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ASSESSMENT OF SCALING PROPERTIES FOR TREATING OILY WASTERWATER

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In this paper, the SY/T 5523-2006 standard used in the field was analyzing the characteristic of water quality in produced water system of Hengshan production plant. The static simulation method was used to analyze the scaling properties of different layers produced water mixed. The results showed that the produced water in Chang 2, Chang 6 of Hengshan Oil Production belonged to the high-salinity water. The fouling mass was above 300 mg/L and the calcium loss rate was more than 10%, when the blending ratio of Chang 2 and Chang 6 was greater than 1:0.7 and the calcium loss rate is less than 1% when the mixed proportion of Chang 2 and Chang 6 ranges from 1:4 to 1:10, so the loss of the long 2 proportion could lead to the scale quantity reduced.

Keywords: Multi-layer Water; Scaling; Compatibility; Hengshan Oilfield

1. Introduction

At present, oil and gas fields commonly use waterflooding when oilfield enters into mature development state[1-3]. The water-flooding system is the best way to oil field produced when wastewater is treated under the current situation of serious shortage of water resources. The way not only solves the problem of water shortages and eliminates oil water drainage problems to cause the environmental problem [4]. The treatment of oilfield produced water is the key role of the waterflooding production in the process of oilfield water injection. As known from extensive production experience, scaling is a destructive problem in the process of oilfield water injection [5-7], which can cause the clogging in ground water injection equipments and well-shafts and the damage of stratum in that the incompatibility of water quality and combination with the thermodynamic instability and chemical incompatibility of water [1, 8, 9].

In recent years, there is more research on the issue of scale formation and

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antiscale for oilfield produced water development in our country. The scaling mechanism and rule of the mixed injection processing have a deep exploration and application, whether if oilfield produced water is on the sea or on land [10-12]. The study of oilfield water scaling mechanism is agreed that the mixture of different water quality of water or the change of working condition (such as pressure, temperature, pH, etc.) lead to the instability of supersaturated salt in the water or stable state temporarily, in the moment of which the ion concentration is greater than the solubility product, and then part of supersaturated salt will be separated out to become scale.

To explore the effect of temperature, pH and pressure on scaling, static experiment, dynamic simulation and computational identification are often used for the research on the scaling [13, 14]. Static simulation test method, called the “bottle test”, will mix the different water samples in different volume ratio, adjust to a certain temperature and then calculate the quantity of deposition scaling by weighing method after stewing for several hours. Static simulation test approach is commonly used, the advantage of which is simple and can be tested easily. In the study, according to standards of oil industry, we analyze the characteristics of produced water system from Hengshan oilfield production. The static simulation method applied analyzes the scaling properties of mixing different the produced water. The scaling tendency of multi-layer water mixture is predicted by ion activity product, and the influence of the scaling properties on two-layer water mixture is explored different mixing proportion and time. To gain the optimum of mixing conditions, their compatibilities are also study.

2. Experimental Section

2.1 Water samples

Water samples (Chang2, Chang6) was collected from the worksite of Hengshan oilfield production, but the sample collection work must be in strict accordance with the relevant requirement of "the method of oil and gas field water analysis" of SYT5523-2006 to operate. The water sample was taken back to preprocess for the subsequent laboratory work.

2.2 Measurement of ions content (EDTA Volume Method)

All chemical reagents were of analytical grade. The content of calcium ion was measured by using calcium carboxylic acid as indicator and the standard of EDTA [15]. The content of calcium ion was determined by the following equation:

$$\text{The content of calcium ion (mol/L)} = \frac{C_{EDTA} \times V_{EDTA} \times 40 \times 1000}{V}$$

Where CEDTA (mol/L) was the concentration of EDTA standard solution (mol/L), VEDTA (mL) was the volume of consumed EDTA titrating Ca2+ and V (mL) was the volume of water sample when Ca2+ was titrated.

The content of sulfate ion was also measured by using calcium carboxylic acid as indicator and the standard of EDTA titration. The content of sulfate ion was determined by the following equation:

$$\text{The content of sulfate ion (mol/L)} = \frac{V_1 \times C_{\text{EDTA}} \times 96}{V} \times 1000$$

V1=V0+V2-VEDTA

Where CEDTA (mol/L) was the concentration of EDTA standard solution (mol/L), V0 (mL) was the volume of EDTA consumed distilled water, V1 (mL) was the volume of EDTA consumed sulfate ion of sample water, V2 (mL) was the volume of EDTA consumed sample water and V (mL) was the volume of water sample.

