Application of Solution Nitriding to Metastable Austenitic Stainless Steel for Improving Hydrogen Embrittlement Resistance

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ABSTRACT

Stable austenitic stainless steel is widely applied to structural materials used in hydrogen environment because of its less susceptibility to hydrogen embrittlement than martenstic or ferritic stainless steels. The nature of this steel is derived from the lower diffusivity of hydrogen atoms in a face-centered cubic (fcc) phase (austenite) than in a body-centered cubic (bcc) phase (α' martensite or ferrite). However, it is known that hydrogen embrittlement occurs in the case that the stability of austenite is insufficient as in 304 type austenitic stainless steel. When 304 stainless steel is cold-rolled, the austenitic structure transforms to deformation-induced martensite due to the metastability of the austenite phase. Nevertheless, deformation-induced martensite plays an important role in strengthening of steel. Therefore, we focus on the relation between the diffusion path of hydrogen and the distribution of deformation-induced martensite to achieve a good balance between hydrogen embrittlement resistance and high strength in deformed metastable austenitic stainless steel. In this study, solution nitriding is applied to metastable austenitic stainless steel sheets as shown **Fig.1**. It is reported that addition of nitrogen to metastable austenite suppresses the transformation to deformation-induced martensite since nitrogen is a strong austenitic stabilizing element. Nitrogen is absorbed into the steel sheets according to Fick's 2nd law in solution nitriding process. If solution nitriding process is ended in a short time before nitrogen is completely absorbed into the steel sheet, the austenite phase in the center area transforms to deformation-induced martensite but austenite phase at the surface never does because of its sufficient stability. This type of steel sheet could be called a "structure-gradient steel sheet". In this research, hydrogen absorption behavior and tensile properties were investigated for structure-gradient steel sheets produced by solution nitriding. As a result, hydrogen absorption using cathodic charge revealed that the amount of hydrogen absorbed into the steel sheet was drastically decreased in the specimens with stable austenite layer formed by solution nitriding. In addition, tensile tests demonstrated that the total elongation was improved in the specimens with stable austenite layer without deteriorating the high strength level. It was concluded that that deformation-induced martensite could be available for strengthening of stainless steel even in a hydrogen environment by applying the microstructure-control through the thickness direction to obtain the stable austenite layer at the material surface.

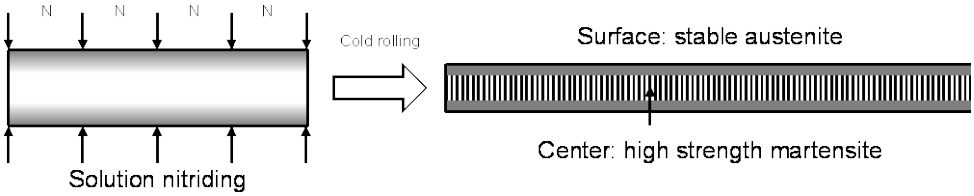

Fig.1 Illustration of microstructure in cold rolled metastable austenite stainless steel sheets with solution nitriding treatment.