Analysis on the Effective Characteristic of Different Displacement Ways of Tertiary Oil Recovery in the Class II Reservoir of Sazhong Development Zone

An Yu
Geological Team of No.1 Oil Production Plant of Daqing Oilfield, Daqing 163000, China
Yu_An@petrochina.com.cn

Abstract. The first industrial tertiary oil recovery of the class II reservoir in the Sazhong Development Zone was the polymer flooding carried out in Block X at the end of 2002, and achieved noticeable effect. As the class II reservoir blocks were exploited one after another, by combining different geological structures and reservoir characteristics with distribution characteristics of remaining oil, the displacement modes successively went through polymer flooding, strong alkali ASP flooding, weak alkali ASP flooding, and salt-resistant polymer flooding, etc. Considering there are big differences in the geological structure, reservoir characteristics and layer combination of different class II reservoir blocks in the Sazhong Development Zone, and the development effects of different displacement modes are different as well; therefore, it is necessary to learn from the phased results achieved in typical blocks and leading pilot, on this basis, further conduct in-depth comparative study of the characteristics of effective rule and the changes of injection-production parameters of the class II reservoir blocks that have carried out tertiary oil recovery under different displacement modes, provide technical support and selection basis for betting modes up and down of the class II reservoir in the future, and it is of great practical significance to the realization of quality and efficiency improvement and sustainable development of the oilfield.

Keywords: class II reservoir, displacement mode, effective characteristic.

1. Introduction
The class II reservoir is mainly the delta distributary plain deposit and delta inner front deposit, have some outer front deposits. Whether in vertical or horizontal, the sedimentary environment of the class II reservoir changes greatly, in general, it presents the characteristics of small-scale channel sand development, many small layers, thin single layer thickness, low permeability, poor sand body connectivity, and serious horizontal and vertical heterogeneity. At present, the tertiary oil recovery blocks in the Sazhong Development Zone are the class II reservoir, and 9 blocks are being injected, including two ordinary polymers flooding, two salt-resistant polymers flooding, five ASP flooding, the enhanced oil recovery and effective characteristics of chemical flooding stage are different.
2. Effective Characteristics of Polymer Flooding

2.1. Oil displacement mechanism
The polymer used in the Sazhong Development Zone is polyacrylamide; it is a macromolecular compound formed by polymerization of acrylamide monomer and is a water-soluble compound [2]. Polymer flooding increases the viscosity of displacement phase and reduces the oil-water viscosity ratio, since the properties of polymer macromolecule will cause retention in the rock, it increases the flow resistance of the displacement phase fluid in the pore, causes the aqueous phase permeability to decrease, further reduces the oil-water mobility ratio, reduces the fingering of water, improves the microscopic swept coefficient, thereby displacing the cluster residual oil after water flooding.

2.2. Effective characteristics of typical blocks
The typical polymer injection block A by scientifically tracking, adjusting and optimizing the stop-polymerization method, the phased recovery rate reached 14.3%, and the comparative standard evaluation was upgraded from B to A (Fig.1). The water cut change rules in the whole process of polymer flooding were divided into five stages: the water cut decline stage, the polymer solution mainly entered the large and medium pores, improved the water absorption section of the heterogeneous reservoir and the adverse oil-water mobility ratio, the injection pressure rose sharply, and the oil wall was initially formed, the water cut dropped rapidly, and the oil production increased sharply [1]; in the effective peak stage, reached the stable period of low water cut, the oil production reached the peak at this stage, the water cut reached the lowest point, the polymer concentration began to rise; in the water cut recovery stage, oil production dropped significantly, water cut rose rapidly, and the injection section began to reverse. In the late stage of polymer injection, the water cut recovery and the decrease range of output slowed down, began to consider taking well groups as a unit organization; in the subsequent water flooding stage, the water cut continued to rise, the injection pressure dropped, the injected water broke through from the high-permeability layer, and the polymer concentration dropped sharply, and the liquid production capacity rose slightly.

3. Effective Characteristics of Salt-resistant Polymer Flooding

3.1. Introduction to chemicals
Salt-resistant polymer is a kind of block copolymerized salt-resistant monomer based on ordinary polyacrylamide, which inhibits molecular chain curling, can maintain higher body viscosity, enhance
salt resistance, and form intermolecular interactions, it is suitable for improving structure viscosity and enhancing viscosity. According to the evaluation results of the fluidity experiment (Table 1), it can be seen that the medium and high salt-resistant polymers have adaptability to the medium permeability layer, they can be smoothly injected into the oil layer above 130 mD and 150 mD, and they have better adaptability with the class II reservoir.

Table 1. Evaluation results of fluidity experiment

| serial number | polymer                | concentration (mg/L) | Porosity (%) | effective permeability (mD) | resistance coefficient | residual resistance coefficient |
|---------------|------------------------|----------------------|--------------|-----------------------------|------------------------|-------------------------------|
| 1             | medium salt resistance | 1000                 | 23.59        | 230.53                      | 71.01                  | 15.00                         |
| 2             | high salt resistance   | 1000                 | 23.34        | 240.66                      | 79.79                  | 16.32                         |
| 3             | medium salt resistance | 1000                 | 22.71        | 136.21                      | 89.26                  | 17.04                         |
| 4             | high salt resistance   | 1000                 | 22.91        | 155.72                      | 93.18                  | 19.09                         |
| 5             | medium ordinary        | 1000                 | 23.08        | 208.13                      | 40.53                  | 8.95                          |
| 6             | high ordinary          | 1000                 | 23.27        | 222.65                      | 51.73                  | 10.33                         |
| 7             | medium salt resistance | 1500                 | 23.10        | 176.29                      | 96.50                  | 23.00                         |
| 8             | high salt resistance   | 1500                 | 23.31        | 196.63                      | 105.24                 | 25.24                         |

3.2. Displacement effect analysis

As can be seen from comparative analysis of the effective characteristics of typical salt-resistant polymer flooding and ordinary polymer flooding blocks, the biggest drop of water cut of the salt-resistant polymer flooding center well is 19.0%, it is 3.4% more than ordinary polymer flooding, the low water cut stable period is as long as 24 months, and the water cut recovery rate is slower than ordinary polymer flooding.