2.3 Measurement of scaling amount

Water sample, stored in an airtight container within the prescribed temperature constant temperature for 30 minutes using static simulation method, was determined scaling ionic content. The scaling amount was calculated by the content changes of scale.

2.4 Trend prediction of the mixed water scaling

The scaling tendency of mixing water was predicted by using ion activity product, which was based on the analysis of all ion concentration from water sample. Solubility product constant was compared with calculating ion activity product under the same temperature for the sample. If the calculation result of ion activity product was greater than that of the solubility product constant, the compounds could form precipitation, but on the contrary, it did not lead to precipitation. Forming precipitation will be easy to scale in the form of the following reaction:

Ca2+ + CO32- → CaCO3 ↓

If Ca2+ + CO32- → CaCO3 ↓

When K (CaCO3) > Ksp (CaCO3), CaCO3 will form precipitation;

When K (CaCO3) = Ksp (CaCO3), CaCO3 will keep the balance state;

When K (CaCO3) < Ksp (CaCO3), CaCO3 precipitation will not be formed, and it is in a stable state.

2.5 Compatibility of formation water and water treated scaling

After mixed formation water and water treated scaling, some problems would be taken into consideration, especially scaling usually resulted in some consequences in oil production system, such as formation damage, pipe plug, corrosion, and even affect the oilfield production. So the compatibility of the formation water in Hengshan Oil Field and the sensitivity of oil reservoir with the treatment water were researched. The formation water and the treatment water were mixed in different proportions. The constant temperature at 30oC was stewed 72 hours. Then the amount of scale was measured according to the changes of different proportions mixing the formation water and the treatment water under the constant temperature.

2.6 X-Ray diffraction (XRD)

X-Ray diffraction was commonly used as the study of the structure [16-18]. The structure of Scale sample was characterized by XRD, and the analysis of XRD will indicate the composition of samples.

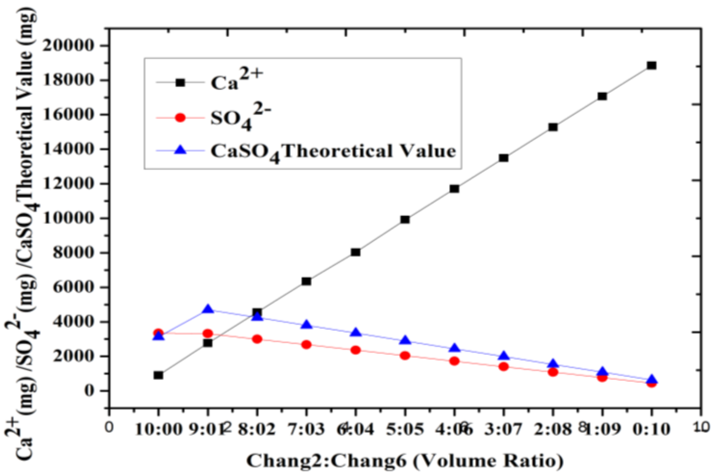
3. Results and Discussion

The influence of the mixed water scaling characteristics was researched by mixed ratio, stock-still time and the compatibility of the formation water and the treatment water. To improve the scaling removal, flocculation was taken into consideration in the mixed Chang2 and Chang6.

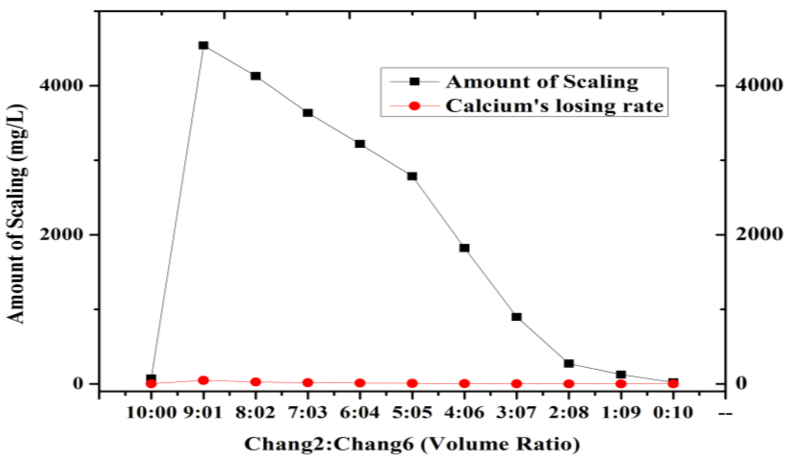
3.1 Effect of blending ratio on scaling performance of mixed Chang2 and Chang6 wastewater

