Adaptive study on polymer flooding of secondary reservoir and infilling uniform

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Abstract: For the main polymer flooding oilfield expansion and infill wells three times the area of deployment, the proposed development mode II oil reservoir of polymer flooding and thin and poor combination of three encryption. In this paper, the use of leading edge water monitoring methods and principles of the plane heterogeneity through physical simulation to study the effects of different mining methods II oil and a combination of the three encryption effects of flooding. Studies have shown that, together with the water flooding recovery can be increased by nearly 19 percent, higher than the water poly alternate drive about 4%, the injection pressure is about three types of reservoir 0.3MPa, flat stage water flood sweep efficiency compared with an average of 30.95%. Meanwhile polymer injection can increase oil recovery by 21%, but the limited ability of three types of oil injection, polymer injection pressure during injection 0.22PV up to 0.8MPa, water flooding stage by an average of 30 percent compared to the plane sweep efficiency. The water flooding recovery poly alternately raise only 15%, an average increase of 26.95 percent driven phase plane sweep efficiency than water. Theoretical results of this study may provide a reliable basis for the future development of efficient thin and poor reservoirs.

1 Introduction

During the “Eighth-Five-Year Plan” and “Ninth-Five-Year Plan”, the polymer flooding technologies have undergone scientific and technological breakthroughs in major oil fields, especially in Daqing Oilfield, and have achieved long-term development. The main oil reservoir has achieved significant effects of increasing oil and reducing water cut, which have been becoming popular in oil fields for high-efficiency development. With the reduction of the potential for polymer flooding in major reservoirs, the industrialized polymer flooding of secondary oil reservoirs has been successively put into production[1-4]. Compared with the main oil reservoirs, the geological conditions of the secondary oil reservoirs are significantly worse[3, 4]. According to the previous research results of polymer flooding technology for secondary oil reservoirs, the polymer flooding of secondary oil reservoirs needs to limit the target, and the lower limit of polymer flooding technology of thickness is 1m and permeability is $100 \times 10^{-3} \mu\text{m}^2$ for secondary oil reservoirs, but the lower limit of water flooding technology of thickness is less than 1m and permeability is less than $100 \times 10^{-3} \mu\text{m}^2$ for poor oil reservoirs[5, 6]. In those units, many problems have been interference each other, but the research of this interference is very less on the adaptability of the secondary and third oil reservoirs. In this paper, basis on the geological characteristics of an oil field, we research the confederative development of the secondary and third oil reservoirs.

2 simulation experiments

2.1 physical model and oil front test method

According to the actual situation, the schematic diagram of the large-scale plane heterogeneity simulation physical model chosen is shown in Figure 1. The model is $60 \times 60 \times 1.5\text{cm}$, and the plane is heterogeneously distributed. The permeability of secondary reservoir is $700 \times 10^{-3} \mu\text{m}^2$ and of infilling uniform is $200 \times 10^{-3} \mu\text{m}^2$ (Δ is injection well, W is water well and P is polymer well; $\bigcirc$ is production well).

The micro-electrode measurement (Figure 1) was used to determine the change in resistivity at each point, and related software was used to determine the distribution of oil and water in each layer at different times to obtain the oil-water front in the displacement process.

Figure 1 Model of simulation plane heterogeneity

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2.2 Experimental Procedure

The water flooding is first performed after the establishment of original state, until the comprehensive water cut reaches 90-93%, and then the flooding experiments are carried out according to the following scheme:

(1) Water and polymer same flooding is carried out (the PV in secondary and third oil reservoirs is about 0.57): Both water well and polymer well are opened, and water and polymer are injected at the same time, and the polymer of 0.57PV (molecular weight is about 1200-1600 $\times 10^6$, concentration is 1000 mg/L, the same below) is injected. The real-time monitoring technology of oil-water front was used to determine the variation law of water, polymer flooding coefficient, injection pressure and recovery;

(2) Water and polymer alternating flooding is carried out (many plugs of water and polymer alternately injection): first open the polymer well and inject polymer 0.30 PV, then close polymer well and open water well, inject water 0.30 PV, last close water well and open polymer well inject 0.27PV, at the same time, open water well and close polymer well, the water cut under the water flooding is more than 98%, carrying out polymer flooding and water flooding alternate experiments;

(3) Simultaneous polymer injection (simultaneous injection of 0.57 PV): The secondary oil reservoirs and third infilling well are simultaneously opened for injection polymer. After the amount of polymer injection in secondary oil reservoirs reached 0.57 PV, polymer well will be changed water well. After the water cut is more than 98%, all the wells are closed.

3 experimental results and analysis

3.1 Analysis

The dynamic curves of water cut and recovery in different schemes are shown in Fig. 2. Under the conditions of water cut 93% in water flooding, the water and polymer flooding can increase the ultimate recovery 18.918%, which is nearly 4 percentage points higher than that of the water flooding. If infilling wells are also injected at the same time, although the permeability of third oil reservoir is low, the amount of injected polymer is limited. The last recovery is very good, under the solution of polymer is final. The biggest drop in water cut is about 64.379%, and the recovery can improve 21.139%.

