Analysis of the index change laws of the B and C strips of Block A after well pattern infilling

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Abstract. After entering the ultra-high water cut stage, it is more and more difficult to tap the remaining oil potential, especially in the B and C strips because of the prominent contradictions between injection and production. It is difficult to adjust a injection well and get a good effect of well stimulation, so oil recovery is low. The index change laws are analyzed and summarized in two test areas of well pattern infilling, which can be used as a reference for the well pattern infilling and efficient development in the B and C strips.

1. A general overview
Combined with the existing well pattern development status and conditions of Block A, and based on the principles of using the exiting well pattern, less drilling or no drilling and reducing test cost, the original well pattern is utilized to infill and adjust in the B and C strips.

1.1. Five-spot area well pattern of 125m well spacing
The feasibility of changing four-spot area well pattern of 350m well spacing in the B band and linear well pattern in the C band to five-spot area well patterns of 125m well spacing will be analyzed below. In the test area, inverted nine-spot area well pattern was adopted, which included 9 injection wells and 40 production wells and explored main oil layers of Group D. All the corner wells are turned into injection and other wells are fully utilized, forming five-spot area well pattern of 125m well spacing. 16 oil wells are turned into injection and E, F oil layers are added to 49 wells.

1.2. Five-spot area well pattern of 175m well spacing
The feasibility of changing four-spot area well pattern of 350m well spacing in the B band and linear well pattern in the C band to five-spot area well patterns of 175m well spacing will be analyzed below. In the test area, inverted nine-spot area well pattern was adopted, which included 6 injection wells and 29 production wells and explored main oil layers of Group G. The corner wells are turned into injection and other wells are fully utilized, forming five-spot area well pattern of 175m well spacing. 6 oil wells are turned into injection. E, H and F oil layers are added to 35 wells, and Group G is blocked.

2. Comprehensive evaluation on the indexes of two sets of infill well pattern

2.1. Evaluation on the indexes of five-spot area well pattern of 125m well spacing
There were 11 old wells, including 2 injection wells and 9 production wells. After the adjustment, there are 49 wells in total, including 25 injection wells and 24 production wells. Compared with that before the adjustment, the total number of wells increases by 38, and the average net pay thickness increases by 4.3m. The injection-to-production-well ratio is more reasonable, reaching 1:1.04.
Before infilling, 9 oil wells had a daily fluid production of 309t, a daily oil production of 10.3t, and a comprehensive water cut of 96.67%. In the early stage after the adjustment, the daily oil production of 24 wells is 41.3t, and the comprehensive water cut is 95.81%. Compared with that before the adjustment, the daily oil production increases by 40.9t, the comprehensive water cut decreases by 1.12%, and the average daily oil production of single well increases from 1.14t to 2.1t.

The water flooding control degree of the original well pattern was 75.2%, and the multi-directional connectivity ratio was 25.0%. After the adjustment, the water flooding control degree is 93.3%, which is 18.1% higher than that before the adjustment, and the multi-directional connectivity ratio is 48.7%, which is 23.7% higher than that before the adjustment.

The oil recovery rate and the recovery efficiency are greatly improved compared with that before infilling. The oil recovery rate was 0.40% before infilling and 0.63% after the adjustment, which is 0.23% higher. The oil recovery before adjustment was 35.99%, and that after the adjustment is 38.79%, which is 2.80% higher than that before adjustment. The recoverable reserves increases by 3.18×10^4t in the test area.

2.2. Evaluation on the indexes of five-spot area well pattern of 175m well spacing

There were 13 old wells in the well pattern of 175m well spacing, including 4 injection wells and 9 production wells. After the adjustment, there are 41 wells in total, including 18 injection wells and 23 production wells. Compared with that before the adjustment, the total number of wells increases by 28, and the average net pay thickness increases by 8.1m.

