Advances in Engineering Research, volume 104
7th International Conference on Mechatronics, Control and Materials (ICMCM 2016)

Laboratory Experiment Research on Multi-slug Alternative Injection Method of Polymer Flooding

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Keywords: enhanced oil recovery; polymer flooding; alternative injection; concentration gradually decreased injection

Abstract. On simulation of reservoir conditions in Daqing Oilfield, the effect of different method of multi-slug alternative injection, concentration gradually decreased injection, and concentration increasing injection on oil displacement efficiency are studied by laboratory experiment. The experimental results show that, under the condition of the same total amount of polymer, recovery percent of reserves of polymer flooding stage will increase with the increase of polymer concentration. The scheme which using the concentration gradually decreased method, the extent of enhancing recovery is maximum, polymer flooding recovery can reach 40.12%, and the ultimate recovery can reach 80.48%.

Introduction

At present, polymer flooding technology has been popularized in various fields of the whole country, oil was produced by polymer flooding in Daqing oil field has reached the scale of 1000×10^4t, Shengli oilfield achieved an annual output about 300×10^4t oil, increased the oil recovery rate of more than 10%, enhanced oil recovery is about 7%, which has achieved great economic benefits. Other such as Liaohe, Dagang, Xinjiang, Henan and Bohai oilfield, etc. The same experiment was carried out, which has achieved good results[1]. The polymer flooding has become an important technology of oilfield development. To improve the oil recovery mechanism of polymer, In recent years, the literature showed polymer not only increase the macroscopic sweep efficiency, because its viscoelasticity also can improve the microscopic oil displacement efficiency[2], literature[3] showed that the high mass concentration of polymer is more advantageous to enhance oil recovery. Different scholars studied the effects of different kinds of methods and combinations of polymer injection on the recovery[4,5]. In this text, polymer flooding conditions in the simulation of Daqing, indoor experiments showed the effects of different concentrations and different combinations of high molecular weight polymer slug on oil, provided basis for the scene to carry out high concentration polymer.

Experimental Condition

Model. Artificial quartz sand epoxy cemented rectangular core with 4.5×4.5×30cm, the model is vertical heterogeneity, positive rhythm and the coefficient of variation was 0.72, Kg=0.85μm^2.

Experimental Oil. Crude oil and kerosene mixed with simulated oil was mixed by crude oil and kerosene in No.3 Oil Production Plant of Daqing Oilfield, the simulated oil viscosity of 45 degrees Celsius is about 10mPa.s.

The Experimental Water. Displacement and distribution of liquid water are synthetic brine, the mineralization degree of saturation model water is 6778 mg/L ($CaCl_2$ 64 mg/L, $MgSO_4$ 262 mg/L), the mineralization degree of polymer water is 508 mg/L ($CaCl_2$ 22 mg/L, $MgSO_4$ 61 mg/L), the mineralization degree of core displacement with water is 3700 mg/L ($CaCl_2$ 35 mg/L $MgSO_4$, 143 mg/L).

Experimental Polymer. Molecular weight of the salt tolerance polyacrylamide is 2.5×10^7 (copolymer), molecular weight of the ordinary polyacrylamide is 1.7×10^7 (HPAM). At the temperature of 45 degrees Celsius, the viscosity of polymer solution with different concentration was tested at 7.34 S^{-1} shear velocity, the test results: the viscosity of 1000mg/L is 42.1mPa.s, 1500mg/L to 58.5mPa.s, 2000mg/L to 79.5mPa.s, 2500mg/L to 111.9mPa.s, 3000mg/L to 134.6mPa.s.

The Experimental Temperature. All the experiments were carried out at 45 degrees Celsius.

Experimental Procedure

Selected the appropriate core, vacuumed 3 hours or more, the mineralization degree of artificial synthetic brine is 6778 mg/L, in order to measure porosity and water permeability. The saturated model is placed in the constant temperature of 45 degrees Celsius for more than 12 hours. The oil drive water when the model has no water at 45 degree Celsius, in order to determine the original oil saturation. Counted water flooding recovery when the model is exported to more than 98% water at displacement rate of 1m/d. Drew up different experimental plans on the premise of the same total polymer content, injected polymer slug according to different schemes. Counted polymer flooding recovery and total recovery when the model is exported to more than 98% water.

Effect of High Concentration Polymer Slug Combination on Oil Displacement

Experimental Scheme. Table 1 shows the injection schemes of different polymer slug combinations. Table 2 shows the effect of different experimental schemes on the oil displacement.

