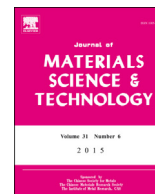




Contents lists available at ScienceDirect

Journal of Materials Science & Technology

journal homepage: www.jmst.org

Preliminary Study on Corrosion Behaviour of Carbon Steel in Oil–Water Two-Phase Fluids

Z.Y. Hu, D.L. Duan*, S.H. Hou, X.J. Ding, S. Li

Institute of Metal Research, Chinese Academy of Sciences, Shenyang 110016, China

ARTICLE INFO

Article history:

Received 11 November 2014

Received in revised form

16 December 2014

Accepted 23 December 2014

Available online xxx

Key words:

Carbon steel

Corrosion behavior

Wetting

Fluid flow

Fourier transform infrared (FTIR) spectroscopy

The corrosion behavior of type 1045 (AISI) carbon steel (CS) in oil–water fluids was investigated by considering the surface wetting state as the breakthrough point. The surface water wetting percentage (SWWP) and corrosion weight loss of CS in different oil–water fluids were measured. The morphology and composition of the corrosion films were detected via scanning electron microscopy, electron-probe face-scanning technology and Fourier-transform infrared spectroscopy. The results indicated that the corrosion weight loss of CS in the oil–water fluids corresponded with SWWP and that the corrosion process was influenced by the participation of oil.

Copyright © 2015, The editorial office of Journal of Materials Science & Technology. Published by Elsevier Limited. All rights reserved.

1. Introduction

With increasing difficulty in oil exploitation, waterflooding oil recovery has been affirmed by domestic and foreign scholars as well as engineers as a means of increasing oil production, and the transportation of water–oil mixtures has gained widespread use in the oil delivery process. To improve the efficiency of oil recovery and delivery, more attention^[1–4] has been directed towards the wetting behaviour of water–oil fluids. As a result, the oil production and transportation is substantially enhanced by waterflooding and water–oil mixture transportation, which also reduce costs. However, tribo-corrosion between the sucker rods and pipes dramatically increases due to the presence of water, as the corrosion and erosion-corrosion loss of the pipeline during oil recovery and transportation^[5]. These factors increase the cost of oil production and transportation because of production interruptions as well as equipment repair and replacement, and so on.

Therefore, an increasing number of scholars and engineers have investigated the erosion corrosion and tribo-corrosion of carbon steel (CS) and stainless steel. Wang et al.^[6] noted that eccentric wear primarily occurs in moderate- and high-water wells because the original lubricating and medium conditions between the pipes

and rods are damaged due to high water content, which facilitates both corrosion and wear. Hedayat et al.^[7] surveyed the corrosion wear behaviour of CS using a specially constructed wear testing machine and a three-electrode electrochemical test system in an oil–water–sand three-phase system with bicarbonate ions and chloride ion. The experimental results showed that the corrosion and wear behaviour of CS in the oil–water system was significantly affected by its organisational structure and hardness. Guo et al.^[8] and Stack and Abdulrahman^[9] studied the synergism between corrosion and erosion and noted that corrosion behaviour was significantly influenced by rotating velocity, impact angle and oil content. Heuer and Stubbins^[10] investigated the erosion-corrosion behaviour of test bars in a multiphase flow using a specially constructed high-pressure, cross-flow, loop apparatus and showed that corrosion rate increased with the flow Froude number and that erosion-corrosion was influenced by the water content and flow state. It was found that sand concentration, slurry flow velocity and impact angles had a large influence on the erosion-corrosion behaviour of stainless steel and carbon steels^[11–14]. For instance, Mohammadi^[13] found that the corrosion-induced surface plasticity was the dominate mechanism of corrosion-enhanced erosion and the dynamic plastic deformation caused by erodent impingement ought to be responsible for erosion-enhanced corrosion in flowing slurry.

Most of the aforementioned studies are focused on the nature of the experimental materials and media, which generally affect

* Corresponding author. Prof., Ph.D.; Tel.: +86 24 23971773; Fax: +86 24 23971778.

E-mail address: duandl@imr.ac.cn (D.L. Duan).

corrosion behaviour of certain systems. However, there are still some problems related to CS corrosion in oil–water two-phase fluids to be studied. Firstly, the reasons why corrosion behaviour changed with the flow velocity and water content are still unclear. Secondly, the relationship between surface wetting state and corrosion behaviour of CS in the oil–water two-phase fluids is rarely mentioned while corrosion originates from the metal surface and then extends inward.

In this study, the surface water wetting percentage (SWWP) of metals in oil–water fluids were tested using a specially constructed device; the tests were based on significant conductivity differences between oil and sodium chloride solution. In order to investigate the relationship between corrosion and surface wetting state and the reasons why the corrosion behaviours of CS varied with the fluid conditions, the linear polarisation resistances (LPRs) and the weight losses of CS samples were investigated under specific surface wetting conditions. Meanwhile, to uncover the corrosion mechanism of CS in oil–water fluids and to lay a foundation for the further study of corrosion damage in the waterflooding oil recovery industry and oil transportation process, the corrosion morphology of the CS samples was detected by scanning electron microscopy (SEM), and the corrosion products on the samples and in the solutions were analysed by Fourier-transform infrared (FTIR) spectroscopy.

