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Effect of Nanostructure on Hydrogen Embrittlement Resistance of the Severely Deformed 316LN Austenitic Steel

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Abstract : Advances in the consumption of hydrogen fuel increase demands of high strength steel pipes and storage tanks. However, high strength steels are highly sensitive to hydrogen embrittlement. Because the introduction of hydrogen into steel during the fabrication process or from the environment is unavoidable, it is essential to improve hydrogen embrittlement resistance of high strength steels through microstructural control. In the present study, the heterogeneous nanostructure with a tensile strength of about 1.8 GPa and the homogeneous nanostructure with a tensile strength of about 2.0 GPa of 316LN steels were generated after 92% heavy cold rolling and high-pressure torsion straining, respectively. The heterogeneous nanostructure is composed of twin domains, shear bands, and lamellar grains. The homogeneous nanostructure is composed of uniformly distributed ultrafine nanograins. The influence of heterogeneous and homogenous nanostructures on the hydrogen embrittlement resistance was investigated. The specimen for each nanostructure was electrochemically charged with hydrogen for 3, 6, 12, and 24 hours, respectively. Under the same hydrogen charging time, both nanostructures show almost the same concentration of the diffusible hydrogen based on the thermal desorption analysis. The tensile properties of the homogenous nanostructure were severely affected by the diffusible hydrogen. However, the diffusible hydrogen shows less impact on the tensile properties of the heterogeneous nanostructure. The difference in embrittlement behavior between the heterogeneous and homogeneous nanostructures was elucidated based on the mechanism of the cracks' growth observed in the tensile fractography. The hydrogen embrittlement was suppressed in the heterogeneous nanostructure because the twin domain became an obstacle for crack growth. The homogeneous nanostructure was not consisting an obstacle such as a twin domain; thus, the crack growth resistance was low in this nanostructure.

Keywords : diffusible hydrogen, heterogeneous nanostructure, homogeneous nanostructure, hydrogen embrittlement
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