Table 1 experimental schemes of different polymer slug combinations

Scheme number	Injection mode
1	W1+P（1000mg/L，2.00PV）+ W2
2	W1+P（1500mg/L，1.33PV）+ W2
3	W1+P（2000mg/L，1.00PV）+ W2
4	W1+P（2500mg/L，0.80PV）+ W2
5	W1+P（3000mg/L，0.67PV）+ W2
6	W1+P（3000mg/L，0.13PV+2500mg/L，0.16PV+ 2000mg/L，0.20PV+1500mg/L，0.27PV+1000mg/L，0.40PV）+ W2
7	W1+P（1000mg/L，0.40PV+1500mg/L，0.27PV+ 2000mg/L，0.20PV+2500mg/L，0.16PV+3000mg/L，0.13PV）+ W2

Note: the total amount of polymer is 2000PVmg/L, W1- water flooding to model outlet water cut 98%; W2 - follow water drive to model outlet water cut 98%; P – polymer flooding

Table 2 Effect of different experimental schemes on oil displacement

Scheme number	Permeability [μm^2]	porosity [%]	oil saturation [%]	recovery ratio [%]		
				water flooding	Polymer flooding	Total
1	0.785	26.14	72.31	41.16	28.55	69.71
2	0.779	26.16	70.49	42.11	32.01	74.12
3	0.862	26.53	73.33	42.72	33.42	76.14
4	0.854	26.38	69.62	40.86	36.45	77.31
5	0.807	26.71	72.39	40.33	36.71	77.04
6	0.797	25.92	71.85	40.36	40.12	80.48
7	0.795	25.55	72.36	41.19	34.67	75.86

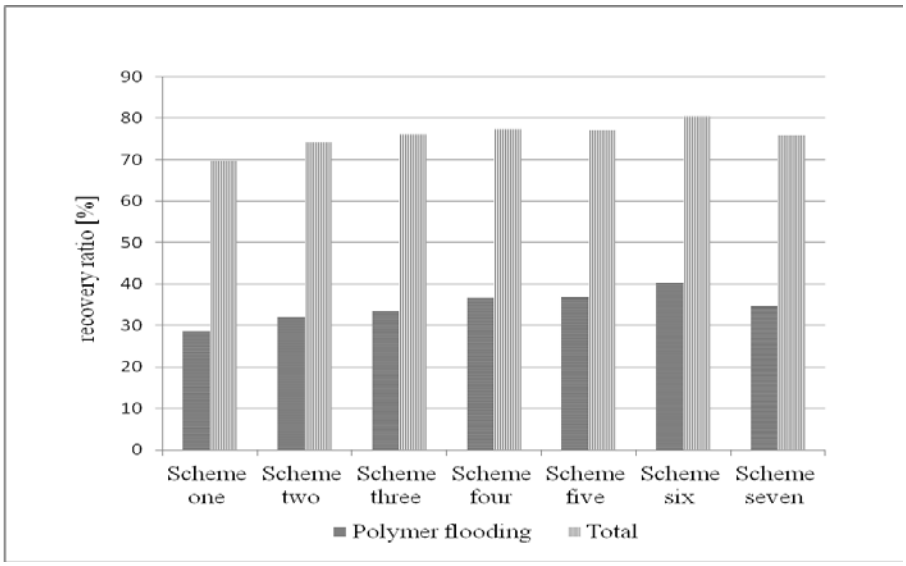

Fig. 1 Comparison of different experimental schemes on the effect of oil displacement

Experimental Results and Discussion. With the concentration of high molecular weight of polymer increasing, the polymer flooding efficiency increasing in the same amount of polymer. Compared scheme 1 to 5, the polymer flooding recovery ratio is less than 30% when the polymer concentration is 1000 mg/L, the final recovery rate is lower than 70%, below the recovery in other concentration of polymers. The polymer recovery was 28.55% when the polymer concentration is 1000 mg/L, 1500 mg/L corresponding to 32.01%, 2000 mg/L corresponding to 33.42%, 2500 mg/L corresponding to 36.45%, 3000 mg/L corresponding to 36.71%, polymer flooding recovery and ultimate recovery rate increased step by step, but from 2500 mg/L to 3000 mg/L increased significantly. It showed that more high viscoelastic concentration polymer solution on residual oil recovery and improved the mobility more effect than expanded at the same time, the sweep volume and improve displacement efficiency. Comparison of scheme 6 and other programs, scheme 6 obtained the highest polymer recovery and ultimate recovery, analyzed the reasons, because of the high concentration of polymer slug injection, polymer with short follow-up plug, and continued to reduce the viscosity of the polymer, and avoided the formation of fingering and dash, expanded the swept volume of polymer. scheme 7, easy to form the fingering and dart phenomenon due to the change of low concentration slug to high concentration slug, and did not get a higher recovery.

Conclusion

In the same amount of polymer, with the concentration of high molecular weight polymer increasing, the polymer flooding recovery yield increasing, the concentration increased to a certain value, the increase of the oil recovery rate decreased.

Enhanced oil recovery of the largest when used of small pieces of plug and continue to reduce the viscosity of the polymer flooding.

Acknowledgement

This project is financially supported by Science and Technology Research Project of Heilongjiang Province Department of Education (12531074).

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