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Influence of produced water with high salinity and corrosion inhibitors on the corrosion of water injection pipe in Tuha oil field

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ABSTRACT

In order to study the corrosion of water injection pipe and the performance of new corrosion inhibitors, the characteristics of corrosion products in pipe were observed by using energy dispersive spectroscopy (EDS) and X-ray diffraction (XRD). Under the static or dynamic condition, the corrosion rate of coupons in produced water was investigated through the weight loss test. The effect of new corrosion inhibitors was evaluated under the dynamic condition. The microscopic corrosion morphology of coupons was observed by using scanning electron microscope (SEM). The results suggest that in the water injection pipe, the main corrosion product is FeOOH, while the corrosion scales are mainly composed of $CaCO_3$ and $Mg_6Al_2CO_3{\cdot}(OH)_{16}{\cdot}4H_2O$. Furthermore, the pipe corrosion was mainly resulted from the dissolved oxygen, Ca^{2+} and other inorganic salt in produced water. A good inhibition effect was obtained due to the synergistic effect of corrosion inhibitors, meanwhile HZ-2 inhibitor was the best among all kinds of corrosion inhibitors prepared by the proportion of oleic acid imidazoline and phosphonic acid salt of 2:1. A high corrosion inhibition rate (89.78%) was obtained when HZ-2 inhibitor dosage and temperature were 350 mg/L and 35 °C, respectively. According to the microscopic corrosion morphology of coupons, it is clear that the corrosion rate could be significantly slowed down by the HZ-2 inhibitor.

1. Introduction

The polymers, sulfate reducing bacteria (SRB), dissolved oxygen (DO), hydrogen sulfide (H_2S) and chloride ion in the produced water all could cause the corrosion failure of pipe, which would result in huge security risk. Meanwhile, it could affect the normal production and cause enormous economic loss [1–3]. In the previous work, the effect of salinity, DO, temperature and flow velocity on the corrosion had been discussed, and the function of a certain corrosion inhibitor or scale inhibitor had been assessed. However, the corrosion of pipe was also affected seriously by the process of scaling [4–8]. As a result, it is difficult to meet the actual demand of corrosion inhibition for the water injection pipes with some certain corrosion inhibitor in the oil field [9–11]. In this study, the characteristics of the produced water and pipe were analyzed, and the structure of corrosion products and the reasons of corrosion were also discussed. Moreover, the static and dynamic coupon corrosion

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experiments were carried out and the synergistic effect of corrosion inhibitors was evaluated under the condition of dynamic corrosion.

2. Assessment of corrosion

2.1. Analysis of produced water and pipe

The selected pipe for the experiment was Q235 steel from water injection line in Tuha oilfield (Fig. 1). Direct-reading spectrograph (spectrovuc-100) was used to analyze the composition of pipe, and the result was showed by mass percent (Table 1).

The produced water was taken from Tuha oilfield with pale yellow color. According to the standard method for water analysis in oil and gas field (SY/T 5523-2000), concentrations of ions in the water were measured, and the water qualities of produced water were shown in Table 2. The produced water including Cl^-, Ca^{2+}, SO_4^{2-} and HCO_3^-, these ions can accelerate corrosion of pipe.

2.2. Spectroscopic analysis of corrosion products and scales

The compositions of corrosion products and scales in the inner wall of water injection pipe from Tuha oilfield were tested by Energy Dispersive Spectrometer (EDS) and X-ray diffraction (XRD) through X-ray spectrometer (Cu Ka radiation, 1.54056 Å) and X'Pert PRO powder diffraction (PANalytical B.V., Netherlands). The reasons of corrosion and the composition of products and scales were analyzed.

2.3. Measurement of weight loss rate

The sample of water injection pipe was processed into some coupons (50 × 25 × 3 mm), and the accurate size was determined by measurement of coupon after being processed. Small hole with diameter of 3 mm was slotted on the coupon, and then, the prepared coupons were polished with 180#, 320# and 600# abrasive paper. Moreover, the coupons were dried to constant weight after being treated by 5.0% HCl + ethanol, and recorded the weight of coupon; Nylon rope was used to hang the coupons at the bottom of rotate pole in the simulated evaluation device (Fig. 2). Under the static and dynamic conditions with different temperatures (i.e., 35, 55 and 75 °C), the coupons were hung in the device, and the corrosion inhibitor was

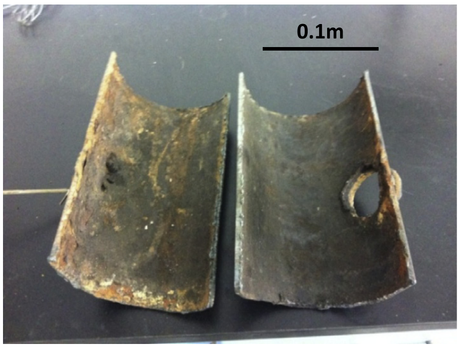

Fig. 1. Sample of water injection pipe from Tuha oilfield.

Table 1
Chemical compositions of water injection line for experiment.

Element	C	Si	Mn	P	S	Cr	Ni	Fe
Q235 steel	0.21	0.10	0.48	0.02	0.02	0.18	0.17	Else

Table 2
Water qualities of produced water from Tuha oilfield.

Type of water	pH	Salinity (mg/L)	$Na^+ + K^+$ (mg/L)	Cl^- (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	SO_4^{2-} (mg/L)	HCO_3^- (mg/L)
$CaCl_2$	6.5	96611	14062	60487	21403	389	171	99