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# Optimization of Anti-Corrosion Technology for Petroleum Bit

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In order to study the corrosion of oil well shaft, tubing and petroleum bit in oil field exploration and development process, the corrosion factors are explored by doing experiments. Then, for effectively solving this problem, some chemical anti-corrosion technologies are listed and anti-corrosion measurements are put forward. The experimental results show that, to a great extent, these measurements can not only reduce the production cost of crude oil, but also can improve the oil recovery rate, thereby reducing production well work-over rate and repair rate and thus solving the problem of oil corrosion. Based on the above findings, it is concluded that the measurements proposed are efficient and essential for solving the corrosion of petroleum bit.

## 1. Introduction

Corrosion is one of the main causes of metal destruction of the equipment in the petroleum industry. It aggravates the damage of the equipment and pipeline, resulting in oil production stop and leakage accidents. In addition, it leads to the loss of crude oil, increases the cost of oil exploitation, and affects the normal oil production. What’s worse, it pollutes the environment and harms people's health. As a result, it is of great significance for the development of petroleum industry for paying attention to the problem of corrosion, preventing or reducing the damage of corrosion, strengthening the corrosion protection of the petroleum industry, and increasing the anti-corrosion level and management level (Albdiry and Almensory, 2016).
For solving the corrosion problem, the reasons are analyzed. What’s more, the experiment is done for discussing the corrosion mechanism. The experiment results are analyzed and at last, the anti-corrosion technologies are introduced and effective, economic, and rational measurements are proposed. With the implementation of these measurements, the cost of petroleum can be reduced and petroleum production rate is increased, and thus the repair rate of petroleum bits is reduced.

## 2. Method

In order to determine the specific components of corrosion products and corrosion reason of petroleum bit, the petroleum bit used in oilfield is taken as the main material for doing corrosion experiment. The petroleum bit is processed, and it is soaked in the corrosive liquid under different control conditions for a certain time. Through the quality difference of the bit before and after immersion, the corrosion rate is calculated. Additionally, by the corrosion rate and situation under different conditions, the influence of major corrosion factors on corrosion rate is evaluated.
The simulated field temperature is determined as 55 DEC. And the solution used is determined for 900mL with the principle of liquid volume for per square centimeter of test piece surface area no less than 20mL and the distance for the solution surface to the upper edge of petroleum bit no less than 1 centimeter.
First of all, take out the water and prepare water with different contents of hepatic gas, salinity, and dissolved oxygen, different pH values, and different bacteria contents. Then, put them into a 1000mL narrow mouthed bottle for the experiment (Aliu et al., 2016). Secondly, take 100mL from the prepared 1000mL water in the narrow mouthed bottle for testing the content of each ion. Thirdly, hang the petroleum bit with weighted and recorded quality in the narrow mouthed bottle with the rest 1000mL water sample, seal up the bottle, and then set the experiment operation conditions. Next, take out the petroleum bit that has reached the experiment time,

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and compare it with that before the corrosion, so as to determine the morphology and composition of corrosion products. Rinse the corrosive solution and products on the petroleum bit with clean water, and then observe and record the corrosion on the surface. Then put the rinsed petroleum bit into the acid solution with buffer agent added for 1 minute. Take out the petroleum bit from the acid solution and immediately rinse the residual liquid on the surface. Scrub the surface of petroleum bit by abstergent powder, clean it, and put it into absolute ethanol and soak for 1 to 2 minutes (Chen et al., 2016). Later, clean and dehydrate it, and take out the petroleum bit and dry it with cold wind at the same time. Eventually, put the dried petroleum bit on the dryer, and accurately weigh it to 0.1mg.
The average corrosion rate is calculated according to the following formula:

$$F = C \times \frac{\Delta G}{S \cdot t \cdot \rho} \quad (1)$$

In the above formula, *F* indicates the corrosion rate, mm/a;
$\triangle G$ refers to the quality difference of petroleum bit before and after the experiment, g;
*S* means the surface area of petroleum bit, $cm^2$;
*T* suggests the corrosion time, h;
$\rho$ is the material density of the petroleum bit, $g/cm^2$;
*C* represents the conversion constant, whose value is $8.76*10^4$.

