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Hydrogen-Microstructure interaction of High Strength Low Alloy Steels (HSLA) used in the oil industry

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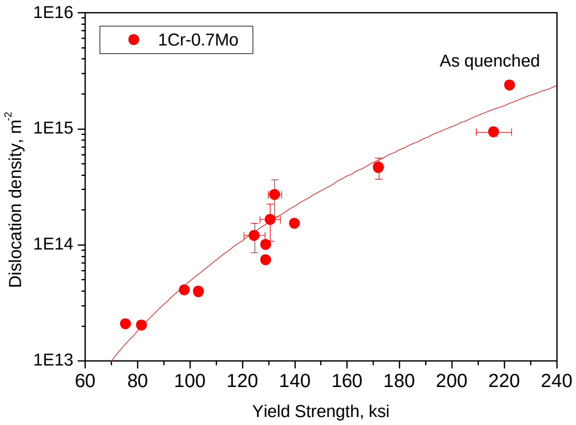
Abstract – Dislocations are thought to be the main hydrogen traps on High Strength Low Allow Steels. Characterization of those microstructural elements and their relation to hydrogen solubility and diffusion is discussed.

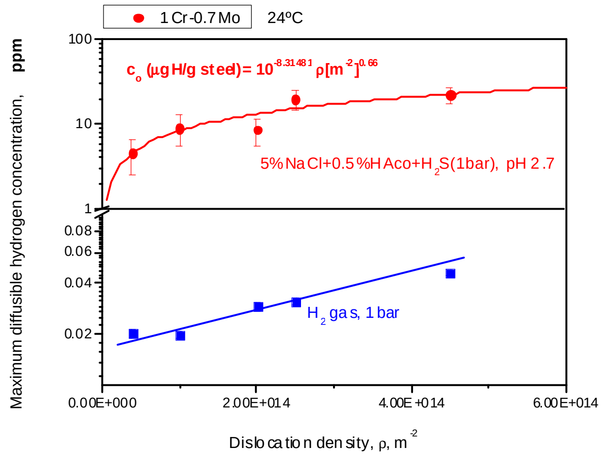
Hydrogen embrittlement is a main concern in steels used for petroleum extraction since they are exposed to hydrogen sulfide which is a promoter of hydrogen insertion. The extreme mobility of hydrogen in ferrous alloys allows it to be sensitive to local stress and strain centers and to accumulate at a wide variety of locations which could act as potential crack initiators. Different locations accumulate hydrogen according to its trapping ability and those more sensitive to fracture determine the possibility of failure. Thus, the nature of hydrogen traps and their main energy of interaction results a major factor for microstructural design. In particular, in quenched and tempered materials, dislocation densities and carbides are the most important hydrogen traps.

It is the aim of this paper to characterize the hydrogen traps present in 0.24C-1Cr-0.7Mo Ti-Nb microalloyed Q+T steel and at the same time to characterize their effect on hydrogen transport and solubility.

Dislocation densities were determined by X-Ray Diffraction technique using a modified Williamson-Hall plot [i,ii,iii]. Hydrogen transport was studied using a Devanathan and Stachurski assembly [iv, v,vi] for two charging conditions: gaseous charging (1 bar H_2) and electrochemical charging (at corrosion potential using NACE A solution: pH 2.7, 1 bar H_2S).



Effect of dislocation densities on yield strength of 1Cr-0.7Mo steel.



Effect of dislocation densities on hydrogen solubility at 24ºC for 1Cr-0.7Mo steel charged at pH 2.7+ H_2S saturated at 1 bar and charged with H_2 gas at 1bar

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