Development effect evaluation of medium permeability oil fields in the western Daqing

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Abstract. Longhupao oilfield is a large medium permeability oilfield with the earliest development and the largest area in the western periphery of Daqing. It belongs to a reservoir controlled by lithology and structure. After decades of water injection development, it has entered the development stage of ultra-high water cut stage. The remaining oil is highly dispersed and it is more and more difficult to tap the potential. In order to make the later development adjustment more targeted, it is necessary to evaluate the development effect of the oilfield. Therefore, starting from the field data of the oilfield, this paper comprehensively uses mathematical formula calculation and reservoir engineering methods to evaluate various indexes such as water drive recovery rate, water injection utilization rate, oil production rate, liquid production rate and comprehensive water cut in the current development stage of Longhupao oilfield, The experience of each stage is summarized to provide reference for the formulation of development adjustment strategy in ultra-high water cut period.

Keyword: Medium permeability; Development effect; Water drive recovery factor; Water injection utilization

1. Introduction

There are various types of Invested reservoirs in the western periphery of Daqing, but most of them are developed by water injection. The quality of water injection results not only directly affects the oilfield development effect, but also directly affects the growth rate of oilfield production and the development adjustment and tapping potential in the later stage. Therefore, timely and effective evaluation of reservoir development effect is very necessary, which is related to the final effect of oilfield development and economic benefits. The ultimate goal of oilfield development is to improve oil recovery. The primary purpose of evaluating oilfield development effect is to adjust the development strategy in time by evaluating the current development effect. Based on the field data, this paper comprehensively uses mathematical formula calculation and reservoir engineering methods to evaluate various indexes (water drive recovery rate, oil production rate, liquid production rate, comprehensive water cut, water drive index, water consumption index, etc.) in the current development stage of Longhupao oilfield.

2. The block overview

In 2004, the infill adjustment between oil well row and oil well row was implemented in the anti nine point method well area north of row 37. A total of 25 infill wells were drilled to improve the recovery rate. In the high water cut stage, the field test of polymer deep profile control was carried out, which laid a foundation for EOR. By the end of 2012, there were 224 oil wells, with a daily liquid production of 1702t, a daily oil production of 152t, a comprehensive water cut of 91.05%, an average daily oil production of 0.9t per well, a production rate of 0.43%, and a cumulative oil production of 480.0027 × 104t, recovery rate 36.47%. There are 157 water injection wells, the annual injection production ratio is 1.74, and the cumulative water injection is 2716.60 × 104m3, cumulative injection production ratio 1.61.

3. Development effect evaluation

3.1 Water drive recovery evaluation

The application of water drive curve can describe and predict the water cut change, oil production, final recovery and recoverable reserves in the production process. According to the specific situation of Longhupao oilfield, eight methods are used to calculate the final water

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drive recovery, such as type A, type B, type C, the relationship between water oil ratio and cumulative oil production, the relationship between water cut and cumulative oil production, the relationship between exponential production decline and dimensionless injection production curve. The evaluation criteria are shown in Table 1.

Table 1 Evaluation criteria for final recovery

comment	very good	good	secondary	Poor	bad
recovery ratio /%	>55	45 ~ 55	35 ~ 45	25 ~ 35	<25

