Research Journal of Applied Sciences, Engineering and Technology 4(21): 4443-4448 , 2012
ISSN: 2040-7467

Submitted: May 01, 2012 Accepted: June 08, 2012 Published: November 01, 2012

Research on Demulsification Features of Polymer Flooding Produced Fluids of O/W with High Water Content for Oilfield and the Demulsification Efficacy

[1]Gui-Quan Jiang, [2]Li Wei and [2]Chun-Ying Li
[1]Wood Material Science and Engineering Key Laboratory of Jilin Province, Beihua University, Jinlin, 132013, China
[2]State Key Laboratory of Urban Water Resource and Environment, Harbin Institute of Technology, Harbin 150090, China

Abstract: In this study, we select the effective demulsifier for crude oil through analyzing the stability factors of polymer flooding Produced Fluids with high water content and carry out the field test research. The results demonstrate the stability of the crude oil emulsion enhanced with the increasing of polymer concentration, which resulting the increasing of the membrane strength of oil-water interface, the elastic shear modulus of oil-water interface decreased. The field tested results of the selected crude demulsifier DQ-10 show that the average water rate in the oil dialed with the free water knockout drums is 5.39%, the water rate in exporting oil is less than 0.3% and the oil content in sewage is not more than 500 mg/L. The test results demonstrate that the prepared demulsifier can ensure the average water rate in oil and the oil content in sewage, which reveals that the demulsifier can be applied in the production of crude oil dehydration and be able to satisfy the demand of production. In that way, the annual expenses for crude oil demulsifier can be decreased by 260,000 Yuan RMB.

Keywords: Demulsifier, efficacy, electro-dehydration process, polymer flooding produced fluids of O/W in oilfield

INTRODUCTION

As the Daqing Oilfield exploitation proceeds, the average water content in produced liquid from oilfields goes up. Currently the major oil-exploiting sites have come into the late developmental stage of high water content, which can be concluded from the fact that the average water content in the produced liquid is above 85% and that that of some oilfields is up to 92% (Chen, 2010).

Comparing to those in the early or middle developmental stage, the produced liquid with high water content and produced water has undergone a relatively big change in terms of characteristics, that is the separation of oil from water has obviously slowed down. As a result, the demulsification of the produced liquid becomes more and more difficult, the water rate in emulsible oil is higher, the oil content in sewage elevates and it is of more difficulty to dispose of the produced water (Hu, 2000; Wang *et al*., 2002). The main problems Daqing Oilfield confronts are:

- The cost of collecting oil rises due to a lack of all-round understanding of the characteristics of high-water-content produced liquid and produced water, especially those of polymer flooding produced liquid and produced water. Then the usage of crude oil demulsifier of produced liquid with high water content gets a large ascension, which leads to an annual increase on the disposal cost of produced liquid with high water content and the crude oil (Wang *et al*., 2002; Cao *et al*., 2002).
- Crude oil demulsifier becomes less efficient, resulting in high difficulty in disposing of sewage in which the oil content rises as well. Consequently, the quality of injection water is badly influenced and a series of environment-protecting problems are brought about, failing to realize a safe and environment-protecting oilfield exploitation (Wei *et al*., 1995).
- We see a change in the nature of produced liquid, namely, the initial produced liquid with the dominant type of water in oil (W/O) is replaced by the later one with oil in water (O/W) as the dominant type (Guo *et al*., 2005; Feng *et al*., 2004; Cui *et al*., 2005).

Therefore, it becomes the key technology to tackle with the problem to find out the suitable crude oil demulsifier that can deal with produced liquid with high water content. With the produced liquid from the late oil-exploiting sites with high water content of Daqing Oilfield as the test medium, the research tries to select the most effective crude oil demulsifier and carries out

Corresponding Author: Gui-Quan Jiang, Wood Material Science and Engineering Key Laboratory of Jilin Province, Beihua University, Jinlin, 132013, China

