Stress corrosion cracking of HP-13Cr stainless steel and design of corrosion resistant alloy for ultra-depth well

Yang Zhao, Wenlong Qi, Tao Zhang*, Fuhui Wang
Corrosion and Protection Center, Northeastern University, Shenyang, 110819, China.

Abstract: Tubing materials for ultra-depth well faced harsh corrosive environments, including well depth up to 8000 m, temperature up to 180 ℃, the partial pressure of CO_2 and H_2S up to 3.8 MPa and 0.5 MPa, concentration of Cl^- up to 6 mol/L, variable fluid and complex stress, during oil and gas extraction process. HP-13Cr stainless steel, a kind of typical tubing material, characterized as appropriate mechanical properties, excellent corrosion resistance and cost-effectiveness. However, severe stress corrosion cracking (SCC) occurred during the exploitation and well completion process, resulting in serious safety hazard, economic loss, and energy leakage risk. Therefore, revealing the SCC mechanism of HP-13Cr stainless steel and predicting the life of tubing is necessary. The novel corrosion-resistant alloy should be designed for harsh oil and gas extraction environment. First, the SCC susceptibility of HP-13Cr stainless steel under high temperature and high CO_2 pressure environment was evaluated, and the SCC mechanism and the initiation of SCC were revealed. Then the measurement and prediction of SCC critical stress intensity factor ($K_{ⅠSCC}$) and crack growth rate (CGR) was conducted. Finally, the design criteria of corrosion-resistant alloy was proposed based on “Dissolution-ionization-deposition” model. And the model verification was also conducted by measuring the corrosion properties of novel HP-13Cr-Cu stainless steel under formation water environment containing H_2S.

Keywords: Stress corrosion cracking, HP-13Cr stainless steel, Corrosion thermodynamics and dynamics, Corrosion prediction, Corrosion resistant alloy design.