materials — Tensile testing — Method for evaluating the susceptibility of materials to the effects of high-pressure gas within hollow test pieces, 2024