Study on the viscosity reduction experiment of stimulation wastewater in oilfield

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Abstract. The stimulation wastewater is a kind of re-discharge wastewater produced by various operational measures according to the production needs, it has high viscosity and is difficult to treat. Based on the analysis of the viscosity characteristics of stimulation wastewater, the viscosity reduction experiments were carried out to evaluate the viscosity reduction effects of two measures. The experimental results show that the natural static viscosity reduction is easy and does not need to consume treatment agent. In the rapid viscosity reduction method, the organic structure can be destroyed by adjusting the pH value or adding oxidizing substances to meet the requirements of viscosity reduction. Among them, ozone has the advantages of fast viscosity reduction, good effect, appropriate amount of hydrogen peroxide, which can strengthen the viscosity reduction in wastewater and shorten the time of natural viscosity reduction. In summary, if enough time is available, static viscosity reduction is the appropriate method; if conditions are not available, natural static viscosity reduction and oxidative viscosity reduction are combined. Hydrogen peroxide is the preferred fast viscosity reducer, which can ensure the effect of viscosity reduction.

1. Introduction

With the exploitation of oil, a large amount of operational waste water, such as water extraction, drilling fluid and stimulation wastewater [1-3]. Among them, the stimulation wastewater is a kind of re-discharge wastewater produced by various operational measures according to the production needs, such as drilling, well washing, fracturing and acidification [4-5]. These stimulation wastewater contains petroleum, solid suspension, inorganic matter and chemical additives, which are complex and difficult to deal with, and pose a great threat to the environment and ecological safety [6-7].

At present, the common methods on the treatment of stimulation wastewater are physical or physical-chemical [8-10]. Physical method mainly uses hydraulic cyclone technology, through the action of centrifugal force, to separate the suspended matter in the wastewater, this method can only remove the suspended matter and some oily substances in the water body. The physical-chemical method is mainly to remove harmful toxic substances from wastewater by adding inorganic coagulants and organic polymer flocculants to the water body. The emulsified oil, the small particulate suspension in wastewater and the viscosity are the main factors affecting the stimulation wastewater treatment. Based on the viscosity characteristics of the stimulation wastewater, the paper conducts a study on the reduction of viscosity experiments, evaluate the effect of viscosity reduction in different methods.
2. The Viscosity Characteristic of the Stimulation Wastewater

Typically, the viscosity of water at 20 centigrade is about 1mPa.s, while the viscosity of the stimulation wastewater is 2-15 times that of water, which is the main problem that the stimulation wastewater is difficult to deal with. The greater the viscosity of wastewater, the worse the fluidity, the chemical agent in the stimulation wastewater is difficult to spread, the transfer of mass pressure is slow, resulting in a long treatment time, and affect the treatment effect. The stimulation wastewater according to the type of additive can be divided into five types of guanidine gum wastewater, thickened wastewater, EM series wastewater, acidification wastewater and biological glue wastewater. In this paper, the viscosity of different types of stimulation wastewater was tested using a six-speed rotary viscometer (ZNN-D6), and the results show that: There are significant differences in the viscosity of different types of wastewater, among which, the average viscosity of guanidine gum, thickened and EM series wastewater is between 12.5-15mPa.s. The acidification wastewater and the biological glue wastewater with an average viscosity of 5mPa.s.

3. The Viscosity Reduction Experiments on the Stimulation Wastewater

The viscosity of the stimulation wastewater is the limiting factor of the stimulation wastewater treatment. High polymer makes the viscosity wastewater is very large, resulting in poor fluidity and sedimentation of water, is not conducive to the removal of suspended solids, which has a great impact on the treatment of the stimulation wastewater. In this paper, focus on the high viscosity of the stimulation wastewater which is guanidine gum wastewater and thickened wastewater, two measures of natural static viscosity reduction and rapid viscosity reduction are proposed, and the experimental analysis is carried out.