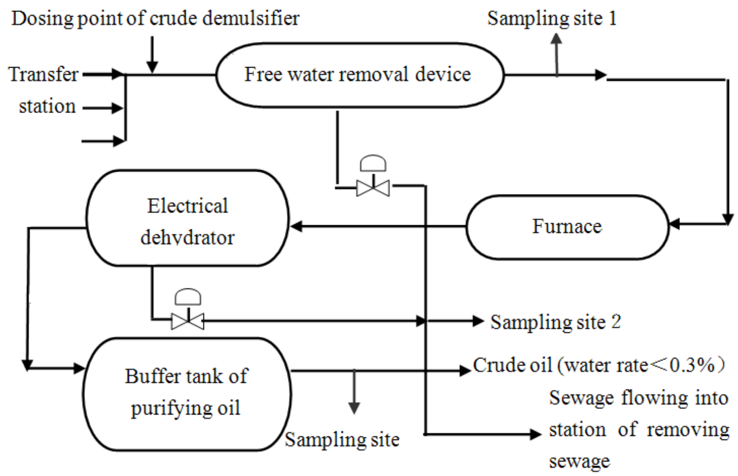

Fig. 1: The process flow chart of produced liquid electrical dehydration

a field experimental study, through analyzing the factors that influence the stability of polymer flooding produced liquid of the O/W oilfield.

In this study, we demonstrate the stability of the crude oil emulsion enhanced with the increasing of polymer concentration, which resulting the increasing of the membrane strength of oil-water interface, the elastic shear modulus of oil-water interface decreased. Moreover, the selected crude demulsifier DQ-10 show that the average water rate in the oil dealed with the freewater knockout drums is 5.39%, the water rate in exporting oil is less than 0.3% and the oil content in sewage is not more than 500 mg/L. We also demonstrate that the prepared demulsifier can ensure the average water rate in oil and the oil content in sewage, which reveals that the demulsifier can be applied in the production of crude oil dehydration and be able to satisfy the demand of production.

MATERIALS AND METHODS

The field test site and the process: The field test site for polymer flooding crude oil demulsifier: some station of electrical dehydration in China's Daqing Oilfield. The everyday disposed produced liquid is 32,000 m^3/d, in which the average water content is around 94% and the polymer content is 146 mg/L, of which the temperature is between 37°C and 47°C, the temperature of electrical dehydrator is between 49ºC and 52°C and the dosage of crude oil demulsifier is 400 kg/d. The process flow chart of the station can be seen in Fig. 1. The disposal system of produced liquid resorts to the method of free water removal at the first stage and that of heating crude oil and electrical dehydration at the second stage. The dosing points of crude oil demulsifier lie in the entries of transferring produced liquid. The produced liquid is separated after passing through the free water removal device, the crude oil with water goes and stays in the furnace until the temperature keeps between 49 and 52°C and then enters the electrical dehydrator to be electrically demulsified and finally the crude oil comes into the buffer tank of purifying oil while the separated sewage with oil flows into the station of removing sewage.

The methods of inspection and analysis: Interfacial intension (interfacial intension meter: FDT-1001), Zeta potential measurement (potentiostat: JS94H), the measurement of oil content resorts to the method (UV spectrophotometry) in SY/T5329-94 Recommended Indicators and Methods of Analysis for the Quality of Water Injection in Clastic Rocks.

RESULTS AND DISCUSSION

Research on the optimization of crude oil demulsifiers of produced liquid with high water content: The research started with the collection of every crude oil demulsifier sample most widely used and effective. Then every selected sample began to match with each other, about which we had a study by having an orthogonal test. Water sample used in the test was from the field. Water rate in crude oil emulsion was 90% with the temperature of dehydration 45°C, the dosage of crude oil demulsifiers after being mixed up 50 mg/L and the time for subsiding 60 min.

As Fig. 2 shows, the sample in white is the least effective because the water content in emulsible oil tops 31.2% and the oil content in the sewage 1390 mg/L, while the sample DQ-10 is the most efficient because of the 14.2%-water content in emulsible oil and the 300

