Corrosion Behavior of L80 Steel in Different Temperature and Sulfur Content

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Abstract. To understand the corrosion behavior of L80 steel in different temperature and sulfur content, the experiment which simulated the downhole corrosive environment was conducted. From the experiment result, when other factors were constant, the lowest corrosion rate was appeared when the temperature was 90°C. The influence of sulfur was complex. When temperature was low, the corrosion rate was decreased with the increase of sulfur content and the experimental result was opposite when temperature was high.

1. Introduction
During the development of oil and gas reservoirs, there often exist acidic elements, such as CO₂ gas, H₂S gas and sulfur element which may corrode the pipes. In recent years, as more and more high temperature and high acidic carbonate reservoirs have been, or will be, developed, it is increasingly imperative to address the pipe corrosions. L80 steel is the most common used steel in oil and gas fields. So it is meaningful to understand the corrosion behavior of L80 steel in different corrosive environment, especially in different temperature and sulfur content. According to the literatures presented before[1-8], most of the research focus on the influence of the partial pressure of sour gas, such as H₂S and CO₂. However in the production of oil field, sulfur which is the corrosive element was found in the content of oil. In this paper, the experiment which simulated the downhole corrosive environment was conducted to test the corrosion behavior of L80 steel.

2. Experiment Preparation
The sample of L80 was used for corrosion test. The chemical composition of L80 steel was shown in table 1. The size of the sample for corrosion test was 50×10×3mm.

Table 1. The chemical composition of L80 steel

| Steel | C   | Mn  | Mo  | Cr  | Al  | Ni  | Cu  | P   | S   | Si  |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| L80   | ~0.22 | ~1.00 | /   | ~1.2 | /   | ~0.50 | ~0.25 | ~0.20 | ~0.010 | ~1.00 |

The medium for corrosion test was shown in table 2. All of medium was prepared by the de-ionized water and AR regent. The sour gas of H₂S and CO₂ was inserted into the autoclave and the content of gas was adjusting by the gas flow valve.
Table 2. The medium composition for corrosion test

| No | T/°C | P_{H2S} MPa | P_{CO2} MPa | Cl/ g.L^{-1} | S/% | H_{2}O/% |
|----|------|-------------|-------------|--------------|-----|----------|
| 1  | 60   | 0.1         | 0.5         | 0.13         | 2   | 30       |
| 2  | 90   | 0.1         | 0.5         | 0.13         | 2   | 30       |
| 3  | 150  | 0.1         | 0.5         | 0.13         | 2   | 30       |
| 4  | 60   | 0.1         | 0.5         | 0.13         | 4   | 30       |
| 5  | 90   | 0.1         | 0.5         | 0.13         | 4   | 30       |
| 6  | 150  | 0.1         | 0.5         | 0.13         | 4   | 30       |
| 7  | 60   | 0.1         | 0.5         | 0.13         | 2   | 70       |
| 8  | 90   | 0.1         | 0.5         | 0.13         | 2   | 70       |
| 9  | 150  | 0.1         | 0.5         | 0.13         | 2   | 70       |
| 10 | 60   | 0.1         | 0.5         | 0.13         | 4   | 70       |
| 11 | 90   | 0.1         | 0.5         | 0.13         | 4   | 70       |
| 12 | 150  | 0.1         | 0.5         | 0.13         | 4   | 70       |

The sample treatment: First, the sample with size of 50×10×3mm was cut from the block of the raw materials of L80 steel, polished by sand paper with grid degree of 300#-1000# and cleaned by alcohol and acetone, and dried for half of an hour in dryer. Finally the mass of the sample was weight out by scale.

Experiment processing: ① All of chemicals were added into the autoclave. ② The support hold three parallel samples were put into the autoclave, and the autoclave was covered tightly. ③ The heater and stirrer were open to mix the medium and make the test temperature up to the need. ④ The down-pressure value and flow counter were open, and the gas of H₂S and CO₂ were inserted into the autoclave. The input value of the autoclave and down-pressure value of the vessel were shut down when the pressure of H₂S and CO₂ was up to the design value. ⑤ The corrosion test was started. The temperature fluctuation range was controlled to ±1°C and the test time was continued to 720h during the test. ⑥ After the experiment was finished. Firstly, the power of heater was shut off, and the sample was taken out from the autoclave after the autoclave was cooled to room temperature. Secondly, the corrosion production on the sample surface was cleaned according to the standard of “GB/16545-1996 corrosive product on the corrosive sample of metal and alloy”, and the sample was cleaned and got rode of water using alcohol and acetone. Finally the mass of sample was weight and recorded after the sample cleaned was kept in the dryer for at least 24h.

