Causes and treatment of adhesive damage in polymer flooding injection pipeline

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Abstract. The viscosity of polymer liquid is an important parameter used in oilfield. Understanding the loss rule and regularity of polymer liquid will help to improve the distribution and water injection quality of polymer liquid and ensure the effective distribution of polymer liquid. According to the oil-water viscosity data of the previous polymer flooding fluid, it is found that the oil-water viscosity is within the range of 5%-20%, with an average of 9.8%. The reasons of single well pipeline viscosity are complex and varied, which are closely related to reducing substances, types and quantities of bacteria, fouling oil suspensions on the inner wall of pipeline, pipeline length and running time. Therefore, from the aspects of Fe2+, pipeline running time and so on, the influence factors and prevention methods of single well pipeline viscosity loss were studied, and the corresponding treatment measures were worked out, and good results were obtained.

Key words: injection pipeline; Polymer; Adhesion loss

1. quotation

The principle of the polymer zone is to increase the hydraulic viscosity through the polymer and thus achieve better recovery. Due to various factors, the viscosity of polymer solution decreases and viscosity loses in the process of water injection, which seriously affects the production effect of oilfield. Therefore, it is very necessary to study the polymer flooding problem in the process of polymer flooding.

2. The key factor of single well viscosity loss

2.1 Distribution law of single well pipeline viscosity loss

According to the research on polymer flooding oil system over the years, it is found that the viscosity of crude oil in polymer flooding oil system is 5% to 15%, with an average of 9.8%. According to different materials, different diameters and different running times, the viscosity loss of single well pipelines at several injection stations in similar regions was calculated. Through the analysis of the test data, the following rules are obtained: under the same working condition, the adhesion loss rate of carbon steel pipe is 2%-3% higher than that of glass steel pipe; The viscous resistance of each pipeline increases with the increase of pipeline length. The results show that the viscosity loss of carbon steel pipe increases with the extension of service time, but the viscosity loss of FRP pipe does not change significantly. The viscosity loss of pipe has little relation with pipe diameter.

2.2 Causes of single well pipeline viscosity

In order to find out the cause of pipe adhesion, the pipes of various materials were selected, and the single well pipe was washed with water to wash away a lot of glue and strips in the pipe. Through comparative analysis of imported and exported water samples, it is found that the concentration of iron ions increases and decreases significantly, as well as the concentration of iron [1]. Among them: after the glass steel wire by washing, the concentration of hot iron almost did not change; Carbon steel pipe after the early cleaning, iron content increased greatly. Through the analysis of the experimental results, it is found that the residual iron ion and gum in the polymer solution are the important factors leading to the viscosity loss.

3. Mechanism of iron ion degradation

This project intends to analyze the decrease of high viscosity property caused by Fe ion in the pipeline through laboratory tests, clarify the influence of Fe ion on the viscosity property of polymer, clarify the mechanism of Fe ion reducing the viscosity property of polymer, and find the way to reduce the influence of Fe ion on the viscosity of polymer.

3.1 Influence of Fe2+ on viscosity of polymer solution without oxygen

In an open system, Fe2+ is easily oxidized to Fe3+ by air, which makes the interaction between Fe2+ and the polymer inadequate. To achieve this goal, a polymer solution with a concentration of 1000 mg/L was prepared in the laboratory with simulated water. The FeSO4 was added under anaerobic conditions, stabilized for a period of time, and the viscosity value was measured. As can be seen from Table 4, when the concentration of Fe2+ is less than 10 mg/L, the influence on the viscosity change of polymer solution is no more than 10% under closed anaerobic conditions.

3.2 Influence of Fe2+ on viscosity of polymer solution under aerobic condition

In the tertiary recovery process, most of which takes place in an open system, Fe2+ is easily oxidized to Fe3+ by atmospheric oxygen. Although sealing measures are taken in some areas, oxygen can still fuse with the solution to gradually oxidize Fe2+ to Fe3+, which is very different from the effect of Fe3+ alone and Fe2+ in the absence of oxygen [2]. In the validation laboratory open system, a polymer solution with a concentration of 1000 mg/L is prepared with simulated water, and FeSO4 is added for 3 hours, and the viscosity is measured. The oxidation treatment from Fe2+ to Fe3+ has a great damage to the viscosity of the polymer solution. Under the concentration of 1 mg/L Fe2+, Has caused viscosity loss in a quarter of the solution.

3.3 Influence of Fe3+ on polymer viscosity

When Fe2 (SO4)3 was added to the polymer solution, it was observed that the viscosity of the polymer solution did not change much with the addition of Fe3+.

3.4 Influence mechanism of iron ion on polymer viscosity loss

Fe2+ is the only known substance that can dissolve polymers close to water in a matter of seconds. Among them, the degradation of macromolecules caused by Fe2+ oxidation to Fe3+ is the most important reason leading to the decrease of solution viscosity. The polyacrylamide solution is very stable in the absence of oxygen, even in the presence of Fe2+ and FeS. However, in actual production and operation, due to the presence of dissolved oxygen and Fe, the viscosity of the polymer system will be reduced.

