ABSTRACT

Seven East District of Karamay Oilfield reservoir up to the middle and late period of development, which has been in high water cut stage. To solve the main problems existing currently in the process of development in the study area, using numerical simulation software to do the fine history matching of formation pressure, cumulative oil production, water cut, cumulative water development indexes, quantitative analysis of remaining oil distribution in the horizontal and vertical, to make it clear that the distribution of remaining oil in the reservoir zone of enrichment; according to the distribution of remaining oil enrichment area and main controlling factors, proposing development and adjustment suggestions, providing a scientific basis for Karamay Oilfield to improve ultimate recovery.

KEYWORDS

Karamay Oilfield reservoir; numerical simulation; distribution of remaining oil; adjustment suggestions.

THE GENERALITY OF THE STUDY REGION

Karamay Oilfield seven East District Reservoir in the northwest margin of the Dzungaria Basin in Xinjiang, Which is at the Baijiantan footwall of Karamay-Urumqi thrust, to northern 5137 well fault reverse fault as the boundary and average buried depth of reservoir is 1770m and average ground elevation is 267m. It is located in Karamay City, Baijiantan District, in the east of Karamay city about 25km. As of April 2015, opening a total of 28 wells, 20 oil wells, 8 water wells. Lower Karamay formation has been a primary target strata. The well pattern is irregular, the injection-production relationship is complex, and the water cut is above 70%.
PROBLEMS IN DEVELOPMENT

The reservoir in the upper Karamay formation began to water flood in 1996. With the increase of water injection rate, the water cut began to increase gradually, and the cumulative injection and production reached a balance. Since 1999, it was in the middle and high water cut stage. The trend of production decline was gradually deteriorated. As of April 2015, water cut reaches to 77.83%. In 2015, the annual injection production ratio was 1.253. Recovery degree was 18.55%, cumulative injection production ratio was 1.25, and the injection production well systems were imperfect, the degree of water drive control was low. Injection production capacity between injection and production well is quite different, and the imbalance of regional injection production ratio. Production decline rate is large, in three decline time periods, the decline rate increased gradually. The utilization rate of development well is low, the proportion of failure wells is high, the group of wells on upper Karamay formation is a total of 22 wells, there are 8 wells shut down, accounting for 36.4%.

Lower Karamay Formation put into development in 1959, as of April 2015, there were a total of 28 wells, opening 14 wells, shutting down 12 wells, accounting for 42.9%. Water cut was 74.4%. In 2015, the injection production ratio is 1.48. Recovery percent was 25.77%. The cumulative injection production ratio was 1.61. Wells injection production capability was different. The regional injection production ratio is imbalance. Decline rate increased gradually.

Analysis on its major control factors:

1. Reservoir physical property of upper Karamay formation is better than that of lower Karamay formation. In production wells which were in better mining condition was relatively better porosity and permeability, and mining poorer regions in lower permeability bands, reservoir physical property is poor or in low pressure belt, lack of energy, resulting in poor production conditions.

2. According to flow chart analysis

At present, water injection is the main form of energy supplement, streamline is issued from the water well to the oil well, streamline starting from the edge and bottom water was less. In the northeast the degree of well network control plane of lower Karamay formation is better than that of upper Karamay formation. In the northwest, the degree of well network control plane was low, streamline in western and central is more sparse, reflecting the current pattern of poor control plane.

![upper Karamay formation flow line chart](image1)

![lower Karamay formation flow line chart](image2)
3. According to the longitudinal pattern of control

We know that the longitudinal reserves conditions were quite different. The use of S42-2, S62, S71, S72-1, S72-2 horizon is better. The use of S11, S12, S21, S32, S41-1, S42-1, S62, S73-3, S74-2 horizon situation is not good.

In summary, first of all, there is a large difference in physical property of the reservoir, which leads to the difference of the exploitation condition. Secondly, there are huge differences of reservoir plane well network control degree and vertical producing degree, leading to the distribution of remaining oil potential difference is greater. Therefore, I put forward the will develop series of strata combination, to raise the degree of recovery in later development.

**LAYER SYSTEM COMBINATION SUGGESTIONS**

Division and combination of reasonable development layer system are fundamental measures of exploitation of multilayer field. The statistics of all layers of porosity and permeability distribution and variation coefficient, dart coefficient and range (Table 1). Reservoir is sand shale layer distribution of mudstone interlayer development. The single layer’s heterogeneity is relatively strong. In layers of heterogeneity is very strong. The difference of single reservoir parameters is very strong, showing obvious interlayer heterogeneity. Therefore, a reasonable division of layer series is necessary, to increase the longitudinal reserves, improve the ultimate recovery.

According to the boundary of the layer system combination, is comprehensive factor. The larger the comprehensive factor, the stronger the heterogeneity of the composite. The formula is

\[ \xi(i) = \frac{J_k(i) \times K_v^i(i)}{N_z(i)} \]

where \( N_z(i) \) is the layer number,

\( J_k \) is the permeability contrast.

\( V_k \) is the permeability variation coefficient.

