EFFECT OF HYDROGEN GAS ON TENSILE PROPERTIES OF AUSTENITIC STAINLESS STEELS AT SUBZERO, ROOM AND ELEVATED TEMPERATURES

Nuria Fuertes [1], Eduard Navalles [1], Birhan Sefer [1], Pontus Rydgren [1], Johan Pilhagen [2], Emil Edin [3], Lars Olof Nordin [3]

[1]Swerim AB, Box 7047, 164 07 Kista, Sweden

[2] Outokumpu Stainless AB, Avesta R&D Center, Avesta, Sweden

[3] LKAB, Material Laboratory, Box 952, SE-971 28 Luleå, Sweden

Corresponding author's e-mail address: nuria.fuertes@swerim.se

Keywords: 316, hollow specimen method, hydrogen gas, SSRT, TDMS, austenite stability, hydrogen embrittlement

ABSTRACT

Hydrogen technologies are important in reaching the goal of a fossil-free society. Examples of applications promoting this is the use of hydrogen as a reductant to produce fossil-free steel, hydrogen fuel cells and gas turbines running on pure hydrogen gas. Storage and transportation of hydrogen gas will be crucial for this transition. Storage of hydrogen gas is particularly important to balance the energy system, by enabling hydrogen gas production based on the access to electric power, not equivalent to the peak demand.

The use of hydrogen gas requires metallic components and constructions. Hydrogen may however deteriorate the mechanical properties of metals. This phenomenon is known as hydrogen embrittlement (HE). In this work the mechanical degradation of austenitic stainless steels was studied by slow strain rate tensile testing (SSRT) using hollow specimens internally pressurized with 200 bar hydrogen gas and argon as a reference. The testing was performed for different types of 316 grades at different temperatures (-50ºC, room temperature and +100ºC).
To reveal whether hydrogen absorption occurred in the hollow specimens testing, the specimens were analyzed using thermal desorption spectroscopy with mass spectrometry (TDMS). Furthermore, post-analyses in terms of fractography using scanning electron microscope (SEM) were performed to reveal the type of failure in argon and hydrogen gas.

In general, austenitic stainless steels are less sensitive to HE compared to ferritic and martensitic steels and are considered to be an excellent choice for hydrogen gas applications. In this work it was seen that the sensitivity to HE is highly dependent on the chemical composition of the steel, which provide austenite stability, as well as on the testing temperature.

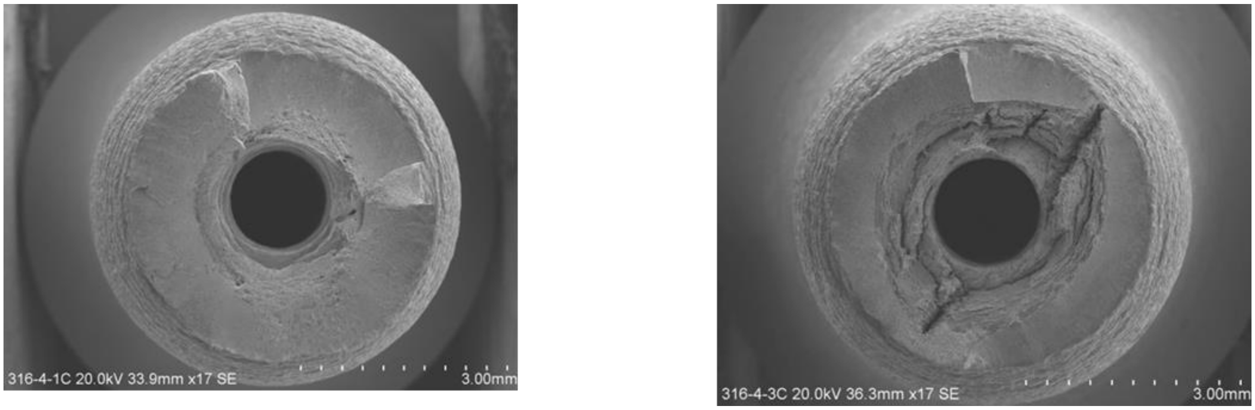

Figure 1. SEM micrographs of fracture surfaces for austenitic stainless steel 316 in argon (left) and hydrogen gas (right) after SSRT using the hollow specimen method at a temperature of -50ºC and a pressure of 200 bar.

Acknowledgements

Vinnova Strategic Innovation Programme Metallic Materials.

References

[1] L. Zhang, M. Wen, M. Imade, S. Fukuyama, K. Yokogawa, Effect of nickel equivalent on hydrogen gas embrittlement of austenitic stainless steels based on type 316 at low temperatures, Acta Materialia 56, 2008.

[2] T. Michler, T. Freitas, H. Oesterlin, C. Fischer, K. Wackermann, F. Ebling, Tensile testing in high pressure gaseous hydrogen using conventional and tubular specimens: Austenitic stainless steels, International Journal of Hydrogen Energy 48, 2023.