Research and Analysis on the Change Characteristics of the Driving State of Low-Molecular Polymers in Three Types of Oil Layers

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Abstract. Daqing Oilfield Co., Ltd. passed the oil field test in Zone A of the company area on the three types of oil layers with effective thickness less than 0.5m and permeability less than 0.050 μm². After the company's oil production area in Block A has been injected for more than 6 years, it has been found that the method has achieved good oil and precipitation effects. This paper analyzes the dynamic characteristics of injection wells and production wells after injection, and compares with the first and second types of oil layers, and summarizes the variation rules of low-segregation driving states of the three types of oil layers, which is important for guiding the development of the three types of oil layers in the future. significance.

Keywords. The third oil reservoir; Tertiary Oil Recovery; Polymer flooding.

1. Introduction
Daqing Oilfield Co., Ltd. has the following areas. The mining area in the A section is 0.5136km², the geological reserves are 59.23×10⁴t, the pore volume is 181.94×10³m³, and the five-point area well pattern is used. The average injection well spacing is 125m. The target layer is high I and high II thin oil reservoirs, with 26 injection and production wells, including 12 injection wells, 14 production wells and 6 central wells. The average single well shot sandstone thickness is 23.8m, effective thickness is 4.0 m, the average effective permeability is 0.051 μm².

In the oil recovery area of Block A, a blank water flooding was carried out in October 2004. In October 2005, 4 million molecular weight polymers were injected with a viscosity of 6-34 mPa•s. In April 2007, 8 million molecular weight polymers were injected and the viscosity was injected. 17-40mPa •s. On May 26, 2009, 6 million molecular weight polymer was transferred to the average viscosity of 15-35 mPa•s. By the end of the injection on March 30, 2012, the cumulative injection of polymer solution was 109.7×10⁴m³, accounting for 0.603 underground pore volume [1]. PV the amount of polymer is 616 mg/L • PV. On March 31, 2012, the oil recovery area in Block A was transferred to the subsequent water flooding. As of September 2012, the cumulative water injection volume was 7.06×10⁴m³, which is equivalent to the underground pore volume of 0.039 PV. The stage recovery rate is 7.26%, the enhanced oil recovery is 4.31%, and the comprehensive water content is 97.5%.
The production well in the central area of the oil recovery area in Block A began to take effect when the polymer dosage was 39 PV•mg/L. When the polymer dosage was 192 PV•mg/L, the water content ratio reached the lowest value, and the daily production liquid was 128 t. 13.9t, the comprehensive water content ratio was 89.1%, and the concentration of coal concentration was 243mg/L. Compared with before the injection, the daily production liquid decreased by 43t, the daily oil production increased by 8.9t, and the comprehensive water content decreased by 7.9 percentage points. In September 2012, the oil recovery area of Block A was in the subsequent water flooding stage[2]. The daily production well of the central production well was 214t, the daily oil production was 5.4t, the comprehensive water content was 97.5%, and the concentration of coal concentration was 247mg/L.

2. Research on dynamic variation law of injection well

2.1. Under the rupture pressure, the injection well can be continuously injected with 1-2 MPa, and the injection pressure rises by 34.4%.

The injection pressure of the injection well in the polymer flooding stage of the A block is maintained at about 12.0 MPa. At the beginning of the injection of 4 million molecular weight polymer, the pressure rises rapidly. The injection pressure rises from 9.6 MPa at the end of water flooding to 12.1 MPa, and the increase rate is 26.0%. Then it rises slowly, and the maximum injection pressure rises to 12.9 MPa, and the increase rate is 34.4%. The bursting pressure is 1.0 MPa. In the 8 million molecular weight stage, the injection wells with high injection pressure of 8 were successively treated with low carbonation, and the injection pressure was maintained at about 12.0 MPa and the fracture pressure was 1.9 MPa. In the phase of 6 million molecular weight polymer conversion, the average injection pressure of the oil recovery area in Zone A is 11.9 MPa, the increase rate is 24.0%, and the fracture pressure is 2.0 MPa. At the end of the polymer flooding, the average injection pressure of the oil recovery area in Block A was 11.7 MPa[3], which was 3.0 MPa higher than that of water flooding, with an increase of 31.25% and a fracture pressure of 2.2 MPa. The maximum injection pressure in the polymer flooding stage increased by 3.3 MPa compared with water flooding, which was lower than that of the first and second oil layers of 0.9 MPa and 1.2 MPa. The maximum increase of injection pressure was 34.4%, which was lower than that of the first and second oil layers by 12.8 and 24.0 percentage points. The main reason is that the injection pressure at the end of the water flooding of the three types of oil layers is 9.6 MPa, which is higher than other oil layers[4].

