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EXPERIMENTAL STUDY ON OPTIMIZATION OF POLYMER SURFACTANT AGENT AFTER POLYMER FLOODING

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ABSTRACT

Polymer surfactant agent flooding is an effective way of displacement after polymer flooding, there are many kinds of polymer surfactant agent in the market at present. This paper has made the typical physical model of core in view of the actual reservoir in Daqing Oilfield which is a typical onshore oil fields, and screened out two kinds of polymer surfactant agent which can meet the needs of actual development by using the method of static experiment and dynamic experiment, used the two kinds of polymer surfactant agent to observe micro molecular thread, analyzed the microscopic differences between the two kinds of polymer surfactant agent, carried out the study of injectivity in view of actual reservoir, combined with formation breakdown pressure and other parameters of actual reservoir to ensure the permeability of the reservoirs which can be injected and concentration of the two kinds of optimized agents, the study could offer actual guidance for the field experiment in Daqing Oilfield.

KEYWORDS

After polymer flooding, polymer surfactant flooding, experimental optimization.

1. INTRODUCTION

Based on a study, this Polymer flooding is adding a small amount of water soluble polymer into the injected water, which can improve mobility ratio by increasing the viscosity of the water phase and reduce water phase permeability and improve sweep efficiency, so as to enhance oil recovery [1-3]. Study showed, when the reservoir heterogeneity is serious, or water flooding mobility ratio is relatively higher, the polymer flooding can obtain obvious effect. Because polymer flooding technology plays an important role in tertiary oil recovery, over the years, many researchers at home and abroad have been working for the research of polymer flooding mechanism, experimental studies have shown that polymer solution of clear water preparation can expand the swept volume and improve the oil displacement efficiency and both of their effect are 50%, Daqing oilfield has been carried out the combination flooding in the area of field experiment, and the improvement value of actual recovery efficient is higher than predicted value, and improved the recovery of 6% to 8% is considered to be effects of viscosity and elastic properties of chemical agents, which can not only improve sweep efficiency, but also improve oil displacement efficiency [4-7]. According to a research, polymer surfactant agent combines both advantages of polymer and surfactant, under the condition of no alkali, it can roll the advantages of increasing the viscosity, reducing the mobility ratio, expanding the sweep efficiency, improving solubilization and emulsifying capacity of crude oil into one, and it is a new type of single component chemical displacement agent with a variety of functional groups [8]. Therefore, this part of the laboratory experiment has studied the viscoelasticity, the stability and shear resistance in allusion the type of Hua ding I, the type of Huading II, the type of Haibo BI, the type of LianHua III polymer surfactant agent which are responsive on the market, and optimized the type of polymer surfactant agent, evaluated the injection capacity of optimized polymer surfactant agent.

2. EVALUATION OF INCREASING VISCOSITY

When the solution concentrations of four kinds of polymer surfactant agents and a common medium molecular weight polymer solution are 800 mg/L, 1000 mg/L, 1500 mg/L, 2000 mg/ L, the data of viscosity which is measured by Brookfield viscometer is shown in Table 1.

It can be seen from Table 1 that the changes of the concentration of the five kinds of chemical agents have an effect on the viscosity, viscosity of the system increases with the increase of concentration. Compared with the medium molecular polymer, the viscosity of four kinds of polymer surfactant agent increase the larger, and the viscosity is higher than the common medium molecular weight polymer solution, it turns out that all of four kinds of polymer surfactant agent have a good effect of increasing the viscosity, and it can continue to improve the viscosity of displacement fluid based on the polymer flooding, effectively control mobility ratio and expand sweep volume. Further analysis, we can find that there are some differences between tackifying effect of the four kinds of polymer surfactant agent, the viscosifying effect of Huading I and Haibo BI polymer surfactant agent is better, and the viscosifying effect of Huading II and LianHua III polymer surfactant agent is relatively weak.

Table 1. The data of relationship between concentration and viscosity (MPa•s).

The type of polymer surfactant agent	**Concentration (mg/L)**			
	800	***1000***	***1500***	***2000***
Huading I	36	58	166	377
Huading II	32	45	147	306
LianHua III	30	40	147	295
Haibo BI	33	53	159	395

Medium(14 million)	14	20	64	122

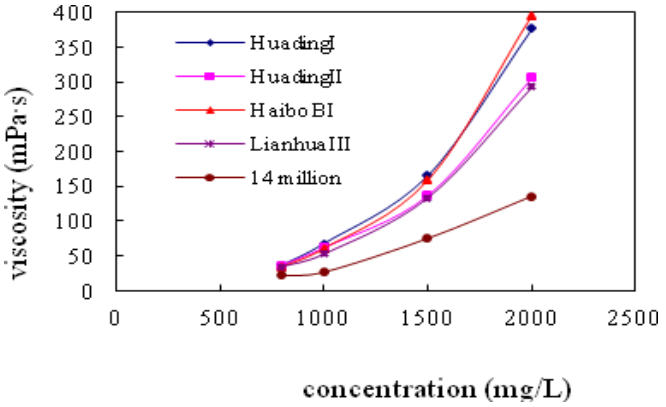


Figure 1: Curve of the relation between concentration and viscosity for five kinds of chemical agent (MPa•s).

3. THE EVALUATION OF STABILITY

viscosity retention rate of Huading I polymer surfactant agent, Haibo BI polymer surfactant agent and the medium molecular weight polymer is higher. It turns out that the stability of these three chemicals is relatively better, the stability of Huading II and Lianhua III polymer surfactant agent is relatively poorer. When the concentration is 1500 mg/L, 2000 mg/L, the viscosities of the four kinds of polymer surfactant agent increase significantly, it turns out that all of them have happened serious self-crosslinking reaction, when the viscosity reaches a certain value, it will fall slowly with the increase of time, but the overall viscosity retention rate is very good.

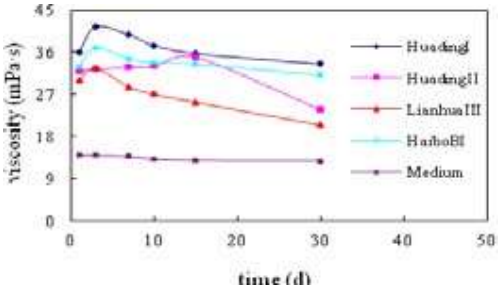


Figure 2: The curve of variation of viscosity changing with time (800 mg/L).

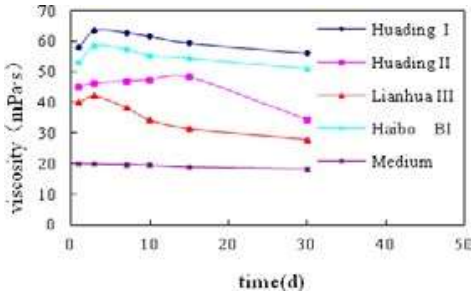


Figure 3: The curve of variation of viscosity changing with time (1000 mg/L).

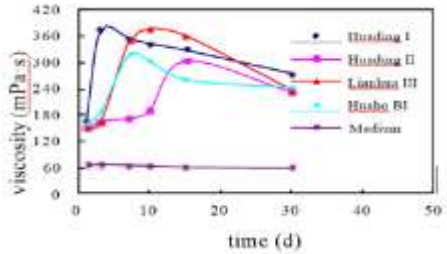


Figure 4: The curve of variation of viscosity changing with time (1500 mg/L).

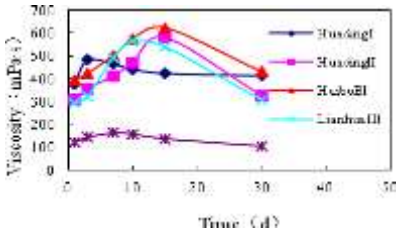


Figure 5: The curve of variation of viscosity changing with time (2000 mg/L).

4. THE EVALUATION OF SHEAR RESISTANCE

We used the way of preparing with clear water and diluting with sewage to prepare the four kinds of polymer surfactant agent solution whose concentration (C) are 1000 mg/L, after the detection of viscosity, injected columnar core which had been saturated with water and whose permeability is 1000×10^{-3} μm² in a injection rate of 0.3 mL/min, and used the core to shear polymer surfactant agent, the viscosity after being sheared are as shown as Table 2.