In the early stage of the injection, due to the poor water quality of the sewage used for dilution, the bacteria exceeded the standard, which caused the viscosity retention rate to drop significantly, the working viscosity in the reservoir was low, the deep section control and water plugging effect were weakened, and the injection pressure rose slowly. Under the condition that the injection viscosity is lower than the ordinary polymer flooding 22.6mPa•s, the increase of injection pressure is similar, it shows that the salt-resistant polymer has high underground working viscosity retention rate [3]. The overall use degree of salt-resistant polymer was better than ordinary polymers in class II reservoir with different polymer injection stages and different permeability. The section inversion happened in ordinary polymer flooding, while the salt-resistant polymer flooding section continued to improve, and the use proportion of reservoir thickness can be increased by more than 20%.

The tackifying property of salt-resistant polymer is significantly better than ordinary polymers in sewage injection systems; under the same dry powder amount, salt-resistant polymer increase the recovery ratio by 6.6 percentage points more than ordinary polymers; under the same increased value of recovery ratio, it can save about 54% polymer consumption than ordinary polymers (Fig.2).
4. Effective Characteristics of ASP Flooding

4.1. Oil displacement mechanism:
The ASP flooding solution includes alkali-surfactant-polymer (ASP). In the ternary composite system, the main role of the surfactant is to change the composition and structure of the oil-water interface, reduce the oil-water interfacial tension, and improve the oil-washing capacity of the oil displacement system; the polymer is mainly used for fluidity control in the oil displacement process, and improves the swept volume of ternary composite system; the main function of the alkali is to significantly reduce the oil-water interfacial tension in cooperation with the surfactant, moreover, the competitive adsorption of the alkali agent in the reservoir pore used to reduce the adsorption loss of the surfactant.

4.2. The problems and countermeasures of ASP flooding
The ASP flooding has a large amount of chemicals, high costs, difficult management, and a lot of work, it is necessary to adopt scientific and effective methods to reduce the impact of twoflooding interference and equipment scaling on the development effect. The sewage, which is produced by the strong alkali ASP flooding has five high characteristics, it includes high pH, high mineralization, high amount, high oil and suspended content [4], it cannot be directly injected back into this block, nor can it reach the water flooding and polymer flooding injection standards, it can only be injected back to subsequent water flooding blocks. When designing the original "13th Five-Year" plan of the Sazhong Development Zone, the tertiary mining block planned to drill a well pattern, on the one hand, it solve the problem of idle reserves, while leaving space for the allocation of ternary produced water allocation, however, due to the impact of oil prices, it is impossible to drill the tertiary well pattern, as a result, it is difficult to balance the ternary sewage in the Sazhong Development Zone.

4.3. Effective characteristics of typical blocks
Effective characteristics of block C of the strong alkali ASP flooding: single agent preparation and triple pump drop injection allocation technique was adopted to realize the adjustability of single agent concentration, and the geological scheme had high adherence rate [5]; under the condition of 125m well
spacing in the class II reservoir, strong alkaline ASP flooding could increase the recovery ratio by more than 20%; the ASP flooding improved the oil displacement efficiency, the contribution rate was about 50%, and the residual oil was effectively used; the adjustment cycle of the initial injection system had been gradually shortened from 3 months to half a month by the continuous development and improvement of the professional management modes, the adherence rate of the overall system plan of the ASP flooding block is over 96.0%, the viscosity loss rate was controlled below 20.0%.

5. Conclusion

High-molecular-weight polymer has better viscosity, greater residual resistance coefficient, and higher viscoelasticity, ordinary polymer flooding of the class II reservoir uses high-molecular-weight polymer pre-slug, which can expand the swept volume and further improve the recovery ratio of polymer flooding. The salt-resistant polymer is better than ordinary polymer flooding in different polymer injection stages and reservoirs with different permeability, the section inversion happens in the ordinary polymer flooding, and the salt-resistant polymer flooding section continues to improve, and the use ratio of oil layer thickness can be increased by more than 20%. Under the condition of small well spacing in the class II reservoir, strong alkali ASP flooding can increase oil recovery by more than 20%; ASP flooding improves oil displacement efficiency, its contribution rate is about 50%, and the residual oil is effectively used.

References

[1] Yan Yaru. Some Understandings of Polymer Flooding Test of the Second Type of Reservoirs in Sazhong Area [J]. Petroleum Geology & Oilfield Development in Daqing, 2004, 23(4): 87-90

[2] Wang Demin. Develop New Theory and Technique of Tertiary Production to Ensure Continuous and Stable Development of Daqing Oil Field (I) [J]. V, 2001, 29(3): 1-5.

[3] Li Yiqiang, Su Weiming, Wang Zhengjin, etc. The Optimal Adjustment Moment of Polymer Flooding For Different Injection-Production Types in Class II Oil Layers [J]. Acta Petrolei Sinica, 2012(4): 647-652.

[4] Xu Guomin. Problems and Countermeasures of Strong Base ASP Flooding [J]. Oil-gasfield Surface Engineering, 2008, (11): 70-71.

[5] Wei Yuhan. The development, tracking and adjustment method of ASP Flooding [J]. Journal of Yangtze University (Natural Science Edition), 2014, 13(11): 118-120.