

### 论文

#### API X56钢在含H<sub>2</sub>S的海洋大气中的应力腐蚀开裂

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摘要:

采用慢应变速率拉伸及Devnathan-Stachurski双电解池技术研究了 X56钢在模拟海洋大气环境中形变及H<sub>2</sub>S含量对其应力腐蚀开裂及氢渗透行为的影响。结果表明, 在H<sub>2</sub>S含量相同时, 拉伸速率越小, 试样断裂延伸率越小。在相同拉伸速率下, 随着H<sub>2</sub>S含量增大, 试样断裂延伸率减小, 扫描电镜微观分析(SEM)表明, 其断裂特征由塑性断裂逐渐转变为脆性断裂。电化学渗氢实验表明, 随着H<sub>2</sub>S含量的增大, 第一干湿循环氢渗透电流并不单调增大, H<sub>2</sub>S对氢渗透电流的作用由H<sub>2</sub>S的表面覆盖度和腐蚀产物膜来共同控制。从多个干湿循环来看, H<sub>2</sub>S可增大氢渗透电流, 材料的渗氢加剧, 脆性增大。

关键词: H<sub>2</sub>S 应力腐蚀开裂敏感性 氢脆 大气腐蚀

#### STRESS CORROSION CRACKING OF X56 GRADE PIPELINE STEEL IN ATMOSPHERIC ENVIRONMENT CONTAINING H<sub>2</sub>S

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Abstract:

Susceptibility to SCC of X56 grade pipeline steel was investigated by slow strain rate test (SSRT) and Devnathan-Stachurski double electrolytic cell in atmospheric environment containing H<sub>2</sub>S. The results showed that the fracture strain decreased while the strain rate decreased in the same H<sub>2</sub>S concentration environment. And the fracture strain decreased with increasing the concentration of H<sub>2</sub>S at the same strain rate  $6.67 \times 10^{-7} \text{ s}^{-1}$ . The SEM fractographs of the specimens also showed that the susceptibility to stress corrosion cracking (SCC) increased. The hydrogen permeation test showed that hydrogen permeation current did not increase with increasing the concentration of H<sub>2</sub>S in the first wet-dry cycle because of the formation of product film. The longer the experiment time, the more the hydrogen atom permeated through the specimen. This trend partially attribute to the surface coverage ratio ( $\theta$ ) of H<sub>2</sub>S and the corrosion product film.

Keywords: hydrogen sulfide stress corrosion cracking hydrogen embrittlement atmospheric environment

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#### 参考文献:

- [1] Van Gelder K, Erlings J G, Damen J W M, et al. The stress corrosion cracking of duplex stainless steel in H<sub>2</sub>S/CO<sub>2</sub>/Cl<sup>-</sup> environments [J]. Corros. Sci., 1987, 27(10-11): 1271-1279
- [2] Barteri M, Mancina F, Tamba A, et al. Engineering diagrams and sulphide stress corrosion cracking of duplex stainless steels in deep sour well environment [J]. Corros. Sci., 1987, 27(10-11): 1239-1250
- [3] Huang Y L, Zhu Y Y. Hydrogen ion reduction in the process of iron rusting [J]. Corros. Sci., 2005, 47(6): 1545-1554
- [4] Devnathan M A V, Stachurski Z. A technique for the evaluation of hydrogen embrittlement characteristics of electroplating baths[J]. J. Electrochem. Soc., 1963, 110(8): 886-894
- [5] GB17378. 4--1998, Seawater analysis--Part 4 of criterion of marine monitoring[S]. (GB17378. 4--1998, 海洋监测规范第4部分-海水分析[S].)
- [6] Masato Kobayashi, Atsushi Nishikata, Tooru Tsuru. Hydrogen embrittlement of reinforced steels in high alkaline chloride environments[A]. 45th Forum on Engineering Science and Technology, Chinese Academy of Engineering & 3rd international symposium on marine corrosion and control[C]. Qingdao, 2006, 93-97
- [7] Tsai S Y, Shih H C. A statistical failure distribution and lifetime assessment of the HSLA steel plates in H<sub>2</sub>S containing environments [J]. Corros. Sci., 1996, 38(5): 705-719
- [8] Qiao L J, Wang Y B, Chu W Y. Mechanism of Stress Corrosion[M]. Beijing: Science Press, 1993: 83

