Study on Electrochemical Monitoring Methods for Stress Corrosion of Typical Stainless Steels

Zhiyong Liu[1,2], Baozhuang Sun[1,2], Yue Pan[1,2], Huaiyun Cui[1,2], Xiaogang Li[1,2], Cuiwei Du[1,2]

[1] *National Materials Corrosion and Protection Scientific Data Center, 30 Xueyuan Road, Haidian District, Beijing, China*

[2] *Key Laboratory for Corrosion and Protection of Ministry of Education, 30 Xueyuan Road, Haidian District, Beijing, China*

liuzhiyong7804@126.com

Abstract Stress corrosion cracking (SCC) poses a significant threat to the safe operation of stainless steel components in critical engineering fields such as nuclear power, petrochemicals, aerospace, and marine vessels. Due to the complexity of its mechanisms and the numerous influencing factors, effective prevention and control of SCC remain challenging. As a result, the mechanisms, diagnostics, and assessment of stress corrosion in stainless steel have long been areas of extensive focus in both industry and academia. SCC in stainless steel is an interactive process involving fracture behavior, passive film failure, and electrochemical behavior. Detailed analysis of failure cases, identification of occurrence patterns, and examination of the primary mechanisms and internal and external microstructural influences are crucial for advancing monitoring, detection, and prevention technologies for SCC. This study summarizes the research progress of our team in understanding the microstructural characteristics and monitoring methods for typical stainless steel SCC failures. Our findings indicate that the SCC behavior of stainless steel aligns with a non-steady-state electrochemical model, with the corrosion fracture mechanism being controlled by a mixed mode of anodic dissolution and hydrogen embrittlement. Furthermore, various precipitates and deformation structures resulting from processes such as cold deformation, sensitization, and heat treatment significantly influence the initiation of SCC. The study elucidates the detailed mechanisms and patterns of these effects. These insights not only enhance the understanding of the mechanisms underlying stainless steel SCC but also provide valuable guidance for preventing SCC and optimizing the corrosion resistance of stainless steel, offering both scientific and practical significance.

Keywords stainless steel, stress corrosion cracking, anti-corrosion design, evaluation technology

Reference

[1] B.Z. Sun, Q.Y. Wang, Y. Pan, et al. Understanding the non-steady Electrochemical mechanism on SCC of 304 SS under applied polarization potentials[J]. Corrosion Science 227, (2024) 111686.

[2] B.Z. Sun, Y. Pan, J.K. Yang, et al. Microstructure evolution and SSCC behavior of strain-strengthened 304 SS pre-strained at room temperature and cryogenic temperature[J]. Corrosion Science, 210 (2023) 110855.

[3] X.J. Yang, M.H. Liu, Z.Y. Liu, et al. Failure analysis of a 304 stainless steel heat exchanger in liquid sulfur recovery units[J]. Engineering Failure Analysis, 116 (2020) 104729.

[4] Z.Y. Liu, W. Wu, W.K. Hao, et al. Technical Note: Stress Corrosion Cracking Mechanism of 304L under a Glycine Environment[J]. Corrosion, 72 (2016) 332-341.

[5] R.K. Liu, J.K. Li, Z.Y. Liu, et al. Effect of pH and H2S concentration on sulfide stress corrosion cracking (SSCC) of API 2205 duplex stainless steel[J]. International Journal of Materials Research, 106 (2015) 608-613.

[6] Z.Y. Liu, C.F. Dong, X.G. Li, et al. Stress corrosion cracking of 2205 duplex stainless steel in H2S-CO2 environment[J]. Journal of Materials Science, 44 (2009) 4228-4234.