Study on cathodic protection criteria of three kinds of Marine high strength steel

Pengfei Yin[1], Zhixian Gao[1], Xiangyang Li[2], Wenping Lu[1], Bo Zhang[1]

[1]*Qingdao NCS Testing and Protection Technology Co., Ltd, Qingdao 266071, China*

[2]*Central Iron and Steel Research Institute, Beijing 100081, China*

ypf1201@163.com

Abstract The development and utilization of marine resources are fundamentally dependent on various types of steel. High-strength steel not only demonstrates exceptional strength but also exhibits a relatively low weight, thereby playing an increasingly pivotal role in the exploitation and utilization of resources within deep-sea environments [1-2]. The corrosive nature of seawater is notably high. When high-strength steel is utilized in seawater conditions, cathodic protection is typically essential for mitigating corrosion. However, the enhancement of high-strength steel's strength correlates with an increased susceptibility to hydrogen embrittlement [3-4]. Particularly, when severe overprotection occurs during cathodic protection, it can lead to hydrogen embrittlement in the material [5-7], presenting a significant risk to the service safety of marine structures. Therefore, investigating the cathodic protection parameters for high-strength steel in marine environments holds considerable importance for preventing both corrosion and hydrogen embrittlement failures [9-10].

In this study, the corrosion protection efficacy of three types of shipboard high-strength steel was evaluated through weight loss corrosion rate testing at various cathodic polarization potentials, while the sensitivity to hydrogen embrittlement of these steels was assessed using slow strain rate tensile testing (SSRT). The minimum and maximum protection potentials for each type of high-strength steel were established based on their respective protective efficacy and hydrogen embrittlement coefficients. The findings indicate that the cathodic protection potential range for 600 MPa-grade steel is -761 mV to -1029 mV(vs.SCE), for 800 MPa-grade steel is -795 mV to -946 mV, and for 1000 MPa-grade steel is -762 mV to -907 mV.

Keywords high-strength steel, cathodic protection, protection potential, SSRT

Reference

[1] Yin-xia Fang, Gengsheng Bao, Xianglong Jin, Prospects for the exploitation and utilization of deep-sea resources in the 21st century, Marine Science Bulletin, 2000, 19(5): 73-77

[2] Bo Hu, China's deep-sea Strategy and construction of maritime Power, People's Forum · Academic Frontiers, 2017, 18(9): 12-21

[3] Rogers H C. Hydrogen embrittlement of metals atomic hydrogen from a variety of sources reduces the ductility of many metals. In: Science, 1968, 159:1057-1064

[4] Sandoz G. A unified theory or some effects of hydrogen source, alloying elements, and potential on crack growth in martensitic AISI 4340 steel. In: Metallurgical and Materials Transactions B, 1972, 3(5):1169-1176

[5] Batt C, Robinson M J. Cathodic protection requirements for high strength steel in sea water assessed by potentiostatic weight loss measurements. In: British Corrosion Journal, 2013, 37(1):31-36

[6]Kim S J, Jang S K, Kim J I. Electrochemical study of hydrogen embrittlement and optimum cathodic protection potential of welded high strength steel. In: Metals & Materials International, 2005, 11(1):63-69

[7] Pengfei Yin, Xiangyang Li, Wenping Lu, et al. Effect of Cathode Polarization on hydrogen embrittlement sensitivity of 10Ni9CrMoV High Strength Steel [J]. Journal of Iron and Steel Research, 2020, 32(5):416-422.

[8] Yu Liu, Yan Li, Qiang Li. Effect of cathode polarization on hydrogen embrittlement sensitivity of X80 pipeline steel under simulated deep sea conditions [J]. Acta Metalica Sinica, 2013, 49(9):1089.

[9] Timing Zhang, Weimin Zhao, Wang Guo, et al. Hydrogen embrittance sensitivity of X65 steel under cathodic protection in simulated seawater [J]. Chinese Journal of Corrosion and Protection, 2014, 34(4): 315. (in Chinese)

[10] Lindley C, Rudd W J. Influence of the level of cathodic protection on the corrosion fatigue properties of high-strength welded joints[J]. Marine Structures, 2001, 14(4–5): 397.