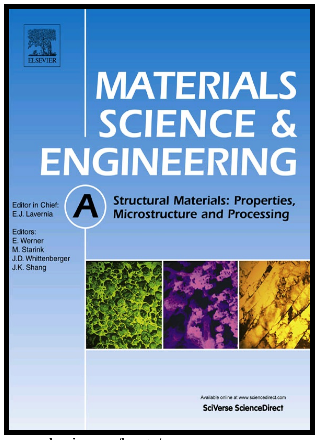

www.elsevier.com/locate/msea

Warm tempforming effect on the hydrogen embrittlement of 1.8-GPa-class ultra-high-strength low-alloy steel

Yuuji Kimura, Tadanobu Inoue, Eiji Akiyama

PII: S0921-5093(17)30997-8
DOI: http://dx.doi.org/10.1016/j.msea.2017.07.091
Reference: MSA35339

To appear in: *Materials Science & Engineering A*

Received date: 13 May 2017
Revised date: 27 July 2017
Accepted date: 28 July 2017

Cite this article as: Yuuji Kimura, Tadanobu Inoue and Eiji Akiyama, Warm tempforming effect on the hydrogen embrittlement of 1.8-GPa-class ultra-high strength low-alloy steel, *Materials Science & Engineering A* http://dx.doi.org/10.1016/j.msea.2017.07.091

Warm tempforming effect on the hydrogen embrittlement of 1.8-GPa-class ultra-high-strength low-alloy steel

Yuuji Kimura*, Tadanobu Inoue, Eiji Akiyama[1]
National Institute for Materials Science, 1-2-1 Sengen, Tsukuba, Ibaraki 305-0047, Japan
Kimura.Yuuji@nims.go.jp
Inoue.Tadanobu@nims.go.jp
akiyama@imr.tohoku.ac.jp
*Corresponding author.

Abstract

Hydrogen embrittlement properties were investigated for 1.8-GPa-class ultra-high strength low-alloy steels by means of slow-strain-rate test of the pre-hydrogen-charged notched specimens, accelerated atmospheric corrosion test, and thermal desorption spectrometry. A Mo-bearing steel with a chemical composition of Fe-0.4C-2Si-1Cr-1Mo (mass%) was quenched and tempered at 773 K for 1 h and then deformed by multi-pass caliber rolling with a cumulative rolling reduction of 76% at 773 K to create an ultrafine elongated grain structure with a strong <110>//rolling direction fiber texture. The warm tempformed (TF) sample was subsequently annealed for 1 h to clarify the hydrogen trapping effect of nanoscale carbides relative to additive Mo. When the TF sample was annealed at 843 K (TFA sample), the hydrogen absorption capacity was enhanced significantly through the formation of nanoscale Mo-rich precipitates in the matrix of ultrafine elongated grains. A high potential for hydrogen embrittlement resistance in an atmospheric corrosion environment was demonstrated in both the TF and TFA samples with an ultra-high tensile strength of 1.8 GPa. The TF and TFA samples were much less susceptible to hydrogen embrittlement as compared to the tempered martensitic samples at an ultra-high tensile strength of 1.8 GPa. The hydrogen trapping states and the high resistance to hydrogen embrittlement in the TF and TFA samples are discussed in association with the anisotropic, ultrafine grained structures with the nanoscale Mo-rich precipitates.

Keywords: Thermomechanical processing; Martensitic steel; Hydrogen embrittlement; Ultrafine-grained microstructure

1. Introduction

Tempered martensitic steels with a tensile strength exceeding 1.2 GPa are particularly prone to hydrogen embrittlement. Hydrogen embrittlement often restricts the practical use of the tempered

[1] Present address: Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan