Analysis of waterflooding characteristics of the second class oil layer in the second area of the eastern Labei block

Yang Di
Geological Brigade of the sixth oil production plant of Daqing Oilfield

Abstract. This paper makes use of the new drilling in the second area of the North East block to make statistics of the watered out state of the second type reservoir section, analyzes the watered out state of the reservoir under the conditions of different thickness level, different permeability water saturation level and different sedimentary micro equal level, basically finds out the basic watered out characteristics of the reservoir in the current development stage, and provides the necessary basis for the development and adjustment of the water accumulation and two drive in the next period. Based on the data and the understanding of the regularity, the foundation is laid for the further exploitation of the potential of the water drive in the second type reservoir.

1. Introduction
Oilfield has entered the stage of follow-up water drive. For the current and future development adjustment, the second kind of reservoir is the main material basis. The second area of the Northeast block has experienced several development stages, including primary adjustment, secondary infilling and polymer flooding industrialization, and the degree of oil production has changed greatly. Especially since entering the stage of ultra-high water cut development, the water flooded thickness of the reservoir has gradually increased, and the situation of water flooded is more and more complex. At the same time, due to the single-layer breakthrough of injected water, the invalid injection production cycle is increasingly serious, which affects the development effect of water drive and polymer drive. Therefore, it has become an important basic work to further understand the sedimentary characteristics of class II oil layers, to make clear the water flooded characteristics of class II oil layers, and to master the distribution law of remaining oil, so as to improve the efficient development level of ultra-high water cut stage.

2. Sedimentary characteristics of class II reservoir
There are 16 sandstone groups and 26 sublayers in the second area of the eastern Labei block. The sedimentary model can be subdivided into large meandering channel, low meandering channel and straight channel, which have the characteristics of relatively large single layer thickness, complex sedimentary characteristics and serious heterogeneity, and mainly develop channel sand and inter River thin layer sand body.

3. Analysis of watered out characteristics of the second type reservoir

3.1 Flooding conditions of different thickness grades
Based on the water flooded interpretation results of 208 new wells, the water flooded conditions of different thickness classes of the second class oil layers in the study area are analyzed
comprehensively.

Table 1 Statistical table of sedimentary characteristics of each small layer of class II oil layer in block II of labeidong block

| Sedimentary environment | Depositional model | Layer name |
|-------------------------|------------------|-----------|
| Flood diversion plain   | Large, medium and low curved distributary channels | SII2+3, SIII6+7 |
|                         | Medium low bend distributary channel | SII1+2, SII5+6, SII7+8, SII10+11, SII13+14, SII15+16, SII1+2, SII3, SII4+5, SII8, SII9+10, PI15+6, PI17, PI18+9, |
|                         | Small low bend straight distributary channel; Underwater small branch distributary channel | SII4, SII9, SII12, PI4, PI5, PI6, PI7, PI11+2, PI3, PI4, PI10, GI1, GI2, GI3, GI4+5 |

The effective thickness of 2.0m and above oil layer accounts for 80.2% of the total effective thickness, the average effective thickness of single layer is 3.3m, and the proportion of water flooded thickness is 99.0%. In the oil layer, the proportion of high water flooded thickness is 57.5%, the proportion of medium water flooded thickness is 32.2%, the proportion of low water flooded thickness is 9.3%, and the proportion of UN flooded thickness is 1.0%.

The effective thickness of 1.0m-2.0m oil layer accounts for 11.1% of the total effective thickness, the average effective thickness of single layer is 1.3m, and the proportion of water flooded thickness is 99.5%. In the oil layer, high water flooded thickness accounts for 57.6%, medium water flooded thickness accounts for 33.9%, low water flooded thickness accounts for 8.0%, and UN flooded thickness accounts for 0.5%.