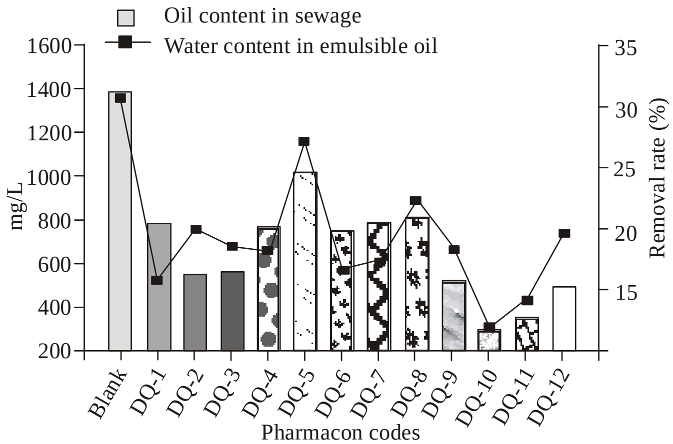

Fig. 2: The selection of demulsifiers of polymer flooding produced liquid

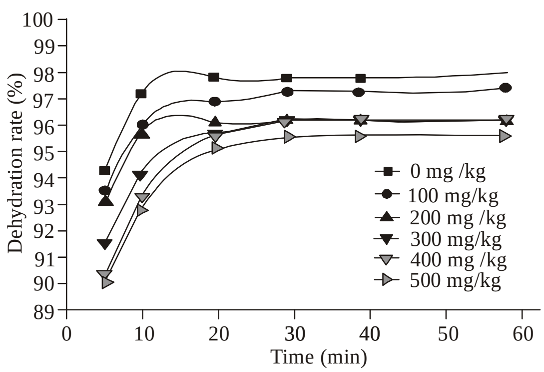

Fig. 3: Produced liquid dehydration time-dehydration rate curve

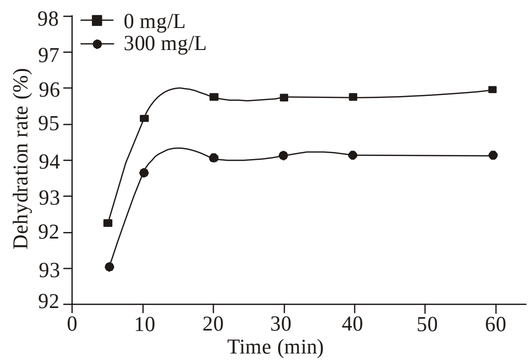

Fig. 4: Produced liquid dehydration time-dehydration rate curve

mg/L-oil content in sewage. During the following test, the demulsifier DQ-10 were hence resorted to.

Analysis on polymer flooding demulsification features:

Impact of polymer concentration on the stability of crude oil emulsion: With temperature of dehydration at 45°C, dosage of the crude oil demulsifier 50 mg/kg and water rate in produced liquid 90% in the test, we tried to examine the dehydration rates of different length of dehydration time, such as 5, 10, 20, 30, 40 and 60 min when the polymer concentration varied among 0, 100, 200, 300, 400 and 600 mg/kg, respectively.

It is clearly seen from Fig. 3 that the higher the polymer concentration is, the smaller the dehydration rate is and the more stable the produced liquid becomes. When polymer concentration is less than 400 mg/kg, the produced liquids after subsiding for 30 min come to an even level and the dehydration rate of them is almost next to that of non-polymer produced liquid, which is indicative of the closeness of the stability of between polymer produced liquid and non-polymer produced liquid. At the same time of dehydration, dehydration rate is reversely proportionate with polymer concentration. It means that as polymer concentration increases, crude oil emulsion becomes more and more stable, rising the difficulty in separating oil from water.

Impact of demulsifiers on stability of crude oil emulsion: With the same conditions as those above, we tried to examine the dehydration rates of different length of dehydration time, such as 5, 10, 20, 30, 40, 60 min when the polymer concentration were only 0 and 300 mg/kg.

We can obviously find in Fig. 4 that the descent of dehydration rate of polymer produced liquid exerts almost no influence on the dehydration rate of oil soluble crude oil demulsifier. Influential factors about the crude oil demulsifier on stability of oil-water interface.

Zeta potential of oil droplets: Two polymer concentrations 0 and 100 mg/kg were added,

Table 1: Analysis on Factors That Influence the Stability of Oil-Water Interface

Polymer concentration (mg/kg)	Zeta potential (10^{-3}V)		Interfacial balance tension (mN.m)		Interfacial elastic modulus 10^{-3}N/m	Interfacial viscosity 10^{-3}Ns/m
	Blank	DQ-10	Blank	DQ-10	Blank	Blank
0	-73.6	-36.9	25.38	5.68	0.019	0.073
50	-67.3	-37.1	24.97	5.81	-0.146	0.433
100	-62.6	-37.6	24.55	6.12	-0.871	0.516