## 3. Result and discussion

### 3.1 Effect of sulfide on the corrosion rate

In the experiment, the effect of sulfide in the water on the corrosion rate is studied. 1000mL distilled water is taken and put into 1~8 eight narrow mouthed bottles. The nitrogen is used to drive out the oxygen for 30 minutes, so as to make sure that there is no dissolved oxygen in the prepared 1000mL water sample. And then $Na_2S$ is put into the eight narrow mouthed bottles to prepare the water samples with different sulfide densities. The density of sulfide is preliminarily controlled within 0mg/L to 100mg/L (El-Shamy et al., 2015). Hydrochloric acid is adopted to adjust the pH value about 7.5, and 100mL solution is taken out for titration sulfide content. The relationship between different sulfide contents and the corrosion rate is explored, and the result is shown in Figure 1 and Figure 2.
From the experimental results, it can be seen that the corrosion rate increases with the increase of hydrogen sulfide concentration in the water sample. The petroleum bit taken out is black, and the corrosion rate is much lower than the standard of 0.076mm/a. The major reason is that the corrosion products and some impure precipitates are easily to gather and stick to the petroleum bit and produce a protective film under the static condition. It hindered the diffusion of corrosive medium or water molecules to the metal surface and dissolved diffusion of metal ions, and meanwhile caused anodic polarization and cathodic polarization. A large area of pitting corrosion can be observed on the surface of the steel sheet after corrosion. For steel corrosion, pitting corrosion is much more harmful than uniform corrosion.

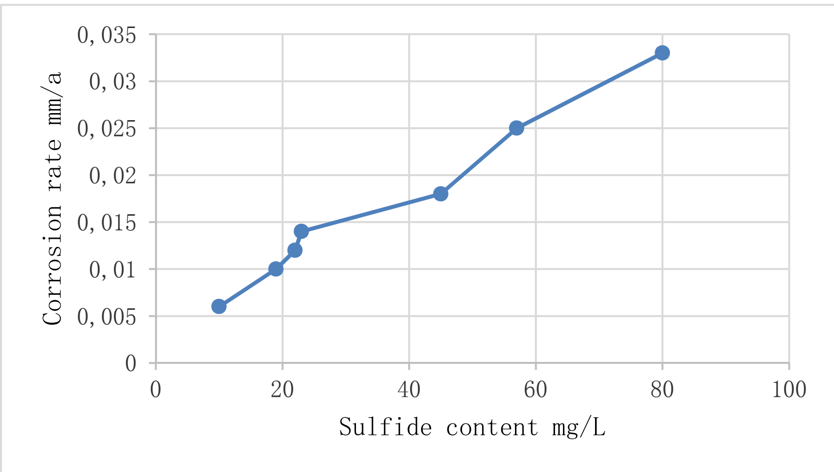


*Figure 1: The effect of sulfide content on the corrosion rate*

*Figure 2: The steel after corrosion experiment*

### 3.2 Influence of C1⁻ content on the corrosion rate

Take 1000mL water sample and put into 1~5 narrow mouthed bottles. Then, add NaC1 to the five bottles and prepare the water sample with different $C1^-$ contents. Take 100mL water sample for titration $C1^-$ content. Measure the corrosion rate under different $C1^-$ concentrations, and the result is shown in Figure 3.

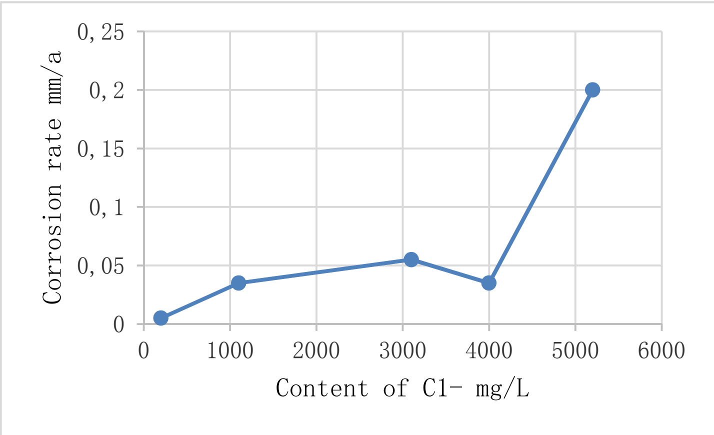


*Figure 3: The influence of C1- on the corrosion rate*

From the experimental result, it can be seen that the corrosion rate increases with the increase of $C1^-$ concentration at first, while when the $C1^-$ concentration increases to 3300mg/L or so, the corrosion rate begins to decrease. The reason is that $C1^-$ has comparatively strong diffusion ability so that it accelerates the corrosion of electrochemistry (Han et al., 2015). In the meanwhile, $C1^-$ has strong penetrating force so that it can accelerate the corrosion through the protective film. Nevertheless, as the $C1^-$ concentration increases to a certain degree, it inhibits the corrosion of sulfide and corrosive $CO_2$, and it makes the entire corrosion rate decreased.

