Hydrogen Influence on Mechanical Properties and Microstructure in Pipeline Steels for Subsea Hydrogen Gas Transport

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Abstract

The crucial role of hydrogen as an energy carrier and in decarbonizing world energy supply, increase its importance in several industrial applications (petroleum refineries, fuel cells, power plants, etc.). Norway has a central role in Europe as an energy provider and operates one of the world's most extensive and integrated subsea transport systems for natural gas. The infrastructure, consisting of ~9000 km of natural gas pipelines, are highly relevant as a large-scale transport system of hydrogen gas to the Europe. The hydrogen related effects on material mechanical response and integrity are being addressed in a research project funded by the Research Council of Norway and an international industry consortium. From the initial screening procedure, slow strain rate tensile testing in air and under in situ hydrogen charging conditions have been performed on four different carbon manganese pipeline steels, including base metal and weld simulated Heat Affected zone. The hydrogen induced degradation of the material's strength and ductility has been determined: the presence of hydrogen significantly influence the strain-to-failure and reduction-in-area in all the materials tested. The results are discussed in correlation with microstructural characteristics, electrochemical diffusion measurements and post-mortem fractography analysis. Additionally, small-scale mechanical approaches and advanced characterization methods based on SEM techniques have been used to elucidate the hydrogen embrittlement susceptibility of microstructural features/phases.