

Study on the Corrosion Law of P110SS Underwater Ultra high Temperature Supercritical CO₂

Xinyu Zhu^{1,2}、Yi Huang³、Wentuo Li^{3,4}、Gao Yu^{3,4}、Qi Fu^{3,4}、Yanzhao Yu^{1,2}

1. *China University of Petroleum (Beijing)*

2. *Beijing Key Laboratory of Material Failure and Corrosion Protection for Oil and Gas Equipment*

3. *CNOOC (China) Co., Ltd. Hainan Branch*

4. *Hainan Province Key Laboratory of Deep Sea Deep Energy Engineering*

abstract:

As offshore oil and gas exploration and development increasingly progress into deeper layers, the operational environment for well pipes becomes more challenging, with materials facing severe risks of corrosion failure under ultra-high temperature and pressure conditions. **Objective:** To elucidate the corrosion behavior and patterns of low-alloy steel well pipes under supersaturated supercritical CO₂, this study focuses on P110SS. Through static weight loss corrosion tests, the influence of a wide temperature range (40°C~250°C) and ultra-high pressure (1 MPa~70 MPa) on the corrosion rate of the material in a supercritical state was analyzed. SEM, EDS, and other analytical methods were employed to characterize the morphology and composition of the corrosion products. **Results:** Under simulated marine conditions with a CO₂ partial pressure of 10 MPa, the corrosion rate of P110SS peaked at 2.43 mm/a at 80°C and decreased continuously with increasing temperature, reaching 0.17 mm/a at 250°C. Below 7.35 MPa, the corrosion rate increased linearly with pressure. However, when CO₂ exited the dense phase, the influence of pressure on the corrosion rate became insignificant. **Conclusion:** Whether CO₂ is in a dense or supercritical state, the corrosion rate of P110SS initially increases and then decreases with rising temperature, without a change in corrosion mode. The corrosion rate was highest at 80°C, gradually decreasing and stabilizing above 180°C, with corrosion rate being controlled by the density of the corrosion products. As CO₂ pressure increases, the corrosion rate rises, with P110SS being more sensitive to CO₂ pressure in the dense phase. This trend is related to the solubility of CO₂ in water. This study provides valuable insights into the corrosion behavior and mechanisms of materials under supercritical CO₂ conditions.

Keywords: Ultra-high temperature; Supercritical CO₂; Low-alloy steel; Corrosion test.