### 3.3 Impact of dissolved oxygen content on the corrosion rate

Take the water samples and put them into 1~5 narrow mouthed bottles. Add N2 to the five bottles for dispelling the oxygen for 2~10 minutes. Then, prepare the solution with different dissolved oxygen contents through controlling the time for adding $N_2$, and pour out enough water sample from the five bottles, so as to accurately measure the content of dissolved oxygen in the water sample (Pu et al., 2015). The relationship between different dissolved oxygen contents and corrosion rate is shown in Figure 4.
It can be seen from the above figure that the corrosion rate increases with the increase of dissolved oxygen content. Dissolved oxygen corrosion is one of the main factors of corrosion in oil well. The data showed that: at room temperature, the corrosion of carbon steel was not observed in the pure water without oxygen. And when the oxygen is dissolved in the water, the corrosion rate increases rapidly with the increase of the concentration of dissolved oxygen, which caused the corrosion of dissolved oxygen.

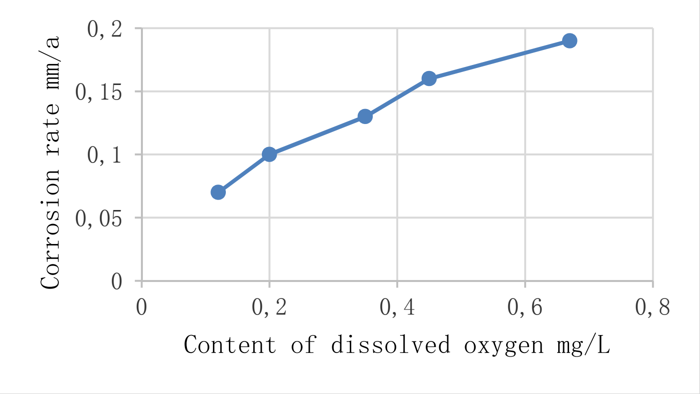


*Figure 4: Impact of dissolved oxygen on the corrosion rate*

### 3.4 Effect of CO2 content on the corrosion rate

Take 1000mL water sample and put into 1~5 narrow mouthed bottles. According to the difference of $CO_2$ added into the water sample, we control the content of $CO_2$ in the water sample used in the experiment and determine the range of $CO_2$ concentration. Then, it is verified and the $CO_2$ concentration is preliminarily determined within 0~90mg/L (Pryhorovska et al., 2015). The prepared $CO_2$ corrosion solutions with different concentrations L are put into the wide mouth bottle, and they are put at 55 DEC water bath for 5 days after they are sealed up. Te corrosion rate with different $CO_2$ concentrations is measured, and the result is shown in Table 1.

*Table 1: Experimental result of static corrosion with different CO2 concentrations*

| $CO_2$ density (mg/L) | 9.6 | 21.4 | 34.8 | 53.2 | 66.8 | 87.9 |
|---|---|---|---|---|---|---|
| Average corrosion rate (mm/a) | 0.057 | 0.073 | 0.853 | 0.103 | 0.121 | 0.132 |

The static test results show that when the carbon dioxide is dissolved in the water, the corrosion rate of metals increases significantly, and the corrosion rate increases with the increase of carbon dioxide content. This is because the corrosion of $CO_2$ is mainly completed by the hydrogen ion in water when the low carbon dioxide content is low. With the consumption of hydrogen ion in water around the cathode, the hydrogen ion is diffused to the cathode to supplement. As a result, the corrosion rate becomes slow. With the increase of carbon dioxide content, the concentration of carbonic acid in water also increases, and the hydrogen ion dissociated by adsorption of hydrogen carbonate is dominant in the process of corrosion. Therefore, the corrosion is enhanced significantly.

### 3.5 Influence of bacteria content on the corrosion rate

The water sample is stored at the temperature lower than 0 DEC for 24h for sterilization, and then it is taken as the diluent. Then, the stoste water sample is diluted in accordance with 1, 2, 4, and 8 times. The solution after dilution is only different in terms of the content of bacteria (Themeli et al., 2016). The prepared solution is put into the wide mouth bottles, and it is put in the water bath at the constant temperature of 40 DEC for 5 days. The corrosion rate is then measured with different bacteria contents, and the result is shown in Table 2.

*Table 2: Experimental result of corrosion with different bacteria dilution times*

| SRB dilution times | Average corrosion rate (mm/a) |
|---|---|
| Normal water | 0.051 |
| 1 | 0.049 |
| 2 | 0.047 |
| 4 | 0.039 |
| 8 | 0.033 |

Note: the bacterial content in the normal water was 2500 /mL after the dilution test

From the above experimental results, it can be seen that, in the case of other control conditions fixed, the corrosion rate decreases with the reduction of the number of bacteria. Therefore, it can be seen that the existence of bacteria in the corrosive medium can promote the corrosion of metals. This conclusion is consistent with the understanding of the hazards of bacteria in the oil industry in domestic and foreign countries. In the oil field water system, the most harmful bacteria are the sulfate reducing bacteria. This is because its metabolite has particularly serious corrosion on metals, and the generated Fe and S are the materials that caused the pipeline plugging.

