

Hydrogen permeation behavior at different positions in the normal direction of X42 and X52 pipeline steels

Huiling Wang^{1,2}, Hongliang Ming^{1,2,*}, Jianqiu Wang^{1,2,3,*}, Wei Ke², En-Hou Han³

1 School of Materials Science and Engineering, University of Science and Technology of China, Shenyang 110016, China

2 CAS Key Laboratory of Nuclear Materials and Safety Assessment, Institute of Metal Research, Chinese Academy of Sciences, Shenyang 110016, China

3 Institute of Corrosion Science and Technology, Guangzhou 510530, China

hlwang21s@imr.ac.cn (Huiling Wang)

Abstract Facing the severe energy shortage and environmental problems, the development of green and low-carbon energy is imminent. Hydrogen energy which has advantages of abundance and long distance transportation is viewed as an important way for the energy transition. The cost of hydrogen transport through existing natural gas pipeline is low, but hydrogen can penetrate into the pipeline steel and cause damage to mechanical properties of pipeline steel. Microstructure is an important factor affecting hydrogen diffusion in pipeline steels. Due to the different stress and heat conditions, the surface and internal microstructure of the rolled pipeline steels is different. The ferrite grain size in surface layer of X42 pipeline steel is smaller than other locations, while the surface layer of X52 pipeline steel has continuous banded ferrite/pearlite structure and grains with uneven size. Besides, the residual strain in central layer of X42 pipeline steel is larger than that in surface layer, while the residual strain in surface layer of X52 pipeline steel is larger. Hydrogen permeation behavior is investigated at different positions in the normal direction of X42 and X52 pipeline steels using the electrochemical hydrogen permeation technique. The results show that the values of the effective diffusion coefficient of surface layer in X42 and X52 pipeline steels are the smallest, while the values of the subsurface hydrogen concentration at steady state are the largest. This is attributed to the fact that grain boundaries and continuous banded ferrite/pearlite structure hinder hydrogen diffusion^[1]. Hydrogen microprint experiment results indicate hydrogen atoms mainly escaped at pearlite, ferrite grain boundaries and near inclusions in X42 and X52 pipeline steels.

Keywords Hydrogen permeation; Pipeline steel; Grain size; Banded ferrite/pearlite structure; Hydrogen microprint technique

Reference

[1] Yazdipour N, Haq AJ, Muzaka K, et al. 2D modelling of the effect of grain size on hydrogen diffusion in X70 steel. *Computational Materials Science*. 2012;56:49-57.