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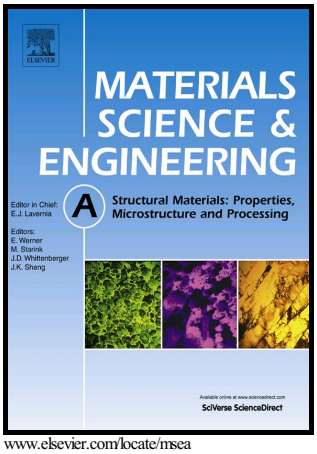

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Effect of sulfate-reducing bacteria and cathodic potential on stress corrosion cracking of X70 steel in sea-mud simulated solution

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A B S T R A C T

The submarine oil and gas pipelines steel buried in sea mud are always influenced by microorganisms and cathodic protection potential. In this paper, the single and combined effect of sulfate-reducing bacteria (SRB) and cathodic potential on stress corrosion cracking (SCC) behavior of X70 pipeline steel in sea-mud simulated solution was investigated by slow strain rate tests and fractographic observation. Whether in sterile or SRB-inoculated solution, the SCC susceptibility at -850 mV_{SCE} showed a decline compared with that at open circuit potential. The reason is that the lower number of corrosion pits and the slighter hydrogen evolution at -850 mV_{SCE} inhibited both of the cracks nucleation and propagation. The SCC susceptibility of X70 steel increased drastically as the cathodic potential shifted from -850 mV_{SCE} to -1200 mV_{SCE} in sterile or SRB-inoculated solution. SRB assisted pitting corrosion and the promotion effect on hydrogen permeation make SRB plays a positive role in promoting SCC susceptibility. The SCC susceptibility can be elevated in the co-existence of SRB and cathodic potential but the combined action between them became limited as the potential shifted negatively, which was attributed to the fact that alkalization of solution caused by cathodic potential restricts the growth of SRB.

Keywords: Sulfate-reducing bacteria; Cathodic potential; Stress corrosion cracking; Pipeline steel; Sea-mud simulated solution

1. Introduction

As “energy highways”, pipelines are always subjected to various failures [1]. It is well accepted that stress corrosion cracking (SCC) is one of the most common and dangerous failure modes resulting in pipeline accidents because of its unpredictability and devastating consequences [2, 3]. SCC is a type of environmentally assisted cracking (EAC) phenomenon involving local corrosion and external static stress [4, 5]. The mechanisms of SCC have been discussed for many years and some have been acknowledged, such as anodic dissolution (AD) and hydrogen embrittlement (HE). For the SCC research associated with pipeline, high-pH SCC and near-neutral pH SCC are usually considered individually based on the electrolyte contacting with pipeline surface [6]. Many studies found that AD dominates the crack propagation of high-pH SCC usually associated with intergranular crack feature, while that HE is considered to be the main mechanism of near-neutral pH SCC which often exhibits transgranular crack appearance [7-9]. SCC is affected by many factors, which can be categorized into environment aspects, metallurgical aspects, and mechanical aspects. For metallurgical aspects, many researchers have confirmed that microstructure is a crucial factor affecting the SCC behavior [10-13]. It was suggested that increased ferrite content can improve the HIC resistance [10], while that martensite and bainite was considered to be susceptible to HE [11]. M-A islands also has the facilitation effect on crack initiation and propagation [14]. However, the different conclusion about the effect of ferrite on SCC was also existed. D. Hejazi et al. found that coarse ferrite grains can enhance the hydrogen build-up in the stress-concentrated zone ahead of the crack tips