The effective thickness of 0.5m-1.0m oil layer accounts for 5.5% of the total effective thickness, the average effective thickness of single layer is 0.7m, and the proportion of water flooded thickness is 99.5%. The oil layer is dominated by medium and high water flooded thickness, the proportion of high water flooded thickness is 46.7%, the proportion of medium water flooded thickness is 42.8%, the proportion of low water flooded thickness is 10.0%, and the proportion of UN flooded thickness is 0.5%.

The effective thickness of oil layer less than 0.5m accounts for 3.2% of the total effective thickness, the average effective thickness of single layer is 0.3m, and the proportion of water flooded thickness is 96.7%. In the oil layer, the proportion of medium water flooded thickness is 47.1%, the proportion of low water flooded thickness is 34.1%, the proportion of high water flooded thickness is 15.5%, and the proportion of UN water flooded thickness is 3.3%.

Generally speaking, the effective thickness of class II oil layer in the study area is 0.5m and above, and the proportion of the thickness of each water flooded layer is not much different, and the proportion of the low water flooded thickness is very small. The water flooded degree of the oil layer with the effective thickness less than 0.5m is relatively low, and the proportion of the low water flooded thickness is large, which shows that the inner part of the thin difference layer less than 0.5m is rich in residual oil.

3.2 Water flooded conditions of different permeability levels

Based on the water flooded interpretation results of 208 new wells, the water flooded conditions of different permeability grades of the second class oil layers in the study area are comprehensively analyzed.

The oil layers with permeability of 0.6 μm2 and above account for 38.2% of the total thickness, and the average thickness of single well is 18.5M. In the oil layer, high water flooded thickness accounts for 70.7%, medium water flooded thickness accounts for 24.7%, low water flooded thickness
accounts for 3.6%, and the proportion of UN water flooded thickness is 1.0%.

The reservoir with permeability between 0.4 μ m2 and 0.6 μ M2 accounts for 32.3% of the total thickness, and the average thickness of a single well is 15.5m. In the reservoir, high water flooded thickness accounts for 55.4%, medium water flooded thickness accounts for 37.2%, low water flooded thickness accounts for 6.8% and no water flooded thickness accounts for 0.6%.

The reservoir with permeability between 0.2 μ m2 and 0.4 μ M2 accounts for 18.5% of the total thickness, and the average thickness of a single well is 8.7m. The reservoir is dominated by medium water flooding, in which the proportion of high water flooding thickness is 40.4%, that of medium water flooding thickness is 44.2%, that of low water flooding thickness is 14.6%, and that of no water flooding thickness is 0.8%.

The reservoir with permeability between 0.1 μ m2 and 0.2 μ M2 accounts for 7.8% of the total thickness, and the average thickness of a single well is 3.4m. In the reservoir, medium water flooded is the main one, of which the proportion of high water flooded thickness is 30.7%, medium water flooded thickness is 38.1%, low water flooded thickness is 29.8%, and the proportion of UN water flooded thickness is 1.4%.

The oil layers with permeability less than 0.1 μ M2 account for 3.2% of the total thickness, and the average thickness of a single well is 1.5m. In the oil layer, low water flooding is the main one, in which the proportion of high water flooding thickness is 14.2%, the proportion of medium water flooding thickness is 29.8%, the proportion of low water flooding thickness is 49.8%, and the proportion of UN water flooding thickness is 6.2%.

Generally speaking, the effective thickness of the reservoir with permeability above 0.4 μ M2 accounts for 70.5% of the total thickness, which shows that the permeability of the second type reservoir in the study area is mainly above 0.4 μ m2, with good permeability, and the highest proportion of high and medium water flooding is 95.4%; for the reservoir with permeability less than 0.4 μ m2, the ratio of low water flooding thickness is large, and the remaining oil is relatively rich.

### 3.3 Water flooding status of different water saturation levels

According to the interpretation data of water flooded layer in newly drilled wells, the total thickness of the layer with water saturation less than 40% is 577.7m, and the thickness ratio is 5.8%. The main reservoir is low water flooded layer, and the thickness ratio of low water flooded layer is 99.3% - 99.5%. It belongs to the remaining oil accumulation layer of ultra-high water cut stage.

