

EFFECT OF AGING ON THE HYDROGEN EMBRITTLEMENT OF THE API X 52 STEEL.Guillermina González Mancera(1), Víctor Cortés Suárez(2), Francisco Sandoval Pérez(2), and Julio Juárez(1). (1)Departamento de Metalurgia, Facultad de Química, UNAM, Cd. Universitaria, México, DF, 01000, (2)Departamento de Materiales, Universidad Autónoma Metropolitana-Azcapotzalco, Av. San Pablo No. 180, Col. Reynosa Tamaulipas, México, DF 02200. Email: ggm@servidor.unam.mx

The hydrogen embrittlement of the steels is often characterized by a change in fracture mode, in addition to a loss in ductility relative to behavior without hydrogen[1]. The hydrogen is produced by the corrosion reactions when metal oxidation occurs in acid environment, and in hydrogen reduction[2]. Cylindrical tensile specimens with 16 mm gauge length and 4 mm gauge diameter were machined from a tube API X 52 steel. The chemical composition of the steel was: 0.08 C, 1.05 Mn, 0.026 Si, 0.041 Nb, 0.054 V and 0.002 Ti, % in mass. Tensile specimens were solubilized at 1200 °C and after that they were heat treated aging at 400, 500 and 600 °C. Hydrogen was introduced in tensile specimens by cathodic charge. Charging solution was 0.5 M H₂SO₄ and small amount of CS₂; density of charging current was 50 mA/cm². Charging time was 24 hrs. at room temperature. All tensile specimens were examined in a scanning electron microscope Model JEOL JSM 5200 after rupture, to determine fracture characteristics and estimate the hydrogen effect. The effect of aging temperature on the hydrogen embrittlement susceptibility of the API X52 steel was studied. In Figure 1 the effect of aging treatment on the microstructure of the API X52 steel is shown. Blank sample presents a structure that consists of pearlite grains in a ferritic matrix. Sample aged at 400 °C presents an acicular structure that consists of iron carbides in a ferritic matrix. Sample aged at 600 °C presents an acicular structure that begins to transform into ferritic and pearlitic equiaxial grains[3,4]. The fracture surfaces of tensile specimens are shown in the Figure 2. In Figure 2a a great area reduction is observed, which is associates with a ductile fracture, while in tensile specimen aged at 400 °C precharged with hydrogen, the ductility is smaller. Also a remarkable secondary cracking is appreciated. For tensile specimen aged at 600 °C precharged with hydrogen, it can be seen that fracture is totally brittle. The presence of hydrogen in steel changes the fracture mode, from ductile to brittle mode. Figure 3 shows the fracture mode in the steel. In the blank specimen the fracture mechanism is voids coalescence, which associates with ductile fracture. In tensile specimen aged at 400 °C, precharged with hydrogen, fracture mode is cuasicleavage. There are ductile tear zones around brittles areas. The tensile specimen aged at 600 °C precharged with hydrogen shows a cleavage fracture mode. This fracture mechanism is associates to the brittle fracture. SEM observation found that the presence of hydrogen in steel promotes the transition f33rm ductile fracture to brittle fracture.

References

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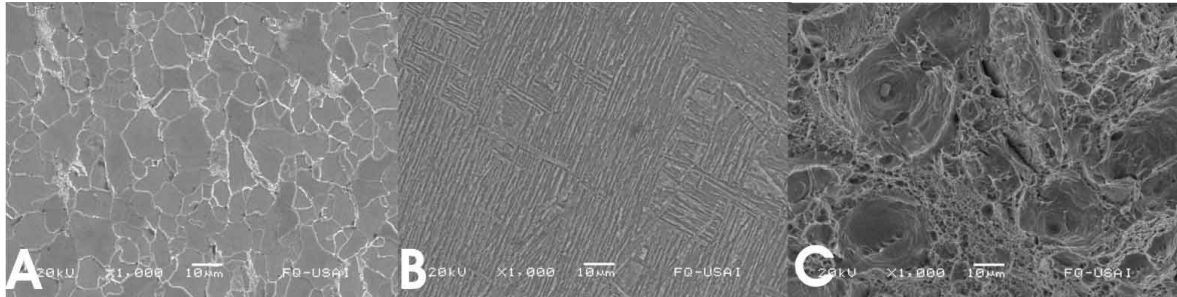


Figure 1. SEM photographs of the microstructures for the API X-52 steel: (A) blank specimen, (B) aged at 400 °C, (C) aged at 600 °C.

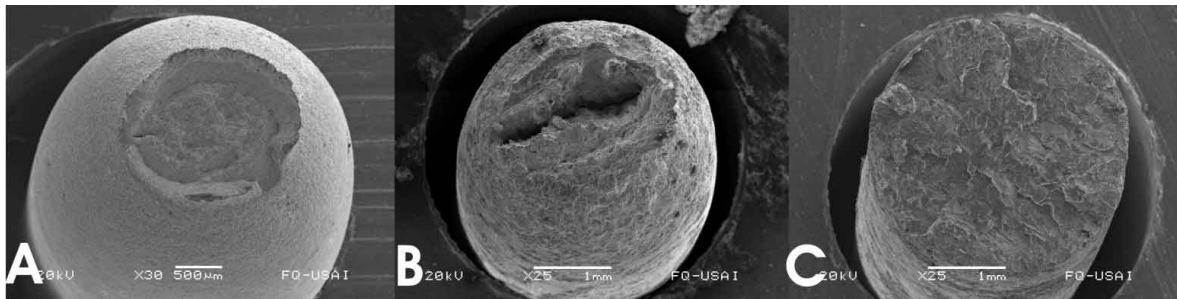


Figure 2. SEM fractographs for the X-52 steel: (A) blank specimen, (B) aged at 400 °C and precharged with hydrogen, (C) aged at 600 °C and precharged with hydrogen.

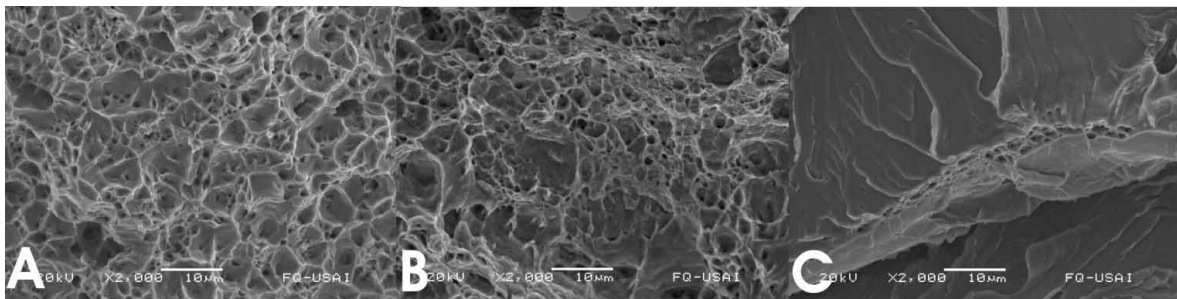


Figure 3. SEM. photographs for the X-52 steel: (A) blank specimen, (B) aged at 400 °C and precharged with hydrogen, (C) aged at 600 °C and precharged with hydrogen.