New method of tapping potential of remaining oil after chemical flooding

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Abstract. In the study area, the chemical flooding type II oil layer and the water flooding type III oil layer exhibited alternating distribution in the horizon. The recovery factor during the chemical flooding stage was relatively low, at 7.44%, and had the potential for mining. Subsequent water flooding phases cannot use conventional potential tapping methods. It is necessary to further explore new targeted potential tapping methods and explore new ways for more cost-effective development. This study makes full use of dynamic data, fine reservoir description data and numerical modeling data to identify the remaining oil in the subsequent waterflooding stage, through coordinated adjustment of well patterns in the second and third types of oil layers, using unblocking, periodic production, reduced-speed oil production, and rotation use wells and other methods to comprehensively tap potential and tap remaining oil.

Key words. Remaining oil, unblocking, periodic production, reduced oil production, alternate well opening.

1. Introduction
The research area was put into development in 1960, and five sets of five-point method area well patterns were deployed, with a minimum injection and production well spacing of 106m (Table 1). The chemical flooding type II oil layer and the water flooding type III oil layer are alternately distributed on the horizon, and the cross-co-firing ratio of the two is 30%. In order to ensure the effect of chemical flooding, according to the plugging principle, 197 cross-co-fired water flooding wells in the area were blocked before the chemical flooding of the second-class reservoir.

The enhanced recovery factor of the second type well pattern during chemical flooding is relatively low at 7.75%, which is about 5 percentage points lower than that of other second type blocks.
Table 1. Basic situation of well pattern

| Mining phase            | Development well pattern | Number of wells | Injection-production well spacing (m) | Main objects of mining |
|-------------------------|--------------------------|-----------------|---------------------------------------|------------------------|
| Water flooding          | Sapa Portugal Basic Well Pattern | 34              | 600×500                               | Sapa oil layer         |
|                         | Sapa Portuguese one-time encryption | 41              | 300×250                               | Sapa oil layer         |
|                         | Sapporo secondary encryption | 97              | 250irregular                          | Sapa oil layer         |
|                         | Sapporo three encryption   | 350             | 106×106                               | High oil layer         |
| Chemical flooding       | Second class oil layer    | 296             | 125×125                               | pal5~palI10           |

2. Identification of remaining oil in the subsequent water flooding stage of the study area
After long-term development in the study area, the remaining oil is dispersed, making it difficult to tap potential. This study makes full use of dynamic data, fine reservoir description data and mathematical model data to identify the three types of remaining oil.

2.1. The well pattern cannot control the remaining oil
The second phase of the Pu Group II has frequent phase transitions, and the development of sand bodies is unstable. The well pattern of the second-class oil layer can not control the sharp extinction area and narrow small river channels, etc., forming residual oil (Figure 1).

![Figure 1. The sharp extinction area and narrow small river channels](image)

2.2. Imperfect injection and production form residual oil
Due to the sharp extinction of the sand body and the sealing of the cross-co-fired layers of the second and third types of oil layers, the well group has no or no injection, and the injection and production are imperfect, resulting in residual oil.

2.3. Plugging three types of effective wells to form remaining oil
During the betting process, three types of wells with water flooding were blocked, and residual oil left behind was formed. During the chemical flooding process, the maximum water cut of the three types of water flooding in the whole area decreased by 0.9 percentage points, and one-third of the three types of water flooding wells were effective. The minimum water cut percentage of the effective wells was 92.1%, and the maximum value of the decline was 3.41 percentage points.
2.4. **Interlayer interference type remaining oil**
The heterogeneity between wells and layers is strong, and poor layers form residual oil. The good layer has strong water absorption capacity, large sweep coefficient, low saturation of remaining oil, poor layer utilization is poor, and there is much remaining oil (Figure 2 to Figure 4).

