Inhibitory Effect of Gas Impurities on Hydrogen Embrittlement of Cr-Mo Steels with Different Strength Levels

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Hydrogen embrittlement, which is material strength degradation due to presence of hydrogen, needs hydrogen dissolution process including hydrogen adsorption on the material surface. When certain gas impurities, such as oxygen and carbon monoxide, are added to hydrogen gas, the impurities prevent the hydrogen adsorption. As the result, hydrogen embrittlement is inhibited by the impurities. This inhibitory effect of impurities can be a new concept for preventing hydrogen embrittlement. However, the details of the inhibitory effect of impurities have not been understood yet. Here, we focused on the effect of material strength on the inhibitory effect.

We conducted fracture toughness tests of a low alloy steel SCM440 with different material strength in hydrogen gases with impurities. The material strengths were 1000 and 2000 MPa of ultimate tensile strength (UTS). The gas impurities added to hydrogen gas were oxygen and carbon monoxide. The hydrogen gas pressure was 1.0 MPa in gauge. The gas temperature was 293 K.

In both strength materials, hydrogen embrittlement was inhibited by the addition of oxygen or carbon monoxide to hydrogen gas. However, the degrees of the inhibitory effects were different between the material. Even at the impurity level at which fully inhibitory effect appeared in the 1000 MPa UTS material, the inhibitory effect of impurities did not appear in the 2000 MPa UTS material. To inhibit hydrogen embrittlement in the 2000 MPa UTS material, more impurities were required. It was demonstrated that the inhibitory effect of impurities is decreased by increasing the material strength.