Analysis on the effect of prolonged injection of oil layer in the Gao 2 Formation of La 8-182 well area in Lamadian Oilfield

Dandan Li
Sixth Oil Production Plant Test Brigade, LTD. Daqing Oilfield Co., Ltd., Daqing 163000, China.
40028203@qq.com

Abstract. At the end of 2012, the three types of oil layers completed the design of the polymer dosage. Since the water content did not rise and the concentration of the polymerization was low, the injection was prolonged from January of the 13th. The extension of the injection phase still has a strong injection capacity, and the water-bearing initial stage is slowly and slowly recovered. In this paper, the characteristics of water cuts in the extended injection phase of the test area are analyzed in combination with different water body water change laws and comprehensive adjustment methods, in order to optimize the three types of oil stratification. The design of the drive scheme provides a basis for accurately predicting the ultimate improvement of the recovery rate of the three types of oil layers.

Keywords: Three types of oil layers; extended injection; water; sand body.

1. Introduction
In this paper, the effects of prolonged injection of three types of oil layers are summarized. The causes of water change in the three types of oil layers during the long-term injection phase are analyzed from the characteristics of water change of different types of sand bodies and the variation law of single well profile, and the final improvement of the three types of oil layers is predicted.

2. The necessity of prolonging the injection of three types of oil layers
At the end of 2012, the three types of oil layer polymer flooding completed the design of polymer dosage 640 PV.mg/L, the degree of recovery in the polymer flooding stage was 12.6%, the stage enhanced oil recovery was 7.1 percentage points, and the total recovery rate was 50.0%. The water content was 92.7%, which remained at a low level and the recovery trend was not obvious. The concentration of the polycondensation was still low at 247 mg/L. In order to explore the ultimate improvement of the recovery of the three types of oil layers, the experimental area began to prolong the injection in January 2013.

3. Prolonged injection effect and understanding of three types of oil layers
As of September 2014, the pore volume of the oil layer injected into the test area was 0.77 PV, the polymer dosage was 1004.5 PV.mg/L, the stage recovery degree was 16.3%, the stage enhanced oil recovery was 9.7 percentage points, and the total recovery rate was 53.4%.
3.1. Still have strong injection capacity
The injection pressure is stable. After the extension of the injection, the daily injection rate is 645 m$^3$, and the average injection pressure is 12.8 MPa. Compared with the polymer flooding stage, the injection pressure is stable, and the fracture pressure is 1.7 MPa, which still maintains a high injection capacity.

The water absorption index is stable. After the injection, the average single well injection strength is 3.2 m$^3$/d.m, and the single well still maintains a strong injection capacity. The thickness of the sandstone is 0.26 m, MPa, which is 30.5% lower than that of the water flooding stage, and it has little change compared with the polymer flooding stage.

3.2. Different sand bodies are still used at a higher level
First, the underwater sand channel sand body is used well. The thickness of this type of sand body is 15.8 m, accounting for 8.7% of the total oil layer thickness. The oil layer is used well in the extended injection stage, and the proportion is over 90% (Fig. 1).

Second, the proportion of the main body sands used decreased. The thickness of this type of sand body is 65.8 m, which accounts for 36.2% of the total oil layer thickness. The proportion of the oil layer used in the extended injection stage decreases slightly (Fig. 2).

![Figure 1. River sand use condition map (6 consecutive).](image1)

![Figure 2. Main body mat sand use condition map (6 consecutive).](image2)
Third, the non-main body mat sand is stable. The thickness of this type of sand body is 55m, which accounts for 30.2% of the total oil layer thickness. The oil layer is stable during the prolonged injection phase (Fig. 3).

Fourth, the off-balance sheet reservoir is still in effect, but the proportion of use is decreasing. The thickness of this type of sand body is 45.3m, accounting for 24.9% of the total oil layer thickness, and the proportion of oil layer utilization in the extended injection phase is decreased (Fig. 4).

Figure 3. Non-main body mat sand use condition map (6 consecutive).

Figure 4. Independent off-state usage status map (6 consecutive).

3.3. Water content remains stable and concentration is still low
After prolonged injection, the water content remained stable, less than 93.2% for up to 14 months, and the current water content was 93.6%, which was 0.7 percentage points higher than that before prolonged injection.

When 0.77 PV was injected into the test area, the concentration of polycondensation was only 305 mg/L, which was not significantly different from that before prolonged injection. The concentration of single well polycondensation is between 132-325mg/L, which is still at a low level. The advancement of the polymer flooding plug front is not broken, indicating that the polymer slug front advances equilibrium (Fig. 5).
3.4. *Different sand bodies take over and delay the water-bearing recovery*

The distribution of sand in the three types of reservoirs is small, so the water content is mainly affected by the mat sand and the off-balance reservoir. The main mat sand is effective in the early and middle stages of the flooding, and the non-main mat sand is effective in the middle of the injection. The outer reservoirs have been effective before and after prolonged injection, and several types of sand bodies have succeeded in extending the low water cut period of the test area [1].

First, the initial application of river sand injection is effective. After the sand body is injected, the leading edge of the polymer advances rapidly, and it is effective at the initial stage of injection and the water content decreases greatly. After the formation of the inertial channel, the water content rises rapidly. Because the test area develops less channel sand, the effect on water content is not obvious.