3.1. Natural Static Viscosity Reduction

The results of the experiment using natural static viscosity reduction are shown in Figure 1. It can be seen that the thickened wastewater after 48 hours of natural static, viscosity from 8mPa.s reduced to 0.64mPa.s, same as water viscosity. In the same period of time, the viscosity of the guanidine gum wastewater reduced from 15mPa.s to 5.79mPa.s, and the decrease was 9.21mPa.s, although the decrease was larger, but the viscosity value was still high, which was significantly different from that of tap water. It can be seen that the thickened wastewater after 48 hours of natural static viscosity reduction is feasible, for the guanidine gum wastewater still need to take auxiliary measures to further reduce the viscosity.

3.2. Rapid Viscosity Reduction

In the rapid viscosity reduction experiments of guanidine gum wastewater and thickened wastewater, two methods were used which are pH regulation viscosity reduction and oxidation viscosity reduction. The Ozone and hydrogen peroxide are selected as oxidants.
3.2.1. The pH Regulation Viscosity Reduction. The relationship between the pH and viscosity of stimulation wastewater is shown in Figure 2. When pH changes between 2-8, the viscosity of the stimulation wastewater decreases rapidly, and then the rate of decline gradually slows down, indicating that the stimulation wastewater viscosity decreases when the pH is raised.

3.2.2. The oxidation Viscosity Reduction. Ozone was chosen as oxidant. Ozone dissolves in water and produces hydroxyl radicals. Strong oxidizing hydroxyl radicals can effectively oxidize macromolecular organic compounds in waste, which can break chains into polymers with small molecular weight and reduce the viscosity of aqueous solution macroscopically. The results of ozone treatment for the viscosity of guanidine gum wastewater are shown in Figure 3. The results show that the higher the concentration of ozone, the better the treatment effect. When the ozone gas flow rate is 5L/min, the viscosity reduction rate of ozone method is as high as 85.5%. The viscosity of water decreases rapidly and can be treated in about 12 minutes.
Hydrogen peroxide was chosen as oxidant. It is a colorless transparent liquid. Because of its active oxygen atom and strong oxidation, it is non-flammable and safe to use at room temperature, but it is combustion-supporting. Therefore, it is necessary to store separately from petroleum products. The results of hydrogen peroxide viscosity reduction are shown in Figure 4. The results showed that the effect of hydrogen peroxide on the viscosity reduction of guanidine gum wastewater and thickened wastewater was similar. When the dosage of 6mg H$_2$O$_2$/L was added, the reduction of guanidine gum wastewater and thickened wastewater was 5.9mPa.s and 6.24mPa.s, respectively.

Combining natural static viscosity reduction with oxidative viscosity reduction, hydrogen peroxide was used to assist oxidative viscosity reduction for the effluent of guanidine gum wastewater after static storage. The experimental results are shown in Figure 5. It can be seen that after 48 hours of natural static viscosity reduction, the viscosity of guanidine gum wastewater decreases to 5.79 mPa.s. When 5 mg/L hydrogen peroxide is added, the viscosity of wastewater finally decreases to 0.9 mPa. It can be seen that the combination of natural static and oxidative can ensure the effect of viscosity reduction.
4. Conclusions

Based on the analysis of the viscosity characteristics of stimulation wastewater, the viscosity reduction experiments were carried out to evaluate the viscosity reduction effects of two measures, i.e. natural static viscosity reduction and rapid viscosity reduction. The experimental results show that the natural static viscosity reduction is easy and does not need to consume drugs, but it takes a long time. For the wastewater which can’t meet the requirement for long time of natural static viscosity reduction, fast viscosity reduction method can be adopted to destroy the structure of organic matter by pH regulation or adding oxidizing substances to meet the requirement of viscosity reduction. Ozone has the advantages of fast viscosity reduction and good effect, but it has the problems of high treatment cost and difficult preparation. Appropriate amount of hydrogen peroxide can strengthen the reduction of viscosity in wastewater and shorten the time of natural static viscosity reduction. In summary, if enough time is available, static viscosity reduction is the appropriate method; if conditions are not available, natural static viscosity reduction and oxidative viscosity reduction are combined. Hydrogen peroxide is the preferred fast viscosity reducer, which can ensure the effect of viscosity reduction.

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