3. Experimental Result and Discussion
The corrosion rate of L80 steel sample in corrosive medium was shown in table 3. The table 3 indicated that the lowest corrosion rate of 0.6833 mm·a⁻¹ of the sample was arrived in the medium that was composed of Temperature of 90°C, S of 4% and water of 70%, and the highest corrosion rate of 2.0835 mm.a⁻¹ of the sample was arrived in the medium that was composed of Temperature of 150°C, S of 4% and water of 30%.
The effect of temperature, sulfur content on the corrosion rate of the sample was shown as following:

1) Temperature: From the Table 3 and figure 1, the lowest corrosion rate was achieved when the temperature is 90°C. It was seen that the corrosion rate of L80 steel decreased with the increasing of temperature firstly when the content of sulfur and water was constant. Then as the increase of temperature, the corrosion rate increased.

2) Sulfur: When sulfur content increased from 2% to 4%, and the content of temperature and water was constant, if the temperature of corrosion medium was lower than 90°C (60°C and 90°C), the corrosion rate of L80 steel would decrease, and the corrosion would be inhibited. However if the temperature of corrosion medium was up to 150°C, the corrosion rate of L80 steel would increase with the increase of sulfur content. At the lower temperature the sulfur maybe only deposited on the surface of the steel. Although the deposition of sulfur could induce the severe localized corrosion, the general corrosion was mild. So the corrosion rate decreased with the increasing of sulfur content. Nevertheless at high temperature the sulfur would react with the corrosion product and the corrosion product would be destroyed. The protection and stabilization of corrosion film was destroyed. So the corrosion rate was increased with the increase of sulfur content. From the experimental result, the contribution of

Table 3. The corrosion rate of L80 steel

| No | T/°C | $P_{H2S}$/MPa | $P_{CO2}$/MPa | $Cl^-$/g.L$^{-1}$ | S/% | H$_2$O/% | V/mm.a$^{-1}$ |
|----|------|---------------|---------------|-------------------|-----|---------|--------------|
| 1  | 60   | 0.1           | 0.5           | 0.13              | 2   | 30      | 1.5568       |
| 2  | 90   | 0.1           | 0.5           | 0.13              | 2   | 30      | 1.0627       |
| 3  | 150  | 0.1           | 0.5           | 0.13              | 2   | 30      | 1.3941       |
| 4  | 60   | 0.1           | 0.5           | 0.13              | 4   | 30      | 1.4670       |
| 5  | 90   | 0.1           | 0.5           | 0.13              | 4   | 30      | 0.7794       |
| 6  | 150  | 0.1           | 0.5           | 0.13              | 4   | 30      | 2.0835       |
| 7  | 60   | 0.1           | 0.5           | 0.13              | 2   | 70      | 1.1466       |
| 8  | 90   | 0.1           | 0.5           | 0.13              | 2   | 70      | 0.9401       |
| 9  | 150  | 0.1           | 0.5           | 0.13              | 2   | 70      | 0.9807       |
| 10 | 60   | 0.1           | 0.5           | 0.13              | 4   | 70      | 1.0967       |
| 11 | 90   | 0.1           | 0.5           | 0.13              | 4   | 70      | 0.6833       |
| 12 | 150  | 0.1           | 0.5           | 0.13              | 4   | 70      | 1.0032       |
sulfur to the L80 steel can be summarized in two aspects as following: on the one hand, the deposition of sulfur could induce the severe localized corrosion; On the other hand, the sulfur could react with the corrosion product and corrosion film.

4. Conclusions

From the result of corrosion experiment, when other corrosive factors, such as water cut, sulfur content and the partial pressure of CO\textsubscript{2} and H\textsubscript{2}S gas were constant, the lowest corrosion rate was appeared when the temperature was 90°C. The influence of sulfur content was complex. When temperature was low(60°Cand 90°C), the corrosion rate was decreased with the increase of sulfur content. When temperature was high(150°C), the corrosion rate was increased with the increase of sulfur content.

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6. References

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