Second, the main body sand is effective in the early stage of injection and near mid-term. Most of these sand bodies are connected in one type. When the concentration of 0.19 PV is increased, the water content is reduced to the lowest point. Because the main part of the test area is developed, it is the main influencing factor for maintaining the low water cut period of the test area after the injection. The water is rising in the late stage of polymer flooding (Fig. 6).

Third, the non-main body mat sand reaches the best effective period in the middle of the injection, and the recovery is slow after the injection. The non-main body mat sand in the test area is mostly connected, and the lowest point is reached when 0.3PV is injected. The decrease in the initial stage of prolonged injection and the later rise is the main factor for maintaining the stability of water content in the test area at the initial stage of injection (Fig. 7).
The water content of the non-main body mat sand fluctuated during the process of injection, and the profile data showed that the profile transfer occurred, which showed that the concentration of the polycondensation showed a fluctuating change after prolonged injection. In the L9-P1902 well, the non-absorbent layer GII7-8, GII9-10, and GII15-17 were used in the early stage of prolonged injection. The concentration of polycondensation decreased from 234mg/L to 190mg/L, and the GII7 was extended after 12 months. The utilization ratio of GII9-10 decreased, and the concentration of polycondensation increased from 234mg/L to 398mg/L [2].

The fourth is that the water-stable stability period is longer after the injection of the extra-surface reservoir, and it is still in the effective period after prolonged injection, and no obvious recovery is observed. The extra-soil reservoirs in the test area are mostly connected. The new layer is effective in the late stage of injection and the prolonged injection, and the water content is stable, which is the main factor for prolonging the water-bearing recovery in the injection phase (Fig. 8).

![Figure 8](image_url)

**Figure 8.** Annual water cut curve of non-main body sand in test area.

Some of the single wells dominated by the off-balance reservoirs still have new layers, which are characterized by a decrease or slowdown in the concentration of polycondensation after prolonged injection. After the L8-P1832 well was extended, the GII4-6 layer of the extra-surface reservoir was added. The new thickness was 2.1m, and the concentration of the poly-concentration decreased from 553mg/L to 444mg/L, which was decreased by 109mg/L.

3.5. **Scheme adjustment can improve the effect of prolonging the injection**

The test area is combined with the oil saturation distribution to control the single-layer rush and balance the small-layer mobilization principle. The comprehensive adjustment of 26 wells is carried out to control the water-bearing recovery and ensure the balanced mining of the reservoir.

Firstly, combined with the remaining oil distribution to match the injection and production parameters.

For the well group with obvious water-recovery and well-connected wells, the molecular weight of the two injection wells was increased, and the molecular weight was raised from 9.5 million to 12 million. After the long-term injection in the main line of the old well network, the water-recovering well was up-regulated and the main liquid supply direction was injected into the well. Concentration; for the decrease of liquid production, the wells of the long well group with low water stability are adjusted to 8 wells, and the ratio is adjusted from 230m³/d to 295m³/d. After adjustment, the daily liquid addition was 9.0t, the daily oil increase was 0.9t, and the water content decreased by 1.5%.

Secondly, the equilibrium pressure system is adjusted to ensure balanced production of oil layers.

The injection zone and concentration of the well group with high injection pressure and low oil saturation are adjusted. Among them, 4 wells were down-regulated, and the average injection pressure decreased by 0.4 MPa after adjustment. The concentration of the injection concentration was lowered 4 times, the concentration was adjusted from 1100 mg/L to 900 mg/L, and the average injection pressure was decreased by 0.3 MPa after the adjustment.
3.6. **Extended injection can increase oil recovery by 1.8 percentage points**

It is estimated that 13 years of follow-up water flooding to 1.1PV can increase oil recovery by 10.1 percentage points. It is expected that the extension of injection to the end of 14th will increase oil recovery by 11.9 percentage points and the recovery rate is 56.7%. Increased oil recovery by 1.8 percentage points, accumulatively increased oil by 7146t.

The economic benefits are high. Through the calculation of the actual input-output ratio in the extended injection phase, the investment is 6.66 million yuan, and the oil increase is 5096t. According to the crude oil unit price of 0.5 million yuan/t and 0.3 million yuan/t, the input-output ratio is 1:3.8 and 1:2.3

4. **Conclusion**

(1). The three types of oil layers still have strong injection-production capacity after prolonged injection;

(2). The replacement of different sand bodies in the three types of oil layers has effectively delayed the water-bearing recovery;

(3). Prolonged injection to increase the recovery range and good economic benefits;

(4). The current water and polycondensation concentration in the test area is still low, and it is recommended to extend the injection to 1.0 PV.

**References**

[1] Zhang Xiaoqin. Ways to Improve the Development Effect of Polymer Flooding in the Second Kind of Oil Layer. Daqing Petroleum Geology and Development, (24 April 2005) pp. 81-83.

[2] Lu Xianliang. Relationship between polymer flooding solution and water control, (9 March 2002) pp. 24-26.

[3] Liang Yujie. Oil reservoir sedimentary characteristics research on 1~3 layer of Portuguese I reservoir group in the one-two area of Xingshugang oilfield eastern part in Daqing [D]. Jilin university, 2013.

[4] Zhou Yujia. Recombination of Poor and Thin Strata in Region Xing1 and Evalution of Development Effect [J]. Journal of Yangtze University, 2014, 11(13): 112-114+6.