EFFECT OF WATER VAPOR CONTENT ON THE TOUGHNESS AND FATIGUE PROPERTIES OF TWO STORAGE STEELS UNDER NG/H2 GAS PRESSURE

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A key point for the development of the hydrogen economy at a large scale is the possibility to use the current natural gas network and storage capacity to transport and store hydrogen. This study is dedicated to evaluating the integrity of materials used for underground aquifer storage regarding to hydrogen embrittlement. In this environment, the water vapor content of the gas stored may progressively increase. It is known that the presence of impurities in the gas, such as H_2O, can promote or inhibit hydrogen embrittlement phenomenon, depending on the nature of the steel. This work investigates mechanical properties of a tempered martensite N80Q steel, and a ferrite-perlite L360 C-Mn steel issued from a completion and a collect tube respectively. The testing environments are NG + 25%H_2 and NG saturated in water vapor at 8.5 MPa and room temperature. These environmental conditions aim at replicating the storage service conditions. Low cycle fatigue on notched specimens, toughness and fatigue crack growth properties are assessed. So far, the mechanical behavior of such steels under hydrogen gas pressure saturated with water vapor has poorly been addressed. Regarding toughness properties, the two steels present different behavior: for the L360 crack has not propagated for any testing environments, while cracks propagated in all the tests for the N80Q. Despite this difference, for the two steels, the toughness does not seem to be affected by hydrogen as the results obtained in NG + 25%H_2 + H_2O and NG + H_2O are similar. Based on the literature C-Mn steels toughness is affected by the presence of dry hydrogen. Hence, the results presented here show that H_2O inhibits hydrogen embrittlement as far as toughness is concerned. FCG (fatigue crack growth) results, on the opposite, clearly highlight the influence of hydrogen on the mechanical behavior of the two steels. The FCG rates are faster from a factor five (resp. 10) in NG + 25%H_2 + H_2O compared to NG + H_2O for the N80Q (resp. L360). In this article, toughness, FGC and LCF (low cycle fatigue) results on the two steels are discussed in terms of microstructure and mechanical loading modes, aiming to quantify and better understand the influence of H_2O on the sensitivity of low alloy steels to hydrogen embrittlement.