Effect of element sulfur on the corrosion mechanism of X80 steel under dynamic supercritical CO_2 water-rich phase environment

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Abstract

The precipitation of elemental sulfur in CO_2 transport pipelines may affect the corrosion mechanism of pipeline materials in supercritical CO_2 environments. This study investigated the corrosion mechanism of X80 pipeline steel in a water-saturated supercritical CO_2-rich phase under dynamic conditions at 40°C and 8 MPa. The results indicated that the general corrosion rate was high both with and without sulfur, and increased with flow rate. However, the pitting factor showed a decreasing trend. At a rotational speed of 900 rpm, the pitting factor in the sulfur-containing condition was less than 5, suggesting that significant pitting corrosion may not occur. This conclusion was further supported by 3D surface morphology analysis. The increase in corrosion rate was related to enhanced mass transfer of the corrosive medium due to flow, while the reduction in pitting tendency may be attributed to decreased contact time between elemental sulfur particles and the metal substrate, reducing the likelihood of under-deposit corrosion. Scanning electron microscope (SEM) results showed that the corrosion product films were loose and porous, providing limited protection to the substrate, which led to high corrosion rates under all conditions. Analysis of the corrosion products revealed that flow rate had no effect on the composition of the products, while the presence of sulfur significantly influenced the composition of the product film.

Keywords: Elemental sulfur; Corrosion product film; Corrosion pits; Supercritical CO_2; Flow

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