![Figure 1. Comparison of water injection in oil field oil production area](image-url)
2.2. Under the condition that the inhalation index is 4.9m³/d•MPa lower than water flooding and the decrease is 37.7%  
After the injection in the oil recovery area of Block A, the inhalation index decreased from 13.0m³/d•MPa at 8.1m³/d•MPa to 8.1m³/d•MPa, which was 4.9m³/d•MPa lower than that of water flooding[5], with a decrease of 37.7%. After injecting, the inhalation index decreased by 43.8%. After the injection of the second type of oil layer, the inhalation index decreased by 21.7%, which was 6.1 percentage points lower than that of the first type of oil layer and 16.0 percentage points higher than the second type oil layer.

![Figure 2. Change law of inhalation index and seepage resistance state of injection well](image)

2.3. After the injection, the seepage resistance increases, and the ability to control the oil-water flow ratio is gradually enhanced.

The Hall curve shows that the resistance coefficient in the polymer flooding stage increases from 1.63 at a molecular weight of 4 million to 1.64 at a molecular weight of 8 million, and rises to 1.71 at a molecular weight of 6 million, indicating that the chemical flooding control oil-water mobility ratio and the ability to expand the volume are enhanced. It has the purpose of improving oil recovery. When the drag coefficient is greater than 1, the injection of polymer is effective, but the larger the better, the research shows that the reasonable range of drag coefficient in the chemical flooding process should be between 1.3 and 2.0, and the coefficient of polymer flooding in the oil recovery zone of block A is 1.63. Between -1.71, within a reasonable range [6].

3. Research on dynamic variation law of oil production wells

3.1. Under the condition that the liquid recovery index is 0.38t/d•m•MPa lower than water flooding and the decrease is 44.2%  
After the injection in the oil recovery area of Block A, the liquid production index decreased from 0.86t/d•m•MPa at the time of blank water flooding to 0.48t/d•m•MPa, which was 0.38 t/d•m•MPa lower than that of water flooding. The amplitude is 44.2%. After the injection of one type of oil layer, the liquid extraction index decreases by 65.7%. After the injection of the second type of oil layer, the liquid production index decreases by 31.3%. After the three types of oil layers were injected, the decrease of
the liquid production index was 21.5 percentage points lower than that of the first type oil layer, which was 12.9 percentage points higher than that of the second type oil layer.

3.2. *Through the multi-effect characteristics of the production wells, the low-value period is stable for 34 months.*

After the low-molecular-weight polymer was injected into the oil recovery area of Block A, the production wells were all effective, and the lowest point of comprehensive water content fell to 89.1%, which was 7.9 percentage points lower than that before injection, 8.9t per day, and water content was 89. The low value period between % and 93% is stable for up to 34 months, and good test results have been obtained.

When the oil recovery area of Zone A is injected with 4 million molecular weight and the polymer dosage is 32 PV•mg/L, the production well enters the initial stage of effectiveness, and the water content ratio decreases, but the amplitude is small, only 2.2 percentage points; the injection of 8 million molecular weight polymer when the polymer dosage is 192 PV•mg/L, the water content ratio drops to the lowest point of 89.1%, which is 7.9 percentage points lower than that of water flooding, and the daily oil production rises from 5.0t to 13.9t at the end of water flooding. The oil is 8.9t, the oil increase ratio is 1.78 times, and the water content is increased to 93.2%. When the polymer is converted to 6 million molecular weight polymer, the water content ratio has a secondary effect period when the polymer dosage is 415PV•mg/L, and the water content ratio is 93.2%. It fell to 91.4%, compared with water flooding, the water content decreased by 5.6 percentage points, the daily oil production was 17.3t, the daily oil increased by 12.3t, and the oil increase ratio was 2.5 times. When the amount of polymer is 494PV•mg/L, the oil recovery area in Block A is in the middle and late stage of injection, and the fracturing stimulation measures are adopted for the four oil production wells. After the fracturing, the daily liquid is 111t and the daily oil is 8.3t. The daily oil production in the central well area is 19.0t, the daily oil increase is 14.0t, and the oil increase ratio is 2.8 times.

Compared with the water content ratio curve of the first and second types of oil layers, the first type of oil layer decreased by 11.9 percentage points, the second type of oil layer decreased by 9.7 percentage points, the maximum water content of the central well in the test area decreased by 7.9 percentage points, and the water content ratio decreased by only one type of oil layer. One of the two types of oil layers is one-third, but the low water content ratio is relatively long.

3.3. *All production wells are effective, showing three kinds of effective characteristics*

The production wells in the oil recovery area of Block A are all effective, but there are differences in the effectiveness between wells. According to the variation characteristics of water production ratio of production wells, 6 central production wells are divided into 3 types, of which 3 wells are in W type, and the water content is reduced from 98.1% before injection to 81.4%, down 16.7 percentage points. The recovery rate was 5.70%; the water content was type with one well, the water content decreased from 95.1% before the injection to 85.9%, decreased by 9.2 percentage points, and the recovery rate was 5.01%; the water content was V type with 2 Well, the water content decreased from 97.8% before the injection to 91.2%, a decrease of 6.6 percentage points, and an increase of 2.18%.

