Evaluation of the delayed fracture performance of high-strength R5 and R6 mooring chain steel by dynamic hydrogen charging and SSRT

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Abstract: This study focuses on R5 and R6 grade mooring chain steels (with strengths of 1000 MPa and 1150 MPa, respectively). It investigates the effect of hydrogen charging potential on the susceptibility to hydrogen embrittlement of these steels through slow strain rate tensile experiments conducted at different cathodic potentials. Fracture morphology was examined using a scanning electron microscope (SEM), and further analysis was performed using electron backscatter diffraction (EBSD) techniques and hydrogen thermal analysis.

The experimental results indicate that cathodic hydrogen charging significantly reduces the plasticity of the mooring chain steels, with sensitivity to hydrogen embrittlement increasing as the potential shifts negatively. However, the yield strength and tensile strength of the specimens are not significantly affected. When the cathodic polarization potential approaches the corrosion potential, ductile fracture predominates. As the hydrogen charging potential shifts negatively, the hydrogen content increases, leading to an enlarged brittle area, with intergranular fracture gradually becoming dominant. One difference between R5 and R6 grades is that R5 grade does not exhibit a clear critical potential, whereas the critical potential for R6 grade is -1150 mV. EBSD results show that after stretching, the grains are significantly refined and elongated in the stretching direction, with grain rotation resulting in changes in crystal orientation. As well as, the KAM values increase significantly.

Overall, these findings provide important insights into the safety of using R5 and R6 grade mooring chain steels and offer theoretical support for the cathodic protection research of high-strength mooring chains in seawater environments.

Keywords: Mooring chain steel; Cathode potential; Hydrogen thermal analysis; Slow strain rate tensile (SSRT)