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Research Article

Optimization of Reasonable Well Spacing for Polymer Flooding and Its Adaptability Analysis

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Abstract: After many years of water flooding, Pu I 2-3 reservoirs has been in the stage of extra-high water cut, by 2016, comprehensive water cut in the study area is 92.5%.Based on watered-out log interpretation results and sealed coring data, application of numerical The remaining oil distribution law was studied by numerical simulation method, The results show that the comprehensive recovery degree of the study area is 43.02%, and the residual oil is mainly distributed in the channel sand, which still has the potential of polymer flooding. Through the field test data analysis and laboratory experiments show that the injection of the earlier opportunity, the more favorable and enhanced oil recovery. Finally, on the basis of geological modeling and numerical simulation, the study of well pattern adaptability is carried out and the reasonable injection-production well spacing is determined.

Keywords: Extra-high water cut; Remainling oil distribution; Reservoir numerical simulation; Well pattern adaptability.

INTRODUCTION

The comprehensive recovery of the study area was 43.02% and the water content was 92.5%. Due to the heterogeneity of reservoirs and the difference of oil and water properties, it is more and more difficult to rely on conventional methods. At present, the chemical flooding is the main tapping measures in the late stage of high water cut, and the polymer flood is an important part of chemical flooding. Polymer flooding can effectively add water viscosity, reduce the water phase permeability, improve the displacement phase and the displacement phase ratio, expand the volume and improve the efficiency of washing [1]. How to optimize the flooding distance and the injection timing of the polymer so as to adapt it to the cement Pu I 2-3 and improve the utilization level of the reservoir, and obtain the better development effect and economic value, which is needed in the development of the research area The problem [2-6].

OIL USE SITUATION

Overview of work area

The test area is located in the western part of the Xing 76 block, which is low in the east and west. The eastern part is flat and the west is blocked by a northwest and westward fault, and the western structure is steep. In the study area, there are three normal faults, with the development of the five-point well pattern with the distance of 250m, the row distance of 125m and the injection well spacing of 175m. The area of the work area is 1.92Km^2 and the geological reserves is 242.10 × 10^4 tons.

Analysis of submerged conditions

From the flooding situation, the effective thickness of the reservoir is more than 2.0m in the study area,and the oil layer is mainly in the middle and low flooding. The flooding ratio between 1.0 ~ 2.0m is about 81.6%.The effective thickness of the reservoir between 0.5 ~ 1.0m is mainly in the middle and low flooding. The flood layer of the thinnest layer with the effective thickness less than 0.5m is low, which is 66.6%, and the oil layer is mainly in the middle and low flooding. From the flooding situation analysis, Pu I 2,3 layer of thick oil use is very good, further water flooding is difficult.

Analysis of water wash

It can be seen from the core water washing data of the closed coring inspection wells that the ratio of the thickness of the water layer of the Pu I 2 layer is 80.8%, and the ratio of the water washing thickness of the Pu I 3 layer is 66.0%. From the vertical point of view, the top of the internal rhythm of the section is not washed, the lower part of the strong water washing, the entire deposition unit showing a different intensity of washing and non-washing section of alternating distribution, there is a certain remaining oil potential.

As of 2016, the comprehensive recovery of the study area was 43.02% and the water content was 92.5%. The numerical simulation results show that the remaining oil in the Pu 2,3 layer, which is mainly distributed in the channel sand, accounting for 67.4% of the total remaining reserves of the two layers. Water flooding is more difficult, plans to carry out polymer flooding on Pu I2,3.

PREFERABLY THE INJECTION TIME

The time of the polymer injection means that the maximum concentration of the polymer can be achieved when the average moisture content of the oil field is reached. It is generally believed that the final result of polymer flooding has nothing to do with the injection timing. Polymer flooding is a way to improve water flooding. It only serves to shorten the development life.

However, the results of the field test showed that the injection timing of the polymer had a significant effect on the increase of the recovery rate.Through the statistical analysis of the data of several foreign mines,the relationship between the oil increment and the water / oil ratio of the polymer is plotted, as shown in Fig. 1.As can be seen from the Fig., the earlier the timing of the injection of the polymer, the lower the water / oil ratio of the reservoir, the greater the polymer increase (the higher the polymer utilization).