Table 2: The data of viscosity for four kinds of chemical agent before and after being sheared.

The type of polymer surfactant agent	*Concentration (mg/L)*	*Viscosity date before being sheared* (*mPa·s*)	*Viscosity date after being sheared* (*mPa·s*)	*Viscosity retention rate(%)*
Huading I	1000	58	43	78.2
Huading II		45	28	62.2
Haibo BI		53	42	79.2
Lianhua III		40	22.4	56.0

It can be seen from Table 2 that the type of polymer surfactant agent has an influence on sheared viscosity, under the same condition of being sheared,the viscosity of four kinds of polymer surfactant agent have reduced at different levels. Compared the four kinds of polymer surfactant agent, the retention rate of viscosity for Haibo BI and Huading I polymer surfactant agent is relatively higher, which respectively are 78.2% and 79.2%, Lianhua III polymer surfactant agent's is the lowest, which is 56%.

According to systematically evaluating the increasing viscosity, stability, and shearing resistance of the four kinds of polymer surfactant agents, we can find that the performances of Haibo BI and Huading I polymer surfactant agent are better than Huading II and LianHua III polymer surfactant agent's, and their viscosities are relatively lower and their shearing resistances are weaker, it turns out that the ability of the chemical agents to control the fluidity is weaker and the effect of expanding the sweep volume is relatively weaker; Their stable performance is weaker, the time of working in formation will be relatively shorter, the ability of Further using remaining oil after polymer flooding are relatively weaker. Therefore, this paper will take the optimized Haibo BI polymer surfactant agent with Huading I polymer surfactant agent as the object of follow-up study, and conduct optimization experiments to the rest of the parameter in view of Haibo BI and Huading I polymer surfactant agent.

Table 3: Experimental data of different polymer.

Levels of permeability (×10^{-3} μm^2)	Concentration of polymer surfactant agent solution (mg/L)	Drag coefficient			Residual resistance coefficient		
		The medium molecular	*HuadingI*	*Haibo BI*	*The medium molecular*	*Hua ding I*	*Haibo BI*
200	1000	98	224	168	48	108	74.6
	1500	110	292	269	50	146	121
	2000	167	433	449	93	200	209
500	1000	70	179	120	31.5	81	56.5
	1500	80	243	245	35	106	105
	2000	120	360	364	50	159	172
1000	1000	40	124	80	20	49	36
	1500	50	182	171	24	77	60
	2000	80	311	322	30	133	143

5. THE STUDY OF INJECTION CAPABILITY

It can be seen from Table 3 that the resistance coefficients and residual resistance factors of the three chemical agents are greatly affected by the permeability and concentration, the resistance coefficient and residual resistance factor of the same chemical agent decreases with the increase of permeability. Under conditions of the same

permeability, the resistance coefficient and residual resistance factor of the same chemical agent increases with the increase of concentration. Under the conditions of the same permeability and same concentration, Huading I's the resistance coefficient and residual resistance factor is the biggest when the concentration is 1000 mg/L or 1500 mg/L, Haibo BI's the resistance coefficient and residual resistance factor is the biggest when the concentration is 2000

mg/L. Combining with the Figure 4, it can be seen that Huading I's viscosity is slightly higher than the other three types of chemical agents when the concentration is 1000 mg/L or 1500 mg/L, Haibo BI 's viscosity increases sharply when the concentration is above 1500 mg/L, and it is significantly higher than other viscosity of three kinds of chemical agents. when the concentration is 2000 mg/L. Therefore the measured the resistance coefficient and residual resistance factor Haibo BI and Huading I have a great relationship with their viscosity, the higher the viscosity is, the larger the resistance coefficient and residual resistance factor is, and its capacity of absorption and detention is more strong, so the effect of plugging and profile control is better; The smaller the viscosity is, the smaller the resistance coefficient and residual resistance factor is, and the matching of core is better.

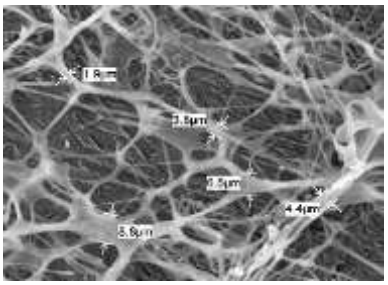


Figure 6: The scanning electron micrograph image of the Huading I 1000X.

