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The effect of Mo addition on hydrogen embrittlement in pipeline steels

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In recent years, hydrogen appears to be a promising alternative to fossil fuels, therefore evolvement of materials for hydrogen transportation and storage facilities is of immense importance. However, exposure of high-strength steels to hydrogen can have a detrimental influence on their performance due to elevated susceptibility to hydrogen embrittlement (HE). In previous studies, the effect of Mo content on the resistance of martensitic steels to sulfide stress cracking was reported. During the sulfide stress cracking, the formation of a sulfide layer on the material surface can affect hydrogen-induced crack propagation. In the case of sulfide-free conditions, there is limited knowledge about the role of Mo in commercially available martensitic steels and its effect on hydrogen embrittlement behaviour.
This study clarifies the role of Mo carbides in the hydrogen uptake of tempered martensitic steels with different chemical compositions and heat treatment. The trapping behaviour of steels and the effect of divergent Mo content on hydrogen diffusivity and HE has been studied utilizing an Electrochemical Permeation Test and Thermal Desorption Spectroscopy (TDS). Slow Strain Rate Tests (SSRT) of electrochemically charged steels were performed to elucidate mechanical performance. The carbide distribution and microstructure of tested steels were observed using high-resolution Scanning Electron Microscopy (SEM), Electron Backscatter Diffraction (EBSD) and X-ray diffraction (XRD).
The results of electrochemical charging revealed higher uptake of hydrogen for the alloy with higher Mo content. TDS analysis indicated one peak below 300 ℃ in the case of both alloys. Mo carbides manifested the ability to trap hydrogen after long-term atmospheric exposure, hence showing characteristics of strong trapping sites. Change of the heat treatment resulted in the control of Mo carbides size and dispersion, as well as dislocation density. The results implied that the steel with higher Mo content, finer Mo2C carbides, and lower dislocation density exhibits superior resistance to HE.
Keywords: hydrogen embrittlement, Mo carbides, martensitic steels

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