At present, the total thickness of the reservoir with water saturation of 40% - 55% is 5199.8m, and the thickness ratio is 52.5%, which is dominated by medium water flooding, in which the thickness ratio of high water flooding is 35.4%, that of medium water flooding is 55.5%, and that of low water flooding is 9.1%. It belongs to the relative enrichment layer of remaining oil in the period of ultra-high water cut.

At present, the total thickness of oil layers with water saturation of 55% - 65% is 3429.2m, and the thickness ratio is 34.6%. The high water flooded thickness ratio is 87.4%, the medium water flooded thickness ratio is 11.6%, and the low water flooded thickness ratio is very small. It belongs to the water control layer of ultra-high water cut period.

At present, the total thickness of reservoirs with water saturation of 65% and above is 693.3m, and the thickness ratio is 7%. Among them, high water flooding is the main one, and the thickness ratio of high water flooding is 95.6%. It belongs to the invalid injection production circulation layer in the ultra-high water cut stage.

Generally speaking, water has been seen at each well point on the plane of class II oil layer in the study area. At present, the water saturation is concentrated in 40% - 65%, with high water cut and highly dispersed remaining oil. At present, oil layers with water saturation less than 40% are rich in remaining oil, accounting for a small proportion of the total thickness. 65% and above oil layers are ineffective injection production circulation layers, accounting for a large proportion of the total thickness.
3.4 Water flooded status of different sand body facies

In the process of oilfield development, the sedimentary types of oil layers are different, and their water flooded conditions are also different. Different sand facies are mainly due to the different physical properties of the reservoir and the perfection degree of injection production relationship, resulting in the difference of water flooded degree of the reservoir.

According to the statistical results of water flooded conditions of different sand body facies, the second type oil layers in the second area of the Northeast block are mainly channel sand body, accounting for 76.4% of the total thickness, of which the proportion of high and medium water flooded thickness is 90.2% and the proportion of low water flooded thickness is 9.8%, and the remaining oil is mainly distributed in the low permeability part of the channel edge.

For example, in the s II 2 + 3 interval of well 19-as28126, the permeability of the UN watered out part is 0.1 μm², and that of the high watered out part is 0.6 μm². The permeability is very poor, and the remaining oil is concentrated in the low permeability part of the small layer.

![Fig. 1 screenshot of logging curve of layer II 2 + 3 of well 19-as28126 (channel sand, curve deformation after water flooding)](image)

The water flooded condition of the main sheet sand mainly depends on the connection with the channel facies reservoir. The main sheet sand in the study area is mainly distributed at the edge of the channel and connected with the channel, accounting for 20.4% of the total thickness, of which the proportion of high and medium water flooded thickness is 88.5%, the proportion of low water flooded thickness is 11.5%, and the proportion of water flooded is very small.

The distribution of non main sheet sand is scattered, the connectivity between wells is poor, accounting for 3.2% of the total thickness, and the degree of water flooding is relatively low, in which the proportion of high and medium water flooded thickness is 63.0%, and the proportion of low water flooded thickness is 37.0%, which is the relatively rich reservoir of remaining oil.

Generally speaking, the oil layers of different sand body facies have been effectively developed, which are mainly middle and high water flooded. The water flooded degree of channel sand body is higher than that of non channel sand body, and the remaining oil is highly dispersed, which is mainly concentrated in the sand body parts with low permeability and large permeability difference at the edge of the channel and the thin sand body with poor petrophysical properties among the distributary.

3.5 Water flooding in different parts of thick oil layer

Select the thick oil layer with effective thickness of more than 2.0m (the key is the thick layer with effective thickness of more than 3.0m, and there are differences in structural interface or permeability), divide the rhythmic section according to the interlayer interface or permeability differential interface, and carry out statistical analysis on the characteristics of different rhythmic sections.

In the upper rhythmic section of the reservoir, the ratio of high water flooded thickness is 50.6%, medium water flooded thickness is 36.9%, and low water flooded thickness is 12.5%.