## 4. Measurements for anti-corrosion

The dissolved oxygen, dissolved salt, sulfate reducing bacteria (SRB), $CO_2$ and sulfide are the major causes of serious corrosion of petroleum bit. The higher the content is, the stronger the corrosion will be, and there is coexisting induced effects between them. They can accelerate the occurrence and extent of corrosion. After understanding the corrosion mechanism, we put forward some corrosion protection measures.

### 4.1 Chemical anti-corrosion technologies

The chemical anti-corrosion technologies mainly include two kinds. The first one is the outer protection technology, and the second one is the protection technology of external embedded anode. In this paper, the first one is mainly discussed. For the outer protective sleeve, what is now widely used at home and abroad is cathodic protection. While with the progress of technology, the development of cathodic protection technology has gradually appeared in many forms. In a whole, they are divided into forced current method and sacrificial anode method. Cathodic protection is to make the metal component as the cathode and to eliminate the electrochemical inhomogeneity of the metal surface by cathodic polarization, so as to achieve the purpose of protection (Zha et al., 2017). Cathodic protection is one of the most economical and effective corrosion protection measures. It has been widely used since 1823. In recent years, it has also been effectively promoted in the protection of petroleum bit corrosion. The cathodic protection principle of sacrificial anode is: anode corrosion and cathode non corrosion in corrosive battery. Using this principle, the sacrificial anode is preferentially dissolved to make the oil and water well casing become a cathode, and the method of realizing protection is called sacrificial anode method. In order to achieve the protection effect, the sacrificial anode not only has enough negative open circuit potential in the open circuit state (i.e. self-corrosion potential), but also has enough closed circuit potential (working potential) in the closed circuit state. In this way, enough driving voltage can be maintained at work.

### 4.2 Other anti-corrosion measurements

In addition to the chemical technologies, there are also some other efficient measurements. On the one hand, the application of tungsten alloy anti sulfur and anti-corrosion petroleum bit will be quite helpful. The Appraisal Committee of the China Federation of Petroleum and Chemical Industry has conducted an authoritative appraisal of tungsten alloy anti sulfur and anti-corrosion petroleum bit. The Appraisal Committee believes that the successful development of anti-corrosion petroleum bit has good effect in oil extreme corrosive environment. It suggests that tungsten alloy plating technology can effectively solve the corrosion problem of high hydrogen sulfide, carbon dioxide and saturated brine. "Anti-sulfur and anti-corrosion petroleum bit can greatly reduce the cost of petroleum production, and it can save a lot of manpower, material resources and financial resources. What’s more, it especially saves a large amount of steels, greatly contributing to resource conservation and environmental protection. On the other hand, the use of coating petroleum bit is also quite efficient. Through the corresponding processing, corrosion inhibiting covering layer is formed on the metal surface. It can directly separate the metal and the corrosion medium. The covering layer is mainly divided into metal coatings and metallic coatings two categories. Most of the metal coatings are achieved by electroplating or hot plating, while metallic coating is the isolated coating. At present, the coating technology that the tubing anti-corrosion uses mainly includes metal coating and organic material coating. For metal coating. According to the principle of electrochemical protection, only when the electrode potential of the metal coating is negative than the electrode potential of the tubing matrix can cathodic protection be achieved, that is, sacrificing anode (coating) to protect the cathode (petroleum bit). For organic material coating, the commonly used coatings are: modified epoxy, epoxy, phenolic epoxy resin or nylon. It requires for uniform coating thickness, and 100% free pinhole of the entire coating surface. Now, epoxy powder is widely in the pipeline anti-corrosion coating application, and the epoxy powder anti-corrosion mainly has the characteristics of good melting, smooth film, less pinhole and so on. Its construction is easy that it can apply electrostatic spraying, dipping, fluidized bed and other methods. The tube wall is not easy to scale, and meanwhile it can reduce energy consumption.

## 5. Conclusion

Through the study on factors for corrosion and corrosion rate, it is known that the sulfide content, $C1^-$ ion, carbon dioxide and so on has great effect on the corrosion of petroleum bit. The corrosion rate changes with the change of $CO_2$ concentration, bacteria content and $C1^-$ concentration. And for solving the corrosion of petroleum bit, there are some efficient measurements, outer protection technology, protection technology of external embedded anode, application of tungsten alloy anti sulfur and anti-corrosion petroleum bit, and use of coating petroleum bit. Only when the influence factors of oil corrosion are systematically and comprehensively considered and efficient protective methods are put forward can the influence of corrosion on the petroleum production be relieved. And thus, the petroleum production cost can be reduced.

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