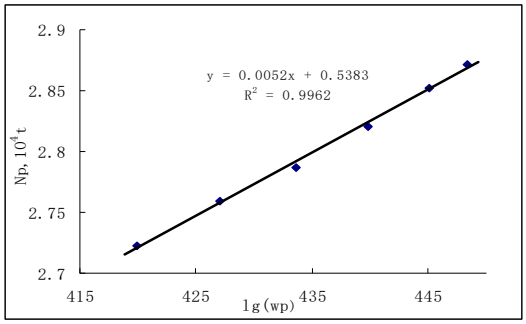

Figure 1. Type a water drive law curve

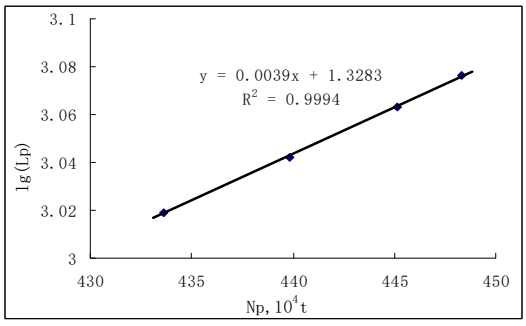

Figure 2. B water drive law curve

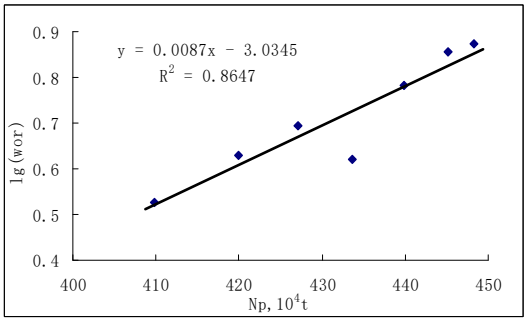

Figure 3. Relationship curve between water oil ratio and cumulative oil production

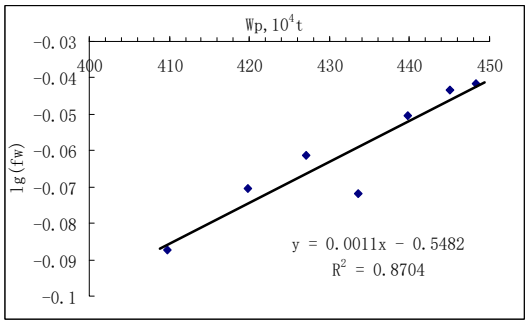

Figure 4. Relationship curve between water content and cumulative oil production

Table 2. The maximum cumulative oil production and final oil recovery calculated by the eight methods are

computing method	Maximum cumulative output / 10000 tons	Final recovery rate /%
first a water drive law	591.09	44.92
B water drive law	619.84	47.11
Water oil ratio and cumulative oil production formula	543.07	41.27
Water content and cumulative oil production law	506.34	38.48

It can be seen from table 2 that the difference between the prediction results of several methods is not great. Therefore, the maximum cumulative oil production of Longhupao oilfield is 565.09 × 104t, the final recovery is 42.95%, and the effect of oilfield water drive development is at the medium level.

3.2 Evaluation of water injection utilization rate

Water drive index

Water drive index refers to the ratio of underground water storage of injected water to underground volume of accumulated oil production. It can directly reflect the utilization rate of water injection and judge the effect of various measures taken by the oilfield. Figure 5 shows the relationship curve between water drive index and recovery degree in Longhupao oilfield.From the curve change, before the recovery degree reaches 25%, the water drive index increases rapidly and steadily, and the water drive effect is good. When the recovery degree is between 25% ~ 27%, the water drive index increases rapidly, indicating that the area is in the process of further improving the water drive effect, but after the recovery degree reaches 28%, the water drive index remains basically unchanged, indicating that the effect of water drive measures is stable.The curve fluctuates and rises on the whole, and there is no decline, indicating that the water drive effect of Longhupao oilfield is generally good.