![Figure 2. Distribution of permeability field](image1)

![Figure 3. Schematic diagram of plane heterogeneous streamlines](image2)

![Figure 4. Schematic diagram of longitudinal heterogeneous streamline](image3)

3. **The second type oil layer well pattern is coordinated with the third type oil layer well pattern to comprehensively tap the remaining oil**
The second type oil layer well pattern is coordinated with the third type oil layer well pattern to comprehensively tap the remaining oil. The overall idea is to use the entire Type 2 and Type 3 reservoirs in the study area as potential targets, breaking the restriction of the well pattern, coordinated adjustment of multiple sets of well patterns, and analyzing the well-position relationship, well spacing, and depth of each deposition unit and well area. The development and connectivity of the stratum finally achieved the goal of perfecting the injection-production relationship of the well group, improving the control of single sand body, and maximizing the potential of remaining oil.

3.1. **Unblocking, improving the control degree of single sand body, tapping the uncontrollable remaining oil**
Use fine oil layer interpretation results to describe the development of sand bodies, and analyze the sub-units and well areas. For narrow and small channels and loamy sands that cannot be controlled by a single well pattern, multiple sets of well patterns are used to complement each other. Unblock the net well point, improve the degree of sand body control, and tap the remaining oil.

After opening the well, the water flooding well C61-5 and the well PII8 that encountered bumpy sand, three wells of the second-class oil layer produced results and the water cut decreased by 0.3 percentage points.

3.2. **Lift the blockage, improve the relationship between injection and production, tap the potential and inject Imperfect remaining oil**
Due to the sharp extinction of the sand body and the sealing of the cross-co-fired horizons of the second and third oil layers, the well group has no or no injection, and the injection and production are imperfect, resulting in residual oil.

Comprehensive analysis of multiple sets of well patterns, after opening the plugging zone, the water cut rise rate of the surrounding two-drive oil wells is controlled. After the first batch of 4 water flooding three wells opened the sealing zone, the water cut of the surrounding 22 two flooding oil wells decreased by 0.4 percentage points, and the daily oil production increased by 5 tons. After the second batch of 36 water flooding wells opened the sealing zone, the daily production fluid of 111 oil wells of the two floodings increased by 300t, the water cut was stable, and the oil production rose slightly.
3.3. Lift the blockage, improve the relationship between injection and production, tap the potential and inject Imperfect remaining oil

Planar adjustment methods such as intermittent production of intercepting wells and low-speed production of diverting wells were implemented, and the remaining oil formed by the three types of wells with effective water flooding was blocked during the potential tapping process.

3.3.1. Intermittent production of shut-in well

Analyze the data of water cut and accumulation in intercepting wells, and implement the method of periodic oil recovery for wells with high water cut and accumulation. Periodic oil recovery was carried out on 13 high-water-cut and high-visibility water-flooding type III oil wells, and the flow pressure of the chemical flooding type II production wells increased by 0.7 MPa.

3.3.2. Low-speed production in diverter wells

Play the role of plane adjustment, adjust the diversion of the three types of water flooding oil wells and chemical flooding of the second oil wells, the oil wells of the two drive down-regulation parameters follow the principle of "high recovery, high water cut, high flow pressure".

After adjusting the diversion of 66 water flooding Class III oil wells and chemical flooding Class II oil wells, the rate of water cut rise was controlled, and the average annual water cut rose by 0.5 percentage points.

3.4. Control well-injected layers, transform thin layers, reduce inter-layer heterogeneity, and tap potential interlayer residual oil.

Subdivided adjustment, trial matching, and test adjustment to control the injection layer, a total of 49 adjustments, the oil pressure rose by 0.15MPa, and the injection volume was basically stable. Fracturing the poorly reformed layer three times, the oil pressure dropped by 1MPa. The water cut of the corresponding 16 produced wells decreased by 0.2 percentage points.

4. Conclusion

When the second type oil layer well pattern is coordinated with the third type oil layer well pattern, the plugging is lifted, the control degree of single sand body is improved, the injection-production relationship is improved, and the remaining oil is tapped.

When the second type oil layer well pattern is coordinated with the third type oil layer well pattern, the intercepting wells are produced in an intermittent manner, and the remaining oil remaining in the mainstream line is tapped.

When the second type oil layer well pattern and the third type oil layer well pattern are coordinated and adjusted, the diversion wells are produced at a low speed, which can increase the utilization of the diversion line oil wells and slow the rise of water cut.
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