3.4. *Research on the slow increase rate and concentration of the concentration of coal in the production well*

The oil production well in the oil recovery area of Block A is effective at the same time. As the water content of the production well gradually decreases, the concentration of the collected polymer shows a steady increase, but the rising speed is slow. The oil recovery area in Block A began to be injected in October 2005. The average concentration of polyconcentration before injection was 61 mg/L. After three months of injection, the concentration of polyconcentration increased from 65 mg/L to 103 mg/L. At the same time, the coal production wells are effective, and the water content of the production wells gradually decreases. When the production wells enter a low value period, the rising rate of the concentration of the collected coals rises rapidly from 170 mg/L to 223 mg/L. As the production wells
work, the concentration of the collected coal continues to rise. However, the amplitude is less than the low value period, and the concentration of the polycondensation is up to 392 mg/L, which is only one-half to one-quarter of the concentration of the polycondensation, and the storage ratio is 92.8%. The main reason for the higher accumulation rate is that the clay content of the three types of oil layers is higher, which is about twice that of the first and second oil layers, resulting in a large adsorption retention of the oil layer polymer.

![Image]

**Figure 3.** Dynamic variation law of oil wells in oil layers under four classifications

4. **Analysis of the change law of oil layer utilization status**

The injection well suction profile is improved after injection, but there are differences in the inhalation conditions during different types of reservoir injection. From the statistical table of the inhalation conditions of the injection wells in the oil recovery area of Block A, the proportion of layers, sandstone thickness and effective thickness of the reservoirs in the above-mentioned reservoirs were 54.8%, 58.9%, and 62.3%, respectively, during the entire injection phase. The water flooding stage increased by 5-10 percentage points; while the number of layers and sandstone thickness of the in-situ reservoirs were more than 12.0% and 12.6%, respectively, which was lower than the blank water flooding stage.

The comparison of the inhalation conditions of the injection wells in the different types of oil layers during the flooding stage shows that the effective thickness inhalation ratio is 50.1% during the blank water flooding in the oil recovery area of Area A, and the effective thickness inhalation ratio is 54.7% when the low concentration period is injected, which is 4.6 percentage points higher than that of water flooding. The effective thickness inhalation ratio of the first type of oil layer is 15.7 percentage points higher than that of water flooding. The effective thickness inhalation ratio of the second type oil layer is 4.7 percentage points lower than that of water flooding, which is lower than that of the first type of oil layer and two Oil-like layer.

4.1. **The oil layer in the watch and the outer layer of the surface of the surface larger than 1m are well inhaled.**

The inhalation conditions of different types of sand bodies in the four million-merging stages of 4 million, 8 million and 6 million indicate that the proportion of sand inhaled by the main sand is 49.0-57.3%, and that of non-main sand sand is 23.9-36.5%, and the outer layer is larger than 1m. The sandstone inhalation thickness ratio is 11.7-27.8%, and the surface sandstone inhalation thickness ratio of less than 1m is 3.8-10.8%. The ratio of suction thickness in the polymer flooding stage of less than 1 m is less than 10.0%, and the inhalation condition is significantly worse than the oil layer in the surface and the outer layer of the surface larger than 1 m.
4.2. The outer surface of the thick gauge decreases as the molecular weight of the injected polymer increases.

The thickness of the extra-thick oil layer with a thickness of sandstone greater than 1 m during the 4 million molecular weight polymer flooding period was 22.2% and 27.8%, respectively. During the 6 million molecular weight polymer flooding, the layer and sandstone thickness inhalation ratio were 27.3%. And 25.3%. During the 8 million molecular weight polymer flooding, the layer and sandstone thickness inhalation ratios were only 15.6% and 11.7%, respectively, significantly lower than the 4 million and 6 million molecular weight polymer flooding.

4.3. Multi-directional inhalation of injection wells is better than two-way and one-way communication

The inhalation condition of the injection well injection stage indicates that the ratio of the sandstone thickness of the injection well to the production well is 21.1-75.2%, which is significantly higher than the one-way and two-way communication 20-40%.

4.4. Continuous sand body inhalation is better than phase change complex sand body

Preliminary analysis of the inhalation condition of the injection well shows that the layer composition of the well has a great influence on the inhalation condition, the layering property is good, the corresponding position of the layer is clear, the inhalation condition is good, and the layering property of the same sedimentary unit is poor, and the number of layers is relatively poor. Many, the wells of the well group are interlaced, and the intrusion condition of the layer with complex connectivity is poor.

5. Conclusion

(1) The characteristics of the three types of oil layer low-dispersion polymer flooding are basically the same as those of the first and second oil layers, and there are multiple precipitation and oil-increasing processes in the oil production well.

(2) The three types of oil layer polymer flooding tests show that the development of the oil layer, the connectivity and the matching of the parameters of the oil reservoir with the underground oil layer are the main factors affecting the inhalation condition of the injection well.

(3) Three types of oil layer low-dispersion polymer flooding is feasible, and can achieve enhanced oil recovery by more than 4 percentage points.

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