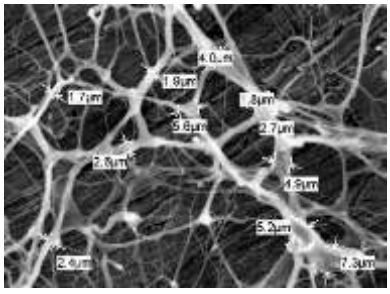
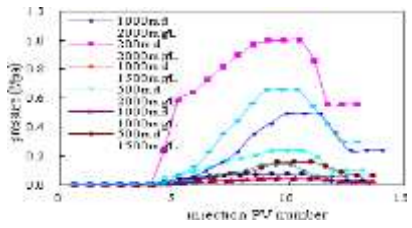


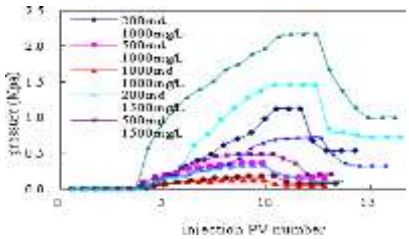
Figure 7: The scanning electron micrograph image of the HaiBo BI 1000X.

It can be seen from the scanning electron micrograph of Huading I and HaiBo BI polymer surfactant solution that Huading I's coil size of the molecular chain is between 1.9-8.8 μm, Haibo BI's ranges 1.7 μm to 7.3 μm, and Huading I's is bigger, so its measured the resistance coefficient is bigger than Haibo BI's.

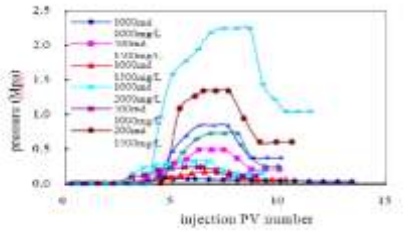
In order to study the trends of injection capacity for the medium molecular weight polymer and polymer surfactant agent capacity, we measured the changes of the injection pressure for three kinds of chemical agents, as shown as the following:



The medium molecular weight polymer



Huading I



Haibo BI

Figure 9: Comparison of injection pressure for different chemical agents.

It can be seen from Figure 9 that both filtrational resistances and injection pressures increase gradually with the increase of injection rate of those three kinds of chemical agents. During the stage of subsequent water flooding, filtrational resistance gets down and injection pressure decreases as part of the chemical agents is produced. The lower the permeability is, and the greater the concentration of the chemical agent is, the greater the filtrational resistance is, and the greater the injection pressure is. When concentration of the medium molecular weight polymer solution is 2000 mg/L and the solution flows through the core whose permeability is 200×10-3 μm2, the injection pressure is the highest, which is around 1 MPa. When the concentration of the medium molecular weight polymer is 2000 mg/L in the field, the solution could be injected into actual

reservoir, and corresponding injection pressure is 6 MPa, considering the actual fracture pressure is 14 MPa in the field and in accordance with the principle of proportion, when the pressure in laboratory experiment is below 2.33 MPa, the solution could be used at the field. The injection pressure of Huading I's and the Haibo BI's are beyond the limit, in addition, this flow test can conduct under the condition of unlimited the number of PV, and the pressure reaches the maximum when the injection rate gets 4 PV, but the injection rate will be so big in actual filed. Based on the above analysis, the solution can be successfully injected in the simulative reservoir when the concentration of Huading I's or Haibo BI's is lower than 2000 mg/L.

6. CONCLUSIONS

The performances of Huading I and Haibo BI polymer surfactant agent are better, and those two kinds of polymer surfactant agent are optimized by the experiments of viscosifying, stability and shearing resistance. Experiments of the resistance factor and residual resistance factor for Huading I and Haibo BI polymer surfactant agents show that the resistance factor and residual resistance factor gets bigger with the increase of concentration, but Huading I's is bigger, which is related to molecular thread size, and molecular thread size of Huading I is bigger. The comparison experiments between Huading I, Haibo BI and the medium molecular weight polymer of injection capacity show that when the concentration of the solution is 2000 mg/L or lower.

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