Before infilling, 9 oil wells had a daily fluid production of 220t, a daily oil production 8.9t, and a comprehensive water cut of 95.96%. In the early stage after the adjustment, the daily oil production of 23 wells is 58.1t, and the comprehensive water cut is 95.16%. Compared with that before the adjustment, the average daily oil production of single well increases from 1.0t to 2.5t, the comprehensive water cut decreases by 0.8%. At present, the average daily water injection volume of 18 injection wells is 62m^3, the daily oil production of 23 production wells is 52.9t, the comprehensive water cut is 95.50%, and the daily increasing oil production of single well is 1.3t.

The water flooding control degree of the original well pattern was 75.2%, and the multi-directional connectivity ratio was 25.0%. After the adjustment, the water flooding control degree is 91.2%, which is 16.0% higher than before, and the multi-directional connectivity ratio is 45.5%, which is 20.0% higher than before.

The oil recovery rate and the recovery efficiency are greatly improved compared with that before infilling. The oil recovery rate was 0.32% before infilling and 0.49% after the adjustment, which is 0.17% higher than that before the adjustment. The oil recovery before adjustment was 35.99%, and that after the adjustment is 38.79%, which is 2.80% higher than that before adjustment. The recoverable reserves increases by 3.18×10^4t in the test area.
2.3. Comprehensive evaluation of two well pattern indexes

2.3.1. Comparison of injection capability
The starting pressure is 5.10Mpa, the injection pressure is 8.21Mpa, and the apparent water absorption index is 7.98m³ / (d·MPa) in the well pattern of 125m well spacing; The starting pressure is 9.71Mpa, the injection pressure is 11.17Mpa, and the apparent water absorption index is 5.32m³ / (d·MPa) in the well pattern of 175m well spacing. Compared with the well pattern of 125m well spacing, the starting pressure of the well pattern of 175m well spacing is 4.61Mpa higher, the injection pressure is 2.96Mpa higher, and the apparent water absorption index is lower by 2.66 m³ / (d·MPa), indicating that the 125m well pattern has stronger water absorption capacity. Two sets of infill well patterns can establish effective injection-production pressure drawdown, but it is difficult to control water injection with 125m well spacing, the preferential percolation pathways are obvious, and water cut rises quickly in the initial stage. Therefore, the well pattern of 175m well spacing is easier to adjust.

2.3.2. Comparison of production status
It can be seen from the production curves of the two well patterns that the daily oil production of a single well with a spacing of 125m and 175m is 2.1t and 2.5t respectively in the initial stage of infilling, and the single well production with 175m well spacing is slightly higher. However, from the comprehensive water cut change of the two well patterns, the water cut of 125m well spacing rises fast in the initial stage because of relatively small well spacing and strong percolation capacity. Considering the whole process of development after infilling, 175m well spacing is more suitable reservoir development of B and C strips in Block A.

2.3.3. Comparison of enhanced oil recovery
The oil recovery of 125m well pattern was 36.77% before the adjustment and 39.00% after the adjustment, which is 2.23% higher than that before the adjustment. After the adjustment of 175m well pattern, the enhanced oil recovery rate is 2.80%. The enhanced oil recovery of 175m well pattern is higher than that of 125m well pattern. Due to the special geological conditions of 125m well pattern, it can not represent the development characteristics of the whole block.

   Based on the above reasons, the 175m well pattern is simulated and infilled into 125m five-spot area well pattern, and the change law of indexes after infilling is predicted by numerical simulation. The oil recovery after adjustment is 39.13%, which is 3.14% higher than that before adjustment. The oil production rate increased from 0.32% before the adjustment to 0.57% after the adjustment, with an increase of 0.25%. Compared with the well pattern of 175m, the oil recovery is only increased by 0.34%.

3. Conclusion
(1) After infilling the well pattern, the recoverable reserves and oil recovery are greatly improved, and the development effect of B and C strips is improved.
(2) Considering the changes of various indicators, the development index of 175m five-spot pattern is better than that of 125m five spot pattern, which is conducive to later adjustment.
(3) After well pattern infilling, timely subdivision adjustment can effectively improve the water absorption condition of thin and poor reservoirs and control the rising rate of water cut.

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