Water sample of Chang2 layer and Chang6 layer from Hengshan oilfield was concocted by a certain proportion, simulating formation temperature and stewing 72hours at 30oC. Then scaling process was observed and amount of scaling was measured. As shown in Fig.1A, Chang2 water samples contained a lot of sulfate ion and calcium ion, which easily leaded to scaling formation when Chang2 and Chang6 water sample was mixed in a certain proportion. But when proportion of Chang2 in the mixed water sample was decreased, amount of scaling was reduced gradually. These indicated that scaling ion was SO42- which was concentrated on Chang2 sample water. So sulfate ion was reduced accordingly, when the proportion of Chang2 water sample was decreased, but calcium ion was far too exceeded.

Fig.1B showed that when the proportion of Chang2 and Chang6 water sample mixed was greater than 4:6, amount of scaling was more than 3100mg/L, but the proportion of Chang2 was lower than 2:8, amount of scaling was reduced and calcium's losing rate was less than 1%. Therefore, the low proportion of Chang2 would be studied further.



(A)



(B)

Fig.1 Effect of scaling performance on different proportions mixing Chang2 and Chang6 water sample

3.2 Effect of stewing time on the scaling properties

To prevent scaling and leading blockage of bottom from mixing water under the ground, descaling was proceeded on ground to the greatest extent. So stewing time was taken into consideration. The low proportion of Chang2 mixing water was standing 0h, 4h, 8h, 12h, 24h respectively, and the amount of scaling was measured.

Fig.2 indicated that the amount of scaling was increasing when standing time was more for the low proportion of Chang2 mixing water. When standing time was more than 8h, amount of scaling had no significant increase. Hence, the scaling reaction of the mixing water was as balanced as possible, standing time at least was required 8h.

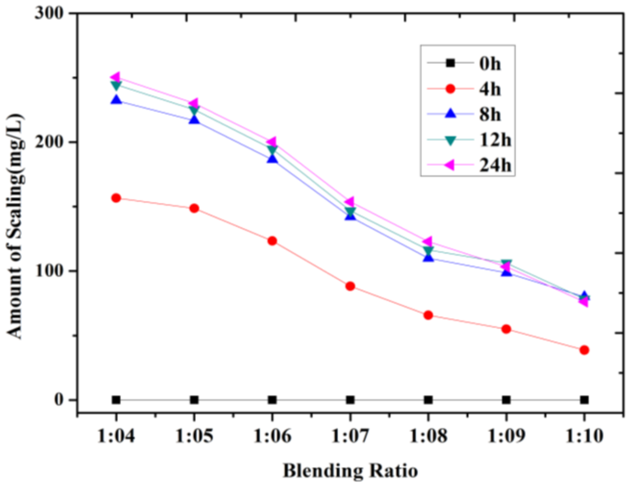


Fig.2 Effect of stewing time on scaling

After the scaling reaction of the mixing water finished, the water treatment was adjusted pH to slightly alkaline, flocculated and filtrated by quartz sand. Then the water treatment was standing 72h at 30℃, detecting the amount of scaling so that the removal effect of scaling reaction and flocculation was observed. The residuals of the mixing water could scale again. The results were demonstrated in Fig.3 that for the mixing water of proportional Chang2, the tendency of second scaling was weaken by flocculation when increasing the reaction time. The amount of scaling in the mixing water could be very little by flocculation when standing time was more than 8h. The result indicated that the scaling reaction in the water was achieved the balance after 8h standing.

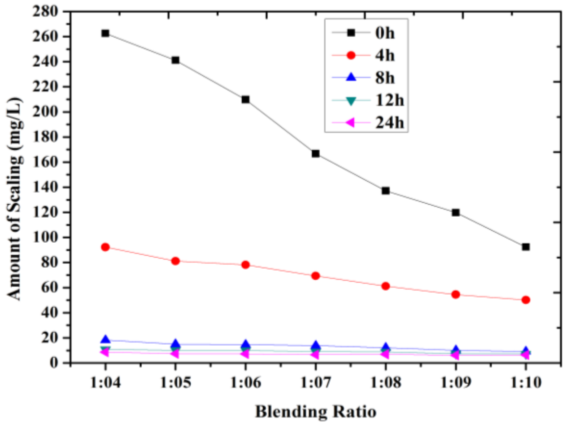


Fig.3 Effect of stewing time on scaling through flocculation

3.3 Compatibility of formation water and water treated scaling

After Chang2 flocculated, the low proportion of Chang2 (Chang2: Chang6 was 1:4 and 1:5) was mixed with Chang6 in different proportions. The water treated and formation water was reconstituted for stewing with 72h at 30℃ and measured the amount of scaling. So the scaling tendency of the treated water and formation water mixed was to determine the compatibility of formation water and water treated scaling.

The result shown in Fig.4, the low proportion of Chang2 mixed water through flocculation was added into Chang6 to form the slightly scaling properties.

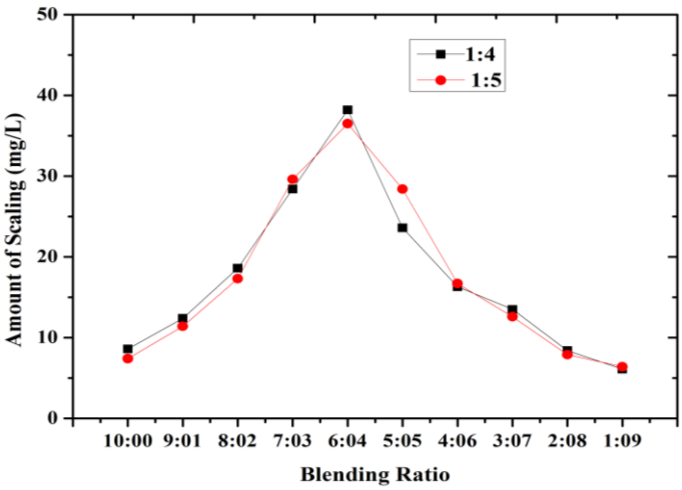


Fig.4 Compatibility of formation water and water treated scaling

And the higher scaling amount was less than 40mg/L. So the low proportion of the Chang2 mixed water by flocculation, reinjected into Chang6 layer, not plugged the layer. Therefore, the low proportion of Chang2 mixed water by flocculation could play a critical role in reinjection to the Chang6 layer.

3.4 X-Ray diffraction (XRD)

The scaling sample corrected from Chang2 and Chang6 mixed water was stoved, applying XRD to analyse the composition. The results shown in Fig.5 was analyzed that the composition of scaling sample was mainly a mixture of two components: 99.26% $CaSO_4 \cdot 2H_2O$ and 0.74%$CaSO_4 \cdot 0.5H_2O$. Hence, the results indicated that the mixed water contained high leves of sulfate scale.

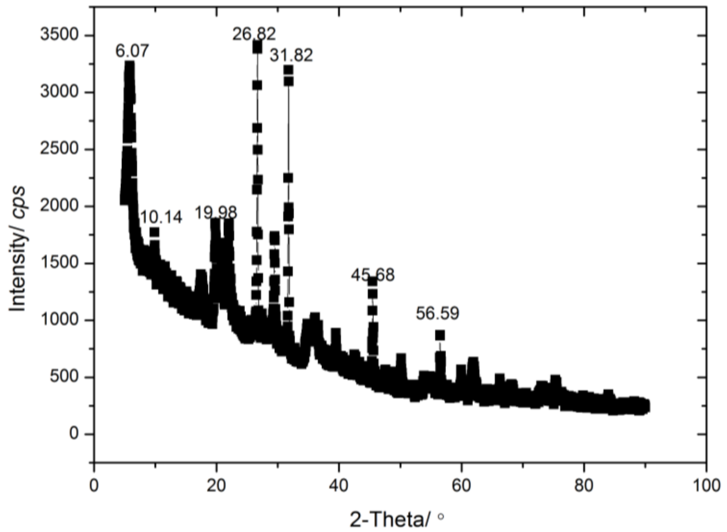


Fig.5 XRD pattern of mixed water sample

4. Conclusions

(1) The performance study of the scaling process in the proportion of Chang2 and Chang6 mixed water can be gained by the selection of blending ratio, stewing time and flocculation with respect to Hengshan oilfield.

(2) The low proportion of Chang2 mixed water by flocculation is mixed with Chang6 layer-water, found that there is a good compatibility and Chang2 treated water may be reinjected to Chang6 layer.

(3) XRD analysis indicates that the scaling sample of Chang2 and Chang6 mixed water is high levels of sulfate scale, which are mainly $CaSO_4$.

Acknowledgements

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