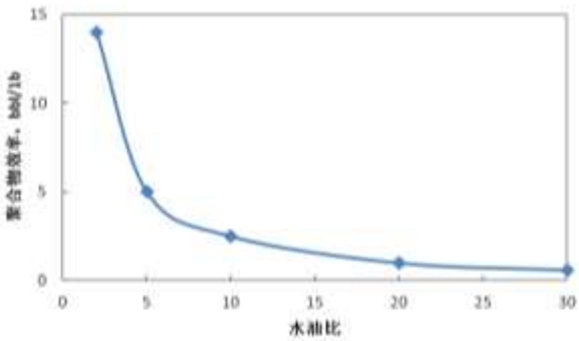

Fig-1: Water-oil ratio and the relationship between polymer fuel flow curve

REASONABLE WELL SPACING PREFERRED

Degree of control of polymer flooding in different injection wells

In the process of oilfield development, the basic principle of well pattern design is to adapt to the maximum distribution of sand bodies in order to achieve the best development effect. In general, the adaptability of the well pattern is evaluated by the degree of well pattern control. The degree of waterflooding control is the ratio of the effective thickness of the oil well connected to the injection well and the total effective thickness of the well in the well [7]. However, it takes into account the drilling thickness of the reservoir. For the polymer solution, it is difficult to enter some of the smaller pores in the reservoir due to its larger volume, which is equivalent to the reduction of the effective pore volume. Therefore, in the calculation of the degree of control of the polymer flooding network, the pore volume of the oil layer which can be entered by the polymer solution under the relative molecular weight of the polymer is counted as the percentage of the total pore volume of the reservoir [8].

The formula for the degree of flood control is:

$$\eta_P = \left(\frac{V_P}{V_T}\right) \times 100\% \quad (1)$$

V_P is calculated from the following formula:

$$V_P = \sum_{j=1}^{m} [\sum_{i=1}^{n} S_{pij} \cdot H_{Pij} \cdot \emptyset_{Pij} \quad (2)$$

Formula:

V_P —The polymer solution can enter the pore volume of the reservoir, m^3;

V_T —The total pore volume of the block, m^3;

S_{Pij} —The control area of the flywheel network in the i - th well of the j - th reservoir, m^2;

H_{Pij}—The thickness of the interpenetration of the injection solution between the polymer solution of the i-th well in the jth oil reservoir, m;

$\emptyset_{Pij}$—The intergranular porosity of the polymer solution in the i-th well group in the jth oil reservoir can be obtained。

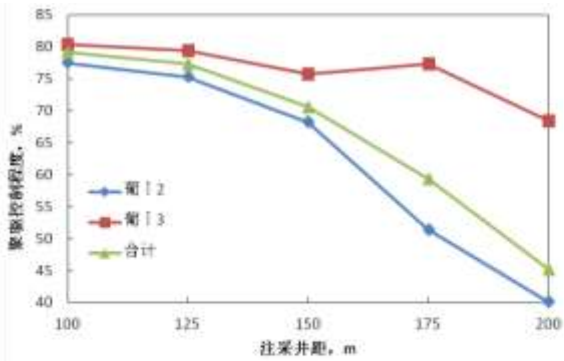

Fig-2: Different injection and production wells away from the degree of polymerization control

According to the above formula, the degree of flood control control is calculated and calculated, as shown in Fig. 2.It can be seen from the Fig. that with the increase of injection and production well distance, the control degree is obviously reduced. When the injection and production distance is greater than 150m, the degree of control decreases; 100m injection and production distance than the 125 meters control degree increased by only 1.8%. In order to control the degree of flood control more than 70%, injection and production wells should be less than 150m.

The relationship between injection rate and injection pressure in different injection wells

The determination of the distance between polymer flooding and production is a complex problem, which is not only limited by the well pattern, but also by the combined effect of polymer solution injection capacity, liquid extraction capacity, injection rate and reservoir permeability. It is important to explore a reasonable injection and production well distance because it directly determines the injection cycle, the effective time and the rate of increase in the recovery of the polymer solution.

According to the characteristics of the experimental plot of the flooding test block in the Daqing Oilfield, the water absorption index of the oil-bearing area in the pure oil area of the study area can be reduced to 0.308m^3 / mMPa, The average burst pressure is 13.8 MPa.

The injection speed formula is:

$$p_{\max} = \frac{L^2 \phi}{180 N_{\min}} \cdot v \qquad (3)$$

Formula：

v —Injection speed，PV/a；

ϕ —Reservoir porosity，%；

L —Injection and production distance，m；

$N_{\min}$ —Minimum water absorption index，$m^3/d \cdot mMPa$；

$p_{\max}$ —Highest wellhead injection pressure，MPa。

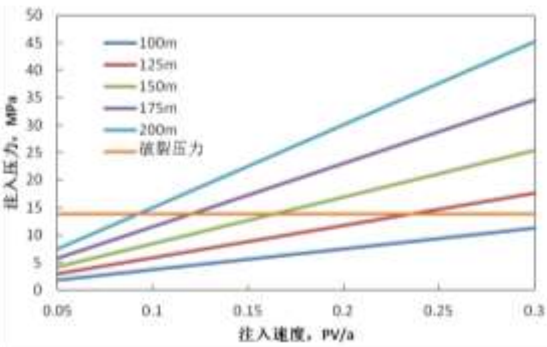

Fig-3: The relationship between the injection rate and the injection pressure in different injection wells

According to the above formula, the maximum well injection pressure under different injection well and different injection speed is calculated, as shown in Fig.3. It can be seen from the Fig. that with the increase of the well distance, the injection pressure increases, the greater the injection rate, the greater the injection pressure rise, the 125m, 150m, 175m under the premise that the well injection pressure does not exceed 13.8MPa, 200m injection and production wells, the injection rate were 0.225PV / a, 0.165PV / a, 0.120PV / a, 0.082PV / a.