This is mainly due to the fact that: Compared with the same flooding scheme, the water and polymer flooding has a small mutual interference in the pressure field and flow field, but because the permeability of secondary reservoir is higher than third reservoir, the first polymer plug is injected and the water well is opened, the injection water enters the secondary reservoir along the split line, thus diluting the original polymer solution, resulting in the second polymer plug (0.27 PV).) and follow-up water flooding stage premature breakthrough (Figure 2);

Figure 2 Dynamic curve of different simulation flooding experiments

on the other hand, due to the difference in permeability and pressure conduction capacity, at the end of the first water flooding, the remaining oil of the third reservoirs is relatively more than the secondary reservoirs, and the pressure of the junction zone is lower (Figure 3),

Figure 3 Pressure changes of the junction of secondary and third reservoirs

so that the turbulence of the injected water will inevitably affect the effective startup of the third reservoir where the remaining oil saturation is already high. This reason can also be further understood and explained by the changing rules of the oil-water front and the sweep coefficient. Of course, the large-scale physical model also only reflects the heterogeneity in the reservoir plane. With the differences in oil layer thickness and layer heterogeneity, this change in the flow field and pressure field during the displacement process will be even complex.

It is shown that the changes in injection pressure for polymer flooding and water flooding in the secondary reservoir and third reservoir in Figure 4.

Figure 4 Pressure curves under different displacements of secondary and third reservoirs

The pressure exceeds 0.8 MPa only in a limited injection volume (0.22 PV) during the injecting polymer in third reservoir, and basically a linear increase, therefore, while the simultaneous injecting polymer can achieve the best oil displacement (oil recovery 21.139%), but consider the low permeability layer of the ability to inject, consider the secondary reservoir and third reservoir at the same time polymer should not be selected.

3.2 front and sweep coefficient of oil and water

The law of water front distribution under the water and polymer flooding is shown in **Figure 5**. At the end of water flooding, the sweep coefficient of secondary reservoir is 0.621, and the sweep coefficient of the third reservoir is 0.272; with the increase of the injection amount, the sweep coefficient increases to the water level. At the end of the water and polymer flooding, the sweep coefficient of the third reservoir reached 0.890, and the third reservoir reached 0.622. The final recovery level was 58.641%.

the sweep coefficient of secondary reservoir: 0.621 the sweep coefficient of secondary reservoir: 0.778 the sweep coefficient of secondary reservoir: 0.890 the sweep coefficient of the third reservoir: 0.272 the sweep coefficient of the third reservoir: 0.523 the sweep coefficient of the third reservoir: 0.622

Figure 5 Distribution of oil-water front in water and polymer same flooding

The law of water front distribution under the water and polymer flooding is shown in Figure 5. The results of the swept coefficient of the Water and polymer alternating flooding showed that the sweep coefficient of the secondary reservoir at the end of the water flooding is 0.623, and the sweep coefficient of the third reservoir is 0.275.

the sweep coefficient of secondary reservoir: 0.623 the sweep coefficient of secondary reservoir: 0.765 the sweep coefficient of secondary reservoir: 0.842 the sweep coefficient of the third reservoir: 0.275 the sweep coefficient of the third reservoir: 0.517 the sweep coefficient of the third reservoir: 0.595

Figure 6 Distribution of oil-water front in water and polymer alternating flooding

At the end of the water and polymer alternating flooding, the sweep coefficient of the secondary reservoir is 0.842 and the coefficient of the third reservoir is 0.595. The final recovery is 55.034% (Figure 6).

At the same time, the results of the sweep coefficient of the injection scheme show that the sweep coefficient of the secondary reservoir at the end of the water flooding is 0.622, and the sweep coefficient of the third reservoir is 0.273; at the end of the polymer flooding, the sweep coefficient of the secondary reservoir reaches 0.875, and the third reservoir reaches 0.620. The degree of recovery is 61.120% (Figure 7).

the sweep coefficient of secondary reservoir: 0.622 the sweep coefficient of secondary reservoir: 0.773 the sweep coefficient of secondary reservoir: 0.875 the sweep coefficient of the third reservoir: 0.273 the sweep coefficient of the third reservoir: 0.529 the sweep coefficient of the third reservoir: 0.620

Figure 7 Distribution of oil-water front in simultaneous polymer injection

4 conclusions

(1) Under the conditions of water flooding to a total water cut of about 93% for the secondary reservoir and third reservoir, the water and polymer same flooding can further increase the recovery rate by 18.918%. However, the water and polymer alternating flooding due to the split line, which can cause premature breakthrough of the polymer solution and result in deterioration of the oil displacement, only about 4 percentage points for the low water and polymer same flooding.

(2) The pressure changes at the boundary of secondary reservoir and third reservoir during the displacement process are the main factors affecting the effective start-up of the low-permeability third reservoir. At the same time, the pressure of the center well is the highest at the time of simultaneous polymer injection.

(3) Although the sweep coefficients of water and polymer same flooding in secondary reservoir and third reservoir are large, the profile control is significant, and the final recovery is 61.120%, the low-permeability third reservoir has high injection pressure, the injection volume is limited, and there is a problem injection capability.

(4) The sweep coefficients of water and polymer same flooding in secondary reservoir and third reservoir are relatively large (0.890 and 0.622), followed by the simultaneous polymer injection (0.875 and 0.620), while the water and polymer alternating flooding is the smallest (0.842 and 0.595).

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