4. Methods to reduce pipeline viscosity

4.1 Oxygenation

To change Fe2+ from diluted water to Fe3+, oxygen exposure equipment was installed at the water injection station to measure Fe2+ before and after oxygen exposure prior to mixing with the polymer. The experimental results show that appropriate increase of oxygen content in wastewater can effectively inhibit the adverse effects of different kinds of fungi on the viscosity of polymer materials in wastewater. From the perspective of oxygen aeration effect, the concentration of Fe2+ can be reduced to 1 mg/L, achieving the goal of oxygen aeration.

4.2 Flushing Pipeline

The multi-channel cleaning of single well pipeline can effectively eliminate the adhesion of reducing substances such as colloidal substances in pipeline to polymer, and can effectively reduce the influence of crude oil, suspended matter and various ions on the viscosity of polymer solution. In order to facilitate operation and save investment, the injection station uses an established well cleaning process and uses diluted water to quickly clean the injection line. Although this method is very difficult to operate, its effect is not significant, and only reduces viscosity to a small extent. Therefore, for a single well pipeline with a viscosity loss rate of more than 10%, It is necessary to adopt more efficient cleaning methods.

4.3 Clean water Rinse

When cleaning the pipeline, in order to ensure the effect of cleaning, first of all, the station process is improved, so that it can be connected with the cement car, and cleaning under clear water at 60℃. As far as scour effect is concerned, the scour effect of clean water + washing aid is the best, followed by that of clean water under pressure. In actual production, using cement truck to pull clean water for cleaning is not only time-consuming and time-consuming, but also unable to meet the needs of large-scale pipeline cleaning [3]. Therefore, the current clean-out process should be used to increase the pressure and flow rate gradually, using diluted effluent initially, so that post-wash cementation is greatly reduced.

4.4 Hole jet flushing

Cavitation jet cleaning technology is a new technology suitable for oil pipeline. It has the characteristics of fast flushing speed and obvious anti-rust effect on oil and water pipeline. First, the mechanism of stomatal ejection. Cavitation jet is a physical fluid dynamics that takes advantage of "hole effect". Driven by high pressure water flow, a low pressure area is formed in the pipeline. The microbubbles in these low pressure areas are rapidly compressed and ruptured, and powerful microjets are ejected instantly to clean the dust in the pipeline. Second, the scour effect of hole jet. In this area, through hole jet cleaning of single well pipeline, the efficient cleaning of oil-water interface is realized, and the anti-fouling ability of oil-water interface is improved.

5. Research on cohesive loss control method of polymer flooding

Viscosity loss refers to the viscosity loss caused by mechanical, chemical and biological degradation of polymer materials in injection molding. The viscosity of the system can be improved and the development effect can be improved by the viscosity of the polymer. Through years of research and practice, the causes and changes of viscosity in polymer solution during injection distribution

were clarified, and a series of viscosity control measures were put forward, so that the viscosity of polymer flooding can be effectively controlled.

5.1 Understanding of cohesive loss rules of polymer flooding in Lamadian Oilfield

In order to understand the viscosity loss law of polymer flooding, it will have certain effects on polymer molecular weight, polymer solution concentration, dilution water quality and maturity time, etc. In this study, we will study the influencing factors of the above aspects, so as to better understand the viscosity loss change law of different injection systems. In this way, the management of adhesion failure can be carried out more clearly. Laboratory test results show that in the same molecular weight, the same aqueous solution, under the same shear force, the viscosity retention rate of the solution is higher, and its shear resistance is stronger. This is because at a higher concentration, the repulsive force between molecules increases, causing the molecular chain to curl, thus reducing the mechanical properties [4]. The mixing tank is made of polymer matrix, and there is almost no adhesion phenomenon during mixing, but the mixing time is too long, so that the macromolecules are completely developed, and its shear resistance decreases.

5.2 Viscous loss control technology of polymer flooding in Lamadian Oilfield

By studying the causes and influencing factors of gelling phenomenon, the prevention and control measures of gelling phenomenon are explored, so as to realize the effective control of gelling phenomenon and ensure the injection of gelling phenomenon with high quality and high efficiency. When determining the concentration of the polymer parent solution, the concentration of the polymer parent solution should be increased as much as possible according to the operating parameters of the polymer injection pump and the design concentration of the individual well, so that the viscosity phenomenon can be fully controlled. Combined with the transport capacity of the preparation station and the transport time in the pipeline, the mother liquor in the mature stage can be reduced as far as possible, and the overall control of viscosity loss can be achieved. On the basis of clarifying the causes and rules of adhesion loss of all kinds of joints, formulate the adhesion loss control criteria of the joints, divide the joints into A. B. C three categories, adopt the "guarantee A. According to the overall idea of "controlling B and treating C", targeted grading and benchmarking should be carried out to improve the treatment efficiency of joint adhesion damage. The viscous-loss treatment method of "flush-washer-separation-repair" has been popularized in Daqing oilfield for many years, but its implementation specifications are still unclear. Therefore, this project proposes a set of viscous-loss treatment measures specifications based on "flush-washer-separation-repair" from three aspects of influencing factors, rule changes and control specifications, in order to enhance the applicability of measures and improve the treatment effect of measures.

