

Effect of Hydrogen Blending Ratio on the Hydrogen Embrittlement Sensitivity of X60 Pipeline Steel

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Abstract Blending a certain proportion of hydrogen into natural gas and transporting it through existing pipelines is the most cost-effective method for long-distance hydrogen transportation. However, the evaluation of the adaptability of hydrogen-blended natural gas pipelines is not yet fully developed. This study investigates the hydrogen embrittlement behavior of X60 steel under hydrogen blending ratios of 0–30% at 12 MPa using slow strain rate tensile (SSRT) tests combined with SEM analysis. In-situ high-pressure gas-phase hydrogen permeation tests were conducted to accurately determine subsurface hydrogen concentrations under different hydrogen blending ratios. The results indicate that as the hydrogen blending ratio increased from 10% to 20%, the subsurface hydrogen concentration, plasticity loss, and hydrogen embrittlement sensitivity significantly increased. Additionally, a positive correlation was observed between subsurface hydrogen concentration and hydrogen embrittlement index. Based on the hydrogen permeation, SSRT results, and fracture morphology analysis, the safe critical range for the operation of X60 hydrogen-blended natural gas pipelines was determined to be a hydrogen blending ratio of 10%.

Keywords Hydrogen-blended natural gas, X60 steel, slow strain rate tensile, hydrogen permeation, hydrogen embrittlement sensitivity

Reference

[1] Wu X, Zhang H, Yang M, et al. From the perspective of new technology of blending hydrogen into natural gas pipelines transmission: Mechanism, experimental study, and suggestions for further work of hydrogen embrittlement in high-strength pipeline steels[J]. International Journal of Hydrogen Energy, 2022, 47(12): 8071-8090.

[2] Zhao W, Zhang T, Zhao Y, et al. Hydrogen permeation and embrittlement susceptibility of X80 welded joint under high-pressure coal gas environment[J]. Corrosion Science, 2016, 111: 84-97.