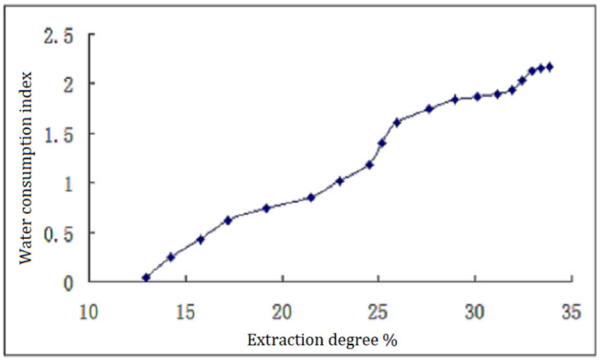

Figure 5. Relationship curve between water drive index and recovery degree

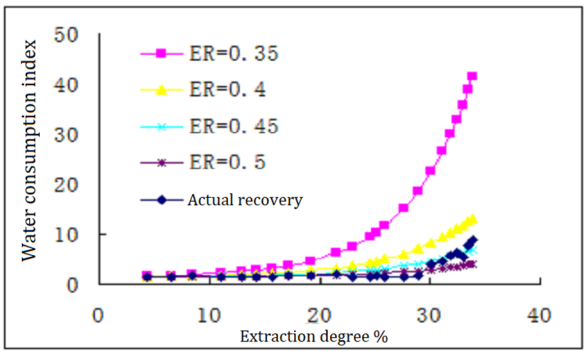

Figure 6. Relationship between water consumption index and recovery degree

3.2.1 Water consumption index

The water injection utilization rate of water injection development oilfield directly affects the water drive development effect, and the water consumption rate is one of the important indexes to evaluate the water injection utilization rate of oilfield. The water consumption index is the ratio of water consumption rate to injection production ratio. Calculate the annual water consumption index of Longhupao oilfield, and make the theoretical chart and actual curve of water consumption index and recovery degree, as shown in Figure 6. It can be seen from the relationship between the start of water recovery index and the final recovery index is 45%, which is consistent with the theoretical recovery index curve. At the initial stage of development, due to sufficient natural energy and edge water energy and small water injection, the water consumption index is small. However, after 2002, the rise of water consumption index accelerated, and the water consumption index rose sharply in the later stage of development. At the same time, from the overall trend of the curve, the more the water consumption index deviates from the recovery degree axis, indicating that the lower the water injection utilization rate, the worse the water drive development effect and the lower the final recovery rate.

3.3 Evaluation of oil production rate and liquid production rate

According to the production performance data of the oilfield, the relationship curves of oil production rate, liquid production rate and recovery degree are drawn, as shown in Figure 7. It can be seen that the exploitation time of natural energy exploitation stage is very short. Although the formation energy is sufficient, due to the small scale of well pattern, the oil production rate, liquid production rate and recovery degree increase slowly. In the stage of water injection development, after several adjustments of injection production well pattern, the oil production and liquid production speed showed wave oscillation without significant rise and fall, indicating that the water drive effect is good. However, after entering the high water cut period, the oil production rate decreases significantly. Corresponding measures must be taken to control the water cut and stabilize the oil production.

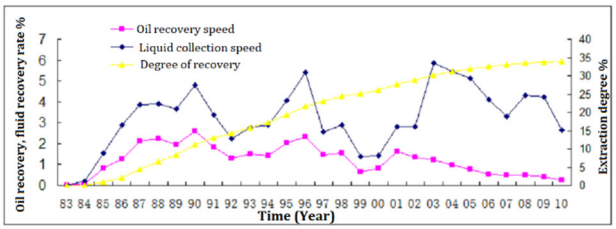

Figure 7. Relation curve of oil production rate, liquid production rate and recovery degree

3.4 Evaluation of immediate water cut recovery ratio

Real time water cut recovery ratio is a very effective characteristic parameter to evaluate the development effect of water drive. It refers to the comprehensive water cut at any time divided by the corresponding recovery degree. The real-time water cut recovery ratio is used to evaluate the water drive development effect of the oilfield, which is usually divided into five levels (Table 3).

Table 3. Evaluation grade of development effect of Longhupao water drive

classification	Immediate water cut recovery ratio	Development effect evaluation
1	<1	best
2	1 ~ 3	good
3	3 ~ 5	medium
4	5 ~ 7	bad
5	>7	Very bad

Figure 8 is the relationship curve between immediate water cut recovery ratio and recovery degree of Longhupao oilfield. It can be seen from the curve that when the recovery degree does not reach 8%, the immediate water cut recovery ratio is greater than 5, indicating that the water drive development effect of this block is not good.With the increase of recovery degree, the immediate water cut recovery ratio decreases, and the water drive development effect gradually becomes better. Subsequently, a series of oil stabilization and water

control measures were taken to reduce the immediate water cut recovery ratio. On the whole, the water drive development effect in this area is OK, but it rises in the later stage.