respectively into the compound simulating crude oil emulsions, with the dosage of crude oil demulsifiers 50 mg/kg. After two-hour-subsiding, we measured Zeta potential of the sewage. Table 1 shows that there is surplus negative charge on the oil-water interface of produced liquid and Zeta potential of the diffused double layer is negative; the higher the polymer concentration is, the higher Zeta potential of the diffuse double layer is (the negative charge on oil-water interface weakens). The impact mechanism of polymer on Zeta potential of the diffuse double layer on the oil-water interface is as follows: Anionic polyacrylamide is absorbed onto the oil-water interface and thus the diffuse double layer on the oil-water interface becomes thicker; as a result, Zeta potential of the diffuse double layer on the oil-water interface increases. The crude oil demulsifier DQ-10 reduces remarkably the negative charge on the surface of and electrical repulsion between oil droplets, but its contribution to the rise of Zeta potential of the diffuse double layer decreases as the polymer concentration increases. Zeta potential with polymer added in is higher than that without polymer. Comparing to the latter one whose oil droplets and suspended solids are both negatively charged and whose Zeta potential is negative, the former one has a much more negative Zeta potential, which demonstrates that polymer molecules with negative charge are absorbed onto the surface of oil droplets and suspended particles. Consequently, electrostatic repulsion between oil droplets or particles is so enhanced that it is extremely troublesome for them to collide, coalesce and flocculate; for another thing, the static hindrance between particles becomes much stronger, which makes it harder to coalesce.

Intensification of interface modulus and interfacial tension: Intensification of interface modulus is one of the major micro features of the oil-water surface of crude oil emulsion. The test measured the different intensifications when polymer concentration varied from 0 to 800 mg/kg.

As is shown in Fig. 5, intensification of interface modulus increases as polymer concentration goes up. There exist in polymer molecules both Lipophilic groups and hydrophilic groups which are somewhat surfactant. Therefore, some active molecules can be

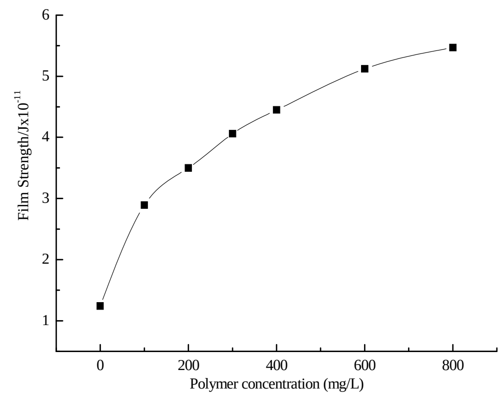

Fig. 5: Polymer concentration-film strength curve

absorbed onto oil-water interface and then combine with emulsifier molecules, creating an integrated modulus on oil-water surface. Absorption layer becomes thicker and thicker as polymer concentration rises, which makes emulsion more stable and more difficult to be demulsified.

Intensification of interface modulus is proportionate with the polymer concentration. If we itch for a more efficient separation of oil from water, it is of great necessity to introduce components able to capture polymer molecules into the molecular structure of crude oil demulsifier. By doing that, the absorption layer of polymer on the interface can be destroyed and so can the interface modulus.

Interfacial balance tension: Polymer concentration has little effect on interfacial balance tension because with polymer concentration increasing, interfacial balance tension decreases slightly. Crude oil demulsifier can lower to a large extent interfacial balance tension, indicating that two kinds of crude oil demulsifier can be absorbed onto the interface to destroy the stability of interface modulus.

Interfacial rheology: As polymer concentration ascends, interfacial elastic modulus descends while interfacial viscosity ascends. The high interfacial viscosity will cut down significantly the velocity of fluid flowing out. If polymer concentration is rather low, fewer polymers can be absorbed onto the interface.

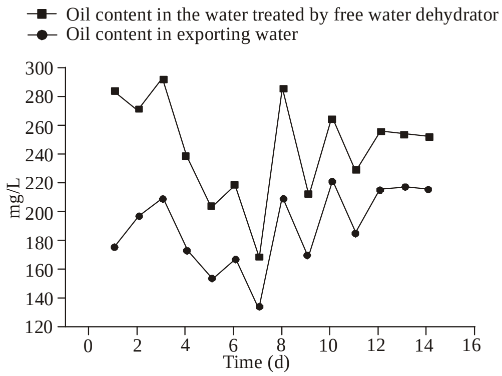

Fig. 6: Removal effect of oil content in field test

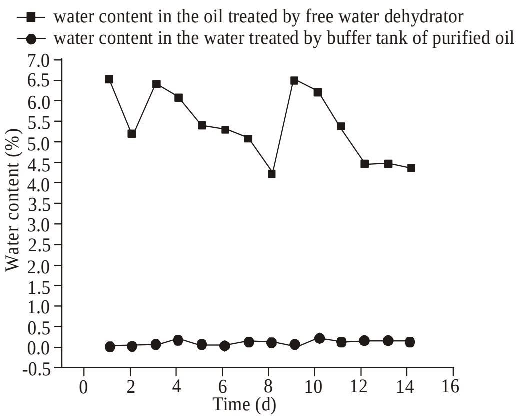

Fig. 7: Removal effect of water rate in field test

Then arrangement of interfacial modulus is less close and thus the active substance finds it easy to move around.