To get the better effect in low permeability layer, comprehensive factor should be less than 5.0, corresponding permeability in 8.0, permeability variation coefficient of 0.6. In the case of the same injection rate, the more the number of the interlayer, the smaller the water absorption percentage of the lowest permeability layer, and the number of the interlayer is as far as possible in the 6~7 layers in the actual development of the development layer system.

According to the effective thickness limit diagram, on the base of the current oil price standards, at the oil price of 2977 yuan /t, the annual operating cost of 65-115 million / well, the effective thickness of the lower limit is 10.35-13.2m.

![Figure 3. Effective thickness limit.](image)
Through the observation of the model well bitmap, upper Karamay formation and lower Karamay formation have been separated mining. Analysis of reservoir thickness map and the remaining oil saturation and the remaining oil abundance,

Layer series on the upper Karamay formation 71201-71207 well area, 71216-71217-71219 well area can be subdivided; because of 71216-71217-71219 wells’ water flooding development effect is poor, so I take this well area as a subdivision of layer series’ key wells area. In the numerical simulation model seeing small layer 5-6, 11-13, 18-22, 29-36, 40-46, 50-52, 59-62, 68-71 there are eight interlayers here, in accordance with the principle of subdivision of series of strata, 1-90, 91-140 division for two layer series of development to develop.

Lower Karamay formation 5094-7161-7160 well area needs subdividing of layer series. Small layers 143-145, 150-152, 161-165, 164-165 are 4 interlayers, in accordance with the principle of layer division, 141-200, 201-260 layer division for two layer series of development to develop. In 5137-71109 well area, small layers 141-145, 151-162, 167-171, 173-182 are 4 intervals, in accordance with the principles of layer division, the 141-210, 211-260 small layers are divided into two sets of development layer system to develop.

Figure 4. Upper Karamay formation reservoir thickness. Figure 5. Lower Karamay formation reservoir thickness.

Figure 6. Upper Karamay formation remaining oil saturation. Figure 7. Lower Karamay formation remaining oil saturation.

Figure 8. Upper Karamay formation remaining oil abundance. Figure 9. Lower Karamay formation remaining oil abundance.
The recommendations of the combination of the layers are as follows: Table 1

| Layer series of development | Horizon combination | The number of interlayer | Reservoir thickness | Coefficient of variation | Range |
|-----------------------------|---------------------|--------------------------|---------------------|--------------------------|-------|
| 71216-71217-71219 well area | 1                   | S₁¹, S₂², S₃², S₄¹-1, S₄¹-2 | 8                   | 31.3 >13.2               | 0.32 <0.5 | 2.99 <8 |
|                            |                     | S₄²-1, S₅¹-1, S₅²-1, S₅²-2 | 0                   | 39.6 >13.2               | 0.35 <0.5 | 2.50 <8 |
|                            |                     | S₆¹, S₆², S₇¹, S₇²-1, S₇²-2 | 0                   | 18.9 >13.2               | 0.76 <1.2 | 7.59 <8 |
|                            |                     | S₇³-3, S₇³-1, S₇³-2, S₇³-3, S₇⁴-1, S₇⁴-2 | 0       | 33.6 >13.2               | 0.50 <1.2 | 7.29 <8 |
|                            |                     | S₆¹, S₆², S₇¹, S₇²-1, S₇²-2 | 0                   | 16.7 >13.2               | 0.85 <1.2 | 7.59 <8 |
|                            |                     | S₇³-3, S₇³-2, S₇³-3, S₇⁴-1, S₇⁴-2 | 0       | 34.4 >13.2               | 0.51 <1.2 | 6.21 <8 |

Through the combination of layers, reservoir thickness is larger than 13.2m which is the economic limit thickness, and the coefficient of variation and range meet layer combination technology limit. In the development, it solves the problem of interlayer heterogeneity.

**CONCLUSION**

By the method of numerical simulation and statistics of each layer and the cumulative oil production and recovery degree and remaining reserves, the cumulative oil production in lower Karamay formation S73-2 layer is the highest, 68.74% of the
total amount of oil is produced by lower Karamay formation, longitudinal use in upper Karamay formation is not balanced. The remaining reserves in S12 layer is the highest, and interlayer remaining potential is different.

We draw some conclusions:

1. The average porosity of the upper Karamay formation is 17%. Permeability is 84.6×10⁻³um², better than lower Karamay formation.
2. Reservoir is sand shale layer distribution of mudstone interlayer development. The single layer’s heterogeneity is relatively strong. In layers of heterogeneity is very strong. The difference of single reservoir parameters is very strong, showing obvious interlayer heterogeneity.
3. In accordance with the principles of the subdivision, in the 71216-71217-71219 well area, the1-90, 91-140 are divided into two sets of development layer system to develop.
4. In the 5094-7160-7161 well area, the 141-200, 201-260 small layers are divided into two sets of development layer system to develop.
5. In the 5137-71109 well area of lower Karamay formation, 141-210, 211-260 small layers are divided into two sets of development layer system to develop.

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