6. Important types and influencing factors of oilfield polymer flooding and water scaling

6.1 Calcium Carbonate

Calcium carbonate (CaCO3) is one of the most common scaling substances in offshore crude oil production, and its solubility in water is very low. The substance is made by combining an ion called carbonate or a hydroate with an ion called calcium.

6.1.1 Effects of carbon dioxide

In general, the number of carbonate ions is much smaller than that of carbonate ions, so it can be regarded as a deposit dominated by calcium carbonate deposits. Increasing the concentration of CO2 can reduce the amount of calcium carbonate deposition. In oilfield water, the lower the concentration of CO2, the more calcium carbonate precipitation. The increase of CO_2 concentration and water pressure can lead to the increase of CO_2 concentration in water.

6.1.2 Influence of pH value

There are usually different carbonic acids in oilfield water. Due to the difference of pH value, the concentration ratio of CO2+H2CO3, HCO3- and CO32- in water is also different at equilibrium. It can be seen from the pH that the higher the pH in water, the more calcium carbonate will precipitate; Otherwise, it will not be easy for sediments to form.

6.1.3 Influence of Temperature

Temperature is another major factor affecting the scale formation of calcium carbonate. The higher the temperature, the greater the normal state of the greater the solubility of most salts in water. Calcium carbonate scaling occurs easily when high temperature injection Wells are injected.

6.1.4 Influence of total pressure

The dissolution of calcium carbonate will be beneficial when pressure is increased and, conversely, will encourage precipitation. In a single phase, from a thermodynamic point of view only, the dissolution degree of calcium carbonate increases as the pressure increases.

6.1.5 Influence of salts dissolved in water

The solubility of calcium carbonate increases with the increase of salt content in aqueous solution with different concentration. The solubility of calcium carbonate in water is determined by its total solubility in water, the greater the total solubility. In general, an increase in pH, as well as a decrease in salt content, increases the scaling

tendency of calcium carbonate with increasing temperature.

6.2 Magnesium Carbonate

When the scale samples brought back from the offshore platform are analyzed, it is often found that there is a small amount of magnesium carbonate scale in the calcium carbonate scale. The precipitation process is as follows: $Mg2++2HCO3-\rightarrow MgCO3\downarrow+CO2\uparrow+H2O$ (6). With the increase of temperature, the decrease of partial pressure of CO2, the increase of pH value and the decrease of salt, and thus the increase of scaling tendency of magnesium carbonate. However, the solubility of CaCO3 is much lower than that of CaCO3, and CaCO3 will precipitate first when present conditions change. In the process of offshore oil platform exploitation, a large amount of seawater is often used, and the Mg ion content in the ocean is relatively high, which will be mixed with the well water to a certain extent. If the well water is relatively alkaline, it is very likely to generate magnesium carbonate scale. Magnesium hydroxide is easily hydrolyzed to magnesite in aqueous solution, and its hydrolysis process is as follows: $MgCO3+H2O\rightarrow Mg(OH)2+CO2\uparrow$(7). Its solubility in aqueous solution is low and decreases with the increase of temperature.

6.3 Calcium Sulfate

Calcium sulfate is another common form of scale found in offshore oil fields. The crystallization rate of calcium carbonate is higher than that of calcium sulfate. Calcium sulfate scale does not dissolve easily under acidic conditions, so it is difficult to remove.

6.3.1 Influence of Temperature

Below 38℃, the solubility of gypsum gradually increases with the increase of temperature, but above 38℃, it gradually decreases.

6.3.2 Influence of dissolved salts in water

When NaCl or other salts that do not contain calcium ions and sulfate ions are present in water, the solubility of calcium sulfate or anhydrous calcium sulfate increases when the concentration is less than 150 g/L, and the increase of salt content leads to the decrease of solubility of calcium sulfate.

6.3.3 Influence of pressure

The solubility of all scale in water increases with the increase of pressure.

6.3.4 Influence of pH value

pH has little effect on the solubility of calcium sulfate.

6.3.5 Iron compounds

In the analysis of scales, trace amounts of ferric compounds are often detected. The water containing CO2 will erode iron and generate ferrous, and the precipitation of iron is related to the pH of the system. When the pH is greater than 7, iron is easily precipitated. The water contains H2S, which forms iron-based sulfides due to iron erosion. When iron and oxygen come into contact, corrosion forms such as Fe (OH)2 and Fe (OH)3 are produced, and precipitates are produced**.**

7. Concluding remarks

In summary, the material, length and running time of the pipeline will have a direct effect on the viscosity loss of the polymer. In the process of surface distributed hydraulic transportation, the content of iron ion should be reduced by appropriate measures such as oxygen. The influence of impurities such as glue in the pipeline on polymer viscosity can be reduced by regular pipeline cleaning. For the pipelines with small viscosity loss, "high temperature water + lotion" can be used for cleaning. For the pipelines with large viscosity loss and more dirt, the method of hole jet can be used for cleaning.

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