Study on effect of the field test: We applied the prepared crude oil demulsifier DQ-10 into the electrical dehydration process of joint station and the dosage of that is set to be 380 kg/d. During the successive 14-day inspection of field process, we took out some sample every 24 h for analysis, especially on oil content and water rate.

Figure 6 unfolds to us that water rate in crude oil is between 4.2 and 6.4%, oil content in sewage between 160 and 289 mg/L and oil content in dehydrated sewage between 124 and 215 mg/L. Besides, the average oil content in water treated by free water dehydrator is 239.4 mg/L, but after the process, the average oil content in exporting water is 179.3 mg/L. Therefore, a conclusion can be made that removal rate of the demulsifier is about 25%.

It is clearly illustrated in Fig. 7 that the average water rate in oil through free water removal device is 5.39%, while that through buffer tank of purifying oil is 0.13%. If we reduce the dosage of purifying oil demulsifier by 15%, water rate in exporting oil is less than 0.3% and oil content in sewage is not more than 500 mg/L. The test verifies that the demulsifier can make ensure the average water content in exporting oil and oil content in sewage, indicating that the demulsifier can be applied into the production of crude oil dehydration and be able to satisfy the demand of production. If the developed crude oil demulsifier DQ-10 can be applied into the electrical dehydration process, the annual fee for crude oil demulsifier can decrease by 260,000 Yuan RMB provided that the daily dosage of crude oil demulsifier is 360 kg and that crude oil demulsifier for every ton of crude oil costs 12,000 Yuan RMB.

CONCLUSION

- The results demonstrate the stability of the crude oil emulsion enhanced with the increasing of polymer concentration, which resulting the increasing of the membrane strength of oil-water interface, the elastic shear modulus of oil-water interface decreased.
- The selected crude demulsifier DQ-10 show that the average water rate in the oil dialed with the free water knockout drums is 5.39%, the water rate in exporting oil is less than 0.3% and the oil content in sewage is not more than 500 mg/L.
- Demonstrate that the prepared demulsifier can ensure the average water rate in oil and the oil content in sewage, which reveals that the demulsifier can be applied in the production of crude oil dehydration and be able to satisfy the demand of production.

ACKNOWLEDGMENT

The authors gratefully acknowledge the support of the National Natural Science Funds of China (50908063), funded projects of Science and Technology, Department of Jilin Province (20080705), funded projects of Science and Technology Bureau of Jilin City (Social development-2007010), funded projects of Education Department of Jilin Province (2008-121).

REFERENCES

Cao, X. and Z. Wang, 2002. Current researches and applications of crude demulsifiers. J. Daqing Petroleum Institution, 26: 34-38.

Chen, T., 2010. Measures to stabilize crude dehydration process. Oil-Gasfield Surface Eng., 2: 45-48.

Cui, C., Y. Yang and C. Zhu, 2005. Research and application of new bio compounded emulsion breakers for crude oil. Petrochem. Corrosion Protect., 22: 5-8.

Feng, Z., Y. Yang and C. Zhu, 2004. Crude oil demulsification and pilot testing with biodemulsifier. J. University Petroleum (Natural Science Version), 3: 56-61.

Guo, H., C. Zheng and Z. Sun, 2005. Development and application of the efficient mixed crude demulsifier SD-10A. Adv. Fine Petrochem., 6: 35-39.

Hu, Y., 2000. Current situations and developments of research on crude demulsifiers. Chem. Techno-Econ., 3: 15-17.

Wang, X., C. Zhu, H. Hu and S. Su, 2002. A review on researches and developments of crude oil demulsifiers. Oilfield Chem., 19: 379-381.

Wei, G. and Z. Zhang, 1995. Researches and applications of crude demulsifiers. Oilfield Chem., 12: 188-190.