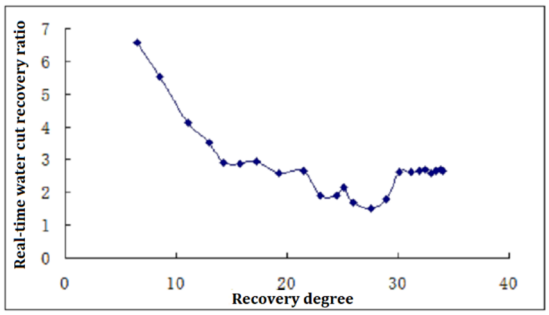

Figure 8. Relationship curve between real-time water cut recovery ratio and recovery degree

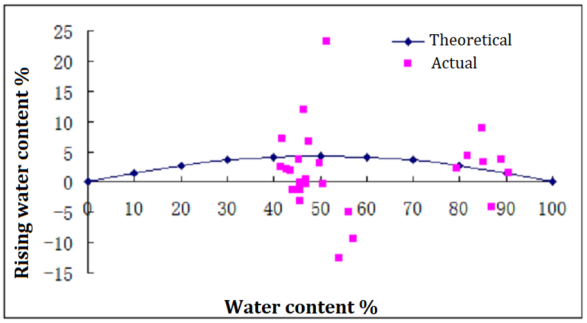

Figure 9. Water content and rising water content curve

3.5 Evaluation of water content rise

It is very important to study and evaluate the variation law of water cut in order to take measures to control the rising rate of water cut in time, which is very important to improve the effect of water injection development. In the actual oil displacement process, the change of water cut in the oilfield is affected by many factors, such as crude oil viscosity, reservoir properties and the control degree of well pattern on the reservoir. The difference is large. Generally, the rising rate of water cut in the oilfield is expressed by the rising rate of water cut. Theoretically, the rising rate of water cut is calculated according to the empirical formula of Tong Zhangzhang. The actual rising rate of water cut refers to the rising value of water cut when 1% of geological reserves are recovered. Figure 9 shows the water cut rise curve of Longhupao oilfield. From the curve, it can be seen that the actual water cut rise fluctuates up and down around the theoretical water cut rise.Due to the relatively large heterogeneity and complex fault structure in this area, the water cut of the corresponding oil well rises rapidly in the initial stage of water breakthrough, but the water cut has not increased significantly after the adjustment of injection and production measures, indicating that the effect of water drive development in this area is good. However, in order to stabilize production, we should study the distribution of remaining oil in the reservoir and take comprehensive water control measures such as blocking, plugging, acid and pumping to control the rise of water cut and slow down the decline of production.

4. Conclusion

(1) The oil recovery of Longhupao oilfield is evaluated by using ksimov Tongzhang curve (type a curve), shazhunov curve (type B curve), water cut and cumulative oil production. The water drive oil recovery of Longhupao oilfield can reach 42.95%, and the water drive development effect belongs to the medium level.
(2) Through the water drive index and water consumption index curve, the water injection utilization rate of Longhupao oilfield is evaluated. The water injection utilization rate of the oilfield is effectively improved in the medium term, and the overall effect of water drive is good. However, in the later stage, the water injection utilization rate decreases, the water consumption index deviates from the recovery degree axis, and the inefficient water injection increases. In the later stage, the subdivision water injection should be increased to improve the water injection utilization rate.
(3) By studying the theoretical curve of comprehensive water cut and recovery degree in the main block of Longhupao oilfield, the development characteristics of Longhupao oilfield are obtained: the oil production period without water and low water cut is short, the recovery degree is low, and the stage water cut rises rapidly.
(4) By studying the comprehensive water cut and water cut rise curve of Longhupao oilfield, the actual water cut rise curve in the later stage of development is above the theoretical water cut rise curve. Compared with theory, the water cut of Longhupao oilfield rises rapidly at present. Water shutoff measures should be taken to control the rise of water cut and achieve high efficiency and stable production.

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