

Study on the Quick Evaluation of Stress Corrosion and Crack Growth Prediction in Low-Alloyed Steel

Huaiyun Cui^{1,2}, Zhiyong Liu^{1,2*}, Zhonyu Cui^{1,2}, Yong Li^{1,2}, Ziyang Zhang^{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

cuihuaiyun@163.com

Abstract Stress corrosion cracking (SCC) has long been a critical factor affecting the safe operation of load-bearing facilities such as pipeline steel and offshore platforms. SCC is influenced by numerous factors, with complex mechanisms that make effective prevention and control challenging. Its delayed onset and sudden occurrence can often lead to severe safety incidents and significant losses. Therefore, assessing the development of SCC and predicting the SCC life of materials are key strategies to prevent unexpected failures and reduce facility-related costs. Currently, the evaluation of SCC susceptibility is primarily based on slow strain rate testing (SSRT), which is time-consuming and cannot provide online assessments of in-service facilities. Moreover, the accurate determination of crack growth rate (CGR) still relies heavily on experimental testing, and existing CGR prediction models face limitations such as insufficient consideration of critical factors, inapplicability to active systems, and excessive undetermined parameters. These drawbacks hinder the practical application of prediction models. To address these issues, this paper proposes a rapid online SCC assessment model and a generalized, simplified CGR prediction model based on the study of the unsteady electrochemical processes at the crack tip. The SCC rapid assessment model requires only electrochemical testing and a limited number of SSRTs to determine the SCC susceptibility distribution of materials under various applied potentials. This model is applicable to different environments and materials, offering broad applicability, operational convenience, and accurate results, with an assessment error of less than 18%, meeting the engineering requirements for SCC evaluation. The generalized CGR prediction model, which requires only electrochemical testing and minimal crack growth testing, can accurately predict the crack growth rate under different potentials, with an error of less than 20%. The establishment of these two models provides valuable guidance for the safety

assessment, life prediction, and selection of protective measures for materials in service.

Keywords low alloyed steel, stress corrosion cracking, crack growth rate, life prediction

Reference

[1] H.Y. Cui, L.X. Wang, J.C. Zhang, et al. SCC quick-evaluation model of high-strength pipeline steel in the typical external environment[J]. *Electrochimica Acta* 498, (2024) 144629.

[2] 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.

[3] Z.Y. Liu, L. Lu, Y.Z. Huang, et al. Mechanistic Aspect of Non-steady Electrochemical Characteristic During Stress Corrosion Cracking of an X70 Pipeline Steel in Simulated Underground Water[J]. *Corrosion* 70, (2014) 678-685.