Considering the influence of polymer flooding degree, injection period, reservoir capacity and existing well pattern, the development index of 125m-175m injection well is forecasted.

DEVELOPMENT INDICATOR FORECAST AND ECONOMIC EVALUATION

Based on the five - point well pattern of 125m, 150m and 175m, the numerical simulation method is used to predict the development index of Pu I2-3 reservoir. Comparison of the water content of different injection and production wells, the cumulative amount of oil compared to Fig. 4, Fig. 5. The results of the forecast and economic evaluation of different injection and production wells are shown in Table 1 and Table 2.

It can be seen from Fig. 5 that the decrease rate of water content increases and the effective time increases with the decrease of mining distance (the degree of control increases), and the minimum moisture content is 125.56% , And the minimum moisture content of 175m injection and production is 1.46% and 3.47% respectively, and the time required to reach the minimum water content decreases with the increase of injection well distance. This is mainly due to the increase in the degree of flood control control is often part of the low permeability of the reservoir, and this part of the reservoir in the early water flooding process of low degree of recovery, with the polymer solution into the low water content Stage of the low permeability of the reservoir to play a role in the process of polymer flooding caused by a decrease in water [9-12].

From Table 1 and Table 2, it can be seen that the mining degree of 125m and 150m is increased by 3.2% and 1.78, respectively, and the total number of wells is increased by 110% and 57.3% respectively. Therefore, in the study area, with the increase of the degree of flood control, the stage of recovery increased, but the internal rate of return and net present value is a decreasing trend. Taking into account the development of indicators and economic benefits, that the use of 175m injection and production wells more appropriate.

Table 1: Prediction of development indicators for different injection wells

Injection and production distance	Note the amount of polymer	Stage of development	Improve oil recovery	Polymer oil content	Accumulated oil
（m）	(mg/L·PV)	（%）	（%）		（104t）
125	1200	13.27	11.43	74.54	32.13
150	1200	11.85	9.79	67.87	28.69
175	1200	10.07	8.72	61.41	24.38

Table 2: Economic results of different injection and production wells

Injection and production distance	Internal Rate of Return	Tired oil	Investment profit ratio	Net present value
m	%	10^4t		ten thousand yuan
125	23.2	32.13	0.18	2217
150	26.4	26.69	0.176	2406
175	28.9	24.38	0.186	2853

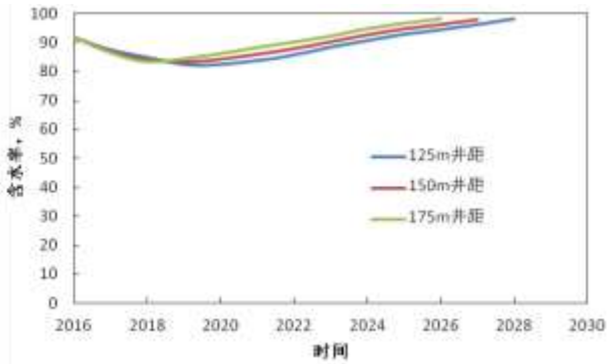

Fig-4: Comparison of water content in different injection wells

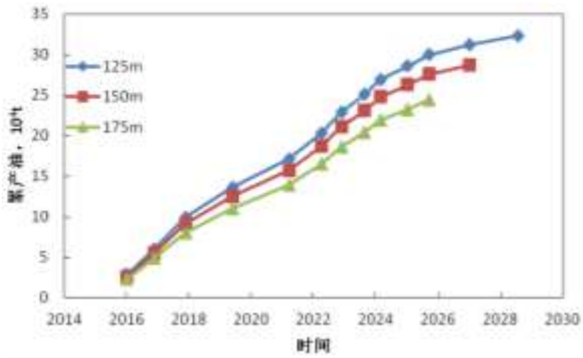

Fig-5: Comparison of the cumulative oil production under different injection wells

CONCLUSION

(1) The comprehensive recovery rate of the reservoir Ⅰ 2 and 3 is 43.02% and the water content is 92.5%. The remaining oil is mainly distributed in the channel sand, and still has a large potential for polymer flooding.

(2) Through the field test data analysis and laboratory experiments show that the timing of injection, the more favorable and improve the recovery rate.

(3) Through the development of forecast and economic evaluation, it is considered that 175m injection and production well spacing is suitable, the recovery rate is 8.72% and the net present value is 28.53 million yuan.

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