2. Experimental

2.1. Measurement of metal surface wetting state

2.1.1. Test media

Type 3 Skaln white oil with a density of 832 kg/m^3 , viscosity of $2.88 \text{ mm}^2/\text{s}$ and surface tension of 27.27 mN/m at 25°C and a 3% sodium chloride aqueous solution were used as the testing media. Oil–water mixed solutions with different water contents were prepared.

2.1.2. Test apparatus

A specially constructed apparatus (Fig. 1) was developed to measure the SWWP of samples at different water contents in the oil–water two-phase fluids at velocities of 0.24, 0.5 and 1 m/s, respectively. Conductivity of wetting film on metal surface was measured by 160 micro conductivity sensors which were embedded in the sample and kept the same level as the sample surface. The conductivity of wetting film can display surface wetting states of metals due to significant conductivity differences between oil and water. Cai et al.^[15] studied the relationship between fluid patterns and surface wetting state using the same method and pointed that in the fluid with oil-in-water or water-in-

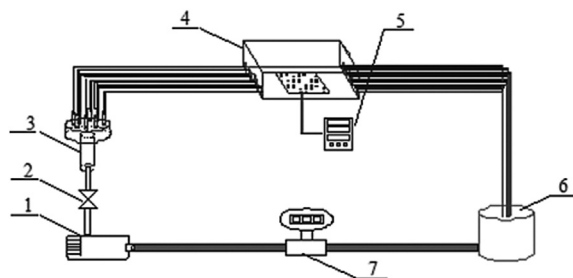


Fig. 1. Schematic of the especially constructed experimental apparatus for oil–water wetting behavior studies: 1—circulation pump, 2—flow rate control valve, 3—manifold, 4—sample test module, 5—information collection and display system, 6—reservoir, 7—oval gear volume flow meter.

oil flow pattern the metal surface was beneficial to water or oil wetting, respectively.

During the tests, the mixed oil–water media in reservoir (6) were pumped through oval-gear volume flow meter (7), flow-rate control valve (2), manifold (3) and sample test module (4), and subsequently returned to the reservoir, forming a closed loop and enabling the oil–water mixed media to uniformly flow over the sample surface. The oval gear volume flow meter (7) was used to measure the flow velocity of the oil–water fluid and the micro conductivity sensors embedded in the sample were employed to determine the resistance of wetting film nearby. And then, the resistances of wetting film were transferred to information collection and display system (5) where the wetting state near the sensors were determined through a comparison between the detected resistances and preconfigured threshold value, and the threshold that distinguishes an oil film from a water film was $10 \text{ M}\Omega$ because the resistance of water film and oil film was $2.5 \text{ M}\Omega$ and infinite, respectively. When detected resistances were lower than the threshold, water wetting was determined, otherwise oil wetting was determined. Finally, SWWP was determined by dividing 160 (the total number of the micro conductivity sensors) with the sensors representing water wetting and saved in the software. Two experiments were conducted under each set of experimental conditions.

2.2. Corrosion experiment

2.2.1. Test samples and media

The test sample was made of Type 1045 (AISI) CS with a size of $60 \text{ mm} \times 36 \text{ mm} \times 5 \text{ mm}$, and its chemical composition (wt%) was 0.45C, 0.2 Si, 0.62 Mn, 0.22 Cr, 0.2 Ni, 0.05 Cu and Fe balance. Before test, the sample was ground, polished, cleaned and weighted. The test fluid comprised type 3 Skaln white oil and 3% sodium chloride aqueous solution, and the water phase content was 5%, 15%, 25%, 35%, 45%, 50% and 60%, respectively.

2.2.2. Test apparatus and process

All corrosion tests were performed in the test chamber at room temperature under atmospheric environment. The test chamber was constructed from a 10-mm-thick plexiglas plate, as shown in Fig. 2. A groove with a depth of 5 mm was carved in the centre of the bottom plate, in accordance with the corrosion test sample size. The well-prepared test sample was then placed inside the test chamber, the test plane was aligned with the bottom of the bottom plate and the inlets and outlets were connected to the hoses, thereby ensuring a smooth layer of fluid on the sample surface.

The test duration was 1 h, and during this experiment, a potentiodynamic polarisation test was conducted using a Princeton Applied Research model 273 potentiostat/galvanostat after an initial potential stabilisation period of 20 min in a electrochemical three-electrode cell with the CS samples as working electrode, and

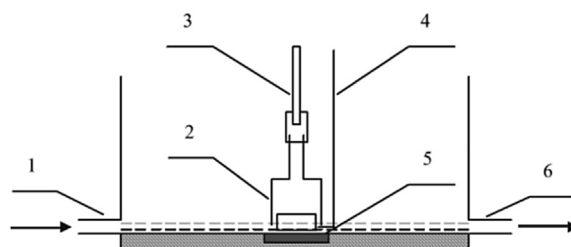


Fig. 2. Schematic of corrosion test sample chamber: 1—inlet, 2—salt bridge, 3—reference electrode, 4—platinum electrode, 5—sample; 6—outlet.

Download English Version:

<https://daneshyari.com/en/article/1555824>

Download Persian Version:

<https://daneshyari.com/article/1555824>

[Daneshyari.com](https://daneshyari.com)