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Hydrogen Embrittlement Susceptibility of Bainite for High Strength Steel Fasteners

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ASTM International, Materials Performance and Characterization
VOL. 6 / NO. 1 / 2017,

The following pages contain the abstract of a journal article on the susceptibility to hydrogen embrittlement of bainitic steel used for manufacturing ultrahigh strength fasteners. The lead author Fadi Saliby, is currently Director of Technical Sales at Bossard Canada. This paper is based on his Master of Materials Engineering thesis at the McGill University. The bulk of experimental work was conducted at McGill University's Hydrogen Embrittlement Facility (MHEF) under the supervision of Salim Brahimi, co-founder of the MHEF and the current Director of Engineering & Technology of the Industrial Fasteners Institute (IFI). The research presented is this paper was funded in part by the IFI in the scope of a USCAR-IFI task group that developed ***GUIDE for Ultra-high Strength Externally Threaded Fastener GUIDE Number: UHSFG-1416U-2014.***

The complete article citation is given below and may be purchased directly from ASTM.

> Saliby, F., Brahimi, S., Rajagopalan, S., and Yue, S., "Hydrogen Embrittlement Susceptibility of Bainite for High Strength Steel Fasteners," Materials Performance and Characterization, Vol. 6, No. 1, 2017, pp. 462–471, https://doi.org/10.1520/MPC20170060. ISSN 2379-1365

Research on Fastener Hydrogen Embrittlement at McGill University in Montreal, Canada began in 2006 as a collaborative effort, co-sponsored by industry and the Government of Canada through the Natural Sciences and Engineering Research Council (NSERC). Industrial partnership was led by the Industrial Fasteners Institute (IFI) and the Canadian Fasteners Institute (CFI), Boeing, Infasco, Nucor Fasteners, Research Council on Structural Connections (RCSC), and ASTM Committee F16.96 on Bolting Technology. The ongoing research follows two distinct tracks: (i) fastener materials susceptibility to HE, and (ii) interactions of fastener materials with coatings and coating processes.

For more information on McGill University's Hydrogen Embrittlement Facility (MHEF), see http://mhef.lab.mcgill.ca.

Mar 1. 2018

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Materials Performance and Characterization

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DOI: 10.1520/MPC20170060

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Materials Performance and Characterization

doi:10.1520/MPC20170060 / Vol. 6 / No. 1 / 2017 / available online at www.astm.org

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Manuscript received May 26, 2017; accepted for publication July 3, 2017; published online November 10, 2017.

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Reference

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ABSTRACT

Industrial fasteners of two different steel microstructures were investigated using incremental step load testing based on ASTM F1624, *Standard Test Method for Measurement of Hydrogen Embrittlement Threshold in Steel by the Incremental Step Loading Technique*. The microstructures consisted of tempered martensite and lower bainite. The purpose was to compare hydrogen embrittlement (HE) susceptibility at different hydrogen charging conditions. The results showed that lower bainite exhibited marginally lower HE susceptibility when tested under moderate hydrogen charging conditions (e.g., −1.0 V). At the most severe hydrogen charging potential of −1.2 V, both microstructures are equally embrittled. These results are explained by the differences in the transport and trapping kinetics of hydrogen in bainite as compared to martensite.

Keywords

metallurgy, steel, bainite, martensite, hydrogen, embrittlement, fracture, hardness, tensile, ductile

Introduction

While the demand for stronger and lighter steels is increasing, hydrogen embrittlement (HE) becomes a greater concern to prevent catastrophic failures. Hydrogen is introduced into steel during manufacturing steps such as acid pickling and electroplating as well as during service from environmental effects such as corrosion [1]. An example of an application in which understanding and eliminating HE is important in the use of high strength fasteners is in the automotive industry to help reduce weight to meet more stringent average fuel economy standards (CAFE) [2].