In the middle rhythmic section of the reservoir, the ratio of high water flooded thickness is 52.2%, medium water flooded thickness is 35.4%, and low water flooded thickness is 12.5%.

In the lower rhythmic section of the reservoir, the ratio of high water flooded thickness is 63.2%, the ratio of medium water flooded thickness is 28.6%, and the ratio of low water flooded thickness is 8.2%.

In general, it can be seen that in the development period of ultra-high water cut, although there are
some differences in the proportion of high water flooded thickness of each rhythmic section in the upper, middle and lower thick oil layers, the correlation with the oil layer position has been small, the proportion of medium high and low water flooded thickness of the oil layer is relatively evenly distributed, and the proportion of low water flooded thickness in the middle and upper part is only 4.3% higher than that in the lower part, so it can be seen that in the development period of ultra-high water cut, there are In the thick reservoir with effective thickness over 2.0m, the remaining oil is mainly distributed in the middle and upper prosodic section, which is characterized by small thickness, poor lithology and many interlayer.

At the same time, it is found that the water flooded degree at the bottom of each prosodic section is relatively high in the section, but the water flooded degree at the top of each prosodic section is different, and the remaining oil is concentrated at the top of the middle and upper prosodic sections in the thick oil layer, which is the main rule of the distribution of remaining oil in the thick oil layer at present, while the water flooded degree at the top of the lower prosodic section is generally high.

For example, in s III 4-8 interval of well l9-ps26028, there are 0.8m and 1.1m low water flooded intervals at the top of the middle and upper prosodic intervals, respectively, with relatively rich remaining oil. The water saturation at the top of the lower prosody section is more than 60%, and the water flooded condition is high water flooded. Therefore, there is no residual oil at the top of each prosody section.

Fig. 2 watered out characteristics of three rhythmic intervals in s III 4-8 interval of well l9-ps26028

4. Conclusion and understanding

First, in the second area of the North East block, the water flooded oil layer is mainly high water flooded, the proportion of high water flooded thickness is over 55.6%, and the proportion of low water flooded thickness is only 11.0%.

Second, from this statistical point of view, the main influencing factor of the degree of water flooding is the permeability. There is a certain relationship between high water flooding and rhythmic horizon in the reservoir, but there is little gap in the ultra-high water cut stage.

Third, the remaining oil in the second type reservoir is highly dispersed. Vertically, it is mainly concentrated on the top of the upper rhythmic section of the thick oil layer. If the permeability of the middle rhythmic section is low, the top will also be rich in remaining oil, and the lower rhythmic section is basically in the state of invalid circulation. In plane, the remaining oil mainly exists in the edge of the river, the thin sand body between the rivers, the area with imperfect injection and production blocked by faults, etc.; in addition, the remaining oil is also distributed in the area with effective thickness less than 0 In. 5m thin sand body. In terms of permeability, the remaining oil is mainly concentrated in the reservoir with effective permeability less than 0.4 μ m2.

Fourth, according to the current standards for potential mining, the water saturation should be below 55%, and the effective thickness proportion accounts for 58.3% of the total effective thickness, including some water flooded layers with oil saturation meeting the conditions for potential mining, which still have more material basis for remaining oil, and are the main targets for fine potential mining in the future.
References
[1] Zhao Wei, Zhao Yunfei, Wang Liming, et al. Reservoir production and comprehensive adjustment direction of Lamadian Oilfield [a]. Daqing Petroleum Geology and development, 2002, 21 (2): 26-28
[2] Han Weidong, Huang Fusheng, AI Ying, et al. Methods for tapping the remaining oil potential of Lamadian Oilfield [a]. Daqing Petroleum Geology and development, 2002, 21 (3): 41-43
[3] Zhang Baosheng, Zhang Shujie, Zhong Ling, et al. Water washing conditions of various oil layers in LaSaXing oilfield [a]. Daqing Petroleum Geology and development, 2002, 21 (6): 40-43