EFFECT OF HYDROGEN AT CRYOGENIC TEMPERATURES ON TENSILE PROPERTIES OF 316L STAINLESS STEEL OBTAINED BY DIFFERENT MANUFACTURING PROCESS

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Austenitic stainless steels are known to achieve high strength and maintain their high ductility at cryogenic temperatures. Therefore, they are good candidate materials for storage and transportation applications at cryogenic temperatures. In the hydrogen economy context, cryogenic hydrogen transport and storage is one of the solutions being studied to ensure its deployment. Nevertheless, some material challenges with storing and transporting of liquid hydrogen (boiling point at atmospheric pressure -253°C) and cryo-compressed gas (slightly higher cryogenic temperatures) have been detected. In particular, the observation of hydrogen embrittlement at low temperatures and high H_2 pressures is most of the times associated to α'- martensite transformation.

In this work, the resistance to hydrogen embrittlement at temperatures down to -150°C at 100bar H_2 has been evaluated for 316L stainless steels obtained by different process routes: plate, bar and additive manufacturing. The rather new hollow specimen technique has been used for the characterization. This technique has been validated by: 1- modelling and 2- by comparing the results with standard tensile specimens tested at the same environment conditions. The temperature screening down to -150°C shows premature failure of the samples tested at 100bar H2 compared to the ones tested at 100bar He for temperatures between 0 and -100°C. The loss of ultimate tensile strength, elongation, and reduction of area is maximized at around -100°C. No or minor H effect on the mechanical properties is observed at -150°C, the mechanical properties obtained under H_2 and He are about the same. In addition, secondary cracking was observed on all the samples tested under H_2 which is indicative of hydrogen embrittlement. A clear effect of the meta-stable austenite on the properties and on the resistance to Hydrogen Embrittlement was observed. Finally, the effect of the manufacturing process, microstructure and internal cleanliness is discussed.