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(乔利杰, 王燕斌, 褚武扬. 应力腐蚀机理[M]. 北京: 科学出版社, 1993: 83)

[9] Li M Q, Cai Z C, He X Y. Electrochemical study of 16Mn steel under H<sub>2</sub>S thin electrolyte film[J]. Mater. Prot., 2006, 39(1): 1-5

(李明齐, 蔡锋昌, 何晓英. H<sub>2</sub>S薄层液膜下16Mn钢腐蚀的电化学研究[J]. 材料保护, 2006, 39(1): 1-5)

[10] Cao C N. Corrosion Electrochemistry[M]. Beijing: Chemistry Industry Press, 1995, 14

(曹楚南. 腐蚀电化学[M]. 北京: 化学工业出版社, 1995, 14)

[11] Li G M, Liu L W, Zheng J T. Corrosion behavior of carbon steel in high pressure dioxide saturated NaCl solutions containing hydrogen sulfide[J]. J. Chin. Soc. Corros. Prot., 2000, 20(4): 204-209

(李国敏, 刘烈伟, 郑家荣. 碳钢在硫化氢及高压二氧化碳饱和的NaCl溶液中的腐蚀行为[J]. 中国腐蚀与防护学报, 2000, 20(4): 204-209)

[12] Ma H Y, Cheng X L, Li G Q, et al. The influence of hydrogen sulfide on corrosion of iron under different conditions[J]. Corros.Sci., 2000, 42(10): 1669-1683

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1. 张耀丰, 丁毅, 陆晓峰, 顾伯勤. 304不锈钢在H<sub>2</sub>S介质条件下的应力腐蚀[J]. 中国腐蚀与防护学报, 2007,27(2): 101-108
2. 杨怀玉, 陈家坚, 曹楚南. H<sub>2</sub>S水溶液中的腐蚀与缓蚀作用机理的研究 III.不同pH值H<sub>2</sub>S溶液中碳钢的腐蚀电化学行为[J]. 中国腐蚀与防护学报, 2000,20(2): 97-104
3. 杨怀玉, 陈家坚, 曹楚南. H<sub>2</sub>S水溶液中的腐蚀与缓蚀作用机理的研究1.酸性H<sub>2</sub>S溶液中碳钢的腐蚀行为及硫化物膜的生长[J]. 中国腐蚀与防护学报, 2000,20(1): 1-7
4. 杨怀玉, 陈家坚, 曹楚南. H<sub>2</sub>S水溶液中的腐蚀与缓蚀作用机理的研究V. 咪唑啉衍生物在H<sub>2</sub>S溶液中的缓蚀作用特征[J]. 中国腐蚀与防护学报, 2001,21(6): 321-327
5. 王佳, 陈家坚, 李相波. 油田排海污水中H<sub>2</sub>S的分布及其对平台钢结构设施腐蚀行为的影响[J]. 中国腐蚀与防护学报, 2003,23(1): 38-45
6. 闫丽静, 牛林, 林海潮. 含H<sub>2</sub>S的硫酸溶液中Cl<sup>-</sup>影响铁阳极溶解的影响\*[J]. 中国腐蚀与防护学报, 1999,19(4): 214-220
7. 闫丽静, 林海潮, 吴维tao. 含H<sub>2</sub>S的硫酸溶液中丙炔醇对铁腐蚀的抑制作用\*[J]. 中国腐蚀与防护学报, 1999,19(4): 221-226
8. 唐建群, 巩建鸣, 涂善东. 不同钢制造LPG球罐在湿H<sub>2</sub>S环境下失效行为的对比研究[J]. 中国腐蚀与防护学报, 2006,26(4): 245-250
9. 郭红, 何晓英. X70钢在含H<sub>2</sub>S弱酸性溶液中的防腐研究[J]. 中国腐蚀与防护学报, 2006,26(6): 355-359
10. 唐建群, 巩建鸣, 涂善东. SPV50Q钢在含H<sub>2</sub>S酸性环境下的腐蚀特性[J]. 中国腐蚀与防护学报, 2007,27(4): 219-223

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