Study of fine tapping potential of poor reservoirs in late stage of high water cut

Bochao Xu
No.6 Oil Mine Technology Team of No.1 Oil Production Plant of Daqing Oilfield Co., Ltd., 163000, China
Bochao@petrochina.com.cn

Abstract. At present, the oilfield development has entered the late stage of high water cut, and the exploitation objects have been changed to the second and third types of oil layers. The distribution of remaining oil is highly fragmented and complex, and the exploitation difficulty is gradually increasing. In view of a series of geological characteristics of Development Zone A, such as "numerous layers, complex reservoirs, severe phase transition and high viscosity", the potential tapping technologies of Class II and Class III reservoirs, such as combination of two and three and ASP flooding, have been carried out one after another. In order to further enhance oil recovery and increase recoverable reserves, a large number of fracturing measures have been implemented to increase oil production. In view of the fact that it is more and more difficult to select wells and layers by this measure, we combine the results of fine reservoir description with dynamic data, take Block B as the investigation object, establish the potential pool of sedimentary unit-level measures, recognize the potential distribution of 82 different sedimentary units, clarify the target units of potential tapping measures, and finally explore relatively perfect ways and means to optimize fracturing well layers, and strive to achieve targeted adjustment and accurately tap potential. At present, in the early stage of fracturing in this area, the average daily oil increase of a single well is 7.9 tons, and the above practices also provide empirical reference and guidance for other similar blocks.

Keywords: Late stage of high water cut; Remaining oil; Fine reservoir description results; Fracture tapping potential

1. Basic general situation of block and geological characteristics of reservoir
Block A is located in the north of Sazhong Development Zone, with three rows from North Area 1 in the north and adjacent to North Row 1 and 2; South to the middle third row, adjacent to the west and west of the central district; From west to west oil-water transition zone; East to 112# fault. The geological reserves are 11.219 million tons, the sandstone of Gaotaizi reservoir is 74.7m, effective 30.2 m, five-point Fab well, 78 oil wells, 73 wells, 49 wells and 38 wells are opened, the annual water cut is 90.2%, the annual injection-production ratio is 1.21, and the cumulative oil production is 5.1521 million tons.
The reservoirs in block B are divided into 4 reservoir groups, 22 sandstone groups and 82 sedimentary units, including 17 sedimentary units in Gao 1 group, 34 sedimentary units in Gao 2 group, 23 sedimentary units in Gao 3 group and 8 sedimentary units in Gao 4 group, and Gao IV 9 enters below the oil bottom. According to the large rivers in Development Zone A—According to the fine geological model of delta sedimentary system and the research results of the overall sedimentary facies belt map of development zone A, there are two subfacies (inner delta front subfacies and outer delta front subfacies) and five types of sand bodies in the high I1- high IV18 sedimentary units in block B. That is, delta inner front branch-net sand body, delta inner front dry branch sand body, delta inner front lump sand body, delta outer front stable sand body and delta outer front unstable sand body.

2. Establish experience gallery and summarize potential tapping objects

2.1. Poor reservoirs account for a large proportion and are the main targets for tapping potential in the near future

According to 26 water drive fracturing wells in 2018, 212 sedimentary facies belt maps and grid maps are drawn. Combined with reservoir development characteristics and remaining oil numerical simulation results, analysis is carried out by well groups, single wells and units, and a measure analysis experience gallery is established. Contents include: fracturing target layer, remaining oil type, sedimentary facies belt map of target layer, target layer grid map, target layer oil saturation map, simulated fluid production, water absorption profile and whole well grid map, summarizing the rules of well and layer selection and guiding the potential tapping direction.

Through comprehensive investigation and comparative analysis, it is concluded that the 106 target layers of 26 water flooding fracturing wells are divided into 6 remaining oil types, namely, poor oil layer type, imperfect injection-production type, interlayer interference type, fault edge and other retention areas type, river channel edge type and oil layer position deterioration type. Among them, poor reservoir type remaining oil accounts for the largest proportion, which is 36.8%, followed by imperfect injection-production type remaining oil, accounting for 27.4%.

![Figure 1. Proportion of remaining oil types in 106 layers of 26 fracturing wells in water flooding](image)

2.2. Fine understanding of poor oil layers and clear potential sand bodies

According to sand body distribution pattern and oil-water well connectivity, poor reservoirs are divided into five types, namely, filling contiguous, edge bridging (thin injection and thick production), lump distribution, edge bridging (thick injection and thin production) and poor contiguous development. Among them, the single sand body has the highest oil increase level after fracturing, with the interval ratio accounting for 68.3% and the oil increase intensity reaching 1.4t/m.
Figure 2. Relationship between different types of sand bodies and oil enhancement intensity

3. Establish a unit-level potential pool to reserve the potential of well layers

With the goal of improving the precision of measures to tap potential, all kinds of fine tracing results are fully applied, and the potential analysis at sedimentary unit level is strengthened according to the summarized rules, so as to form a potential pool of measures with oil to find and wells to provide guarantee for realizing targeted adjustment and accurately tapping potential.

It takes 3 hours to manually screen potential well numbers in a sedimentary unit, which is very inefficient. It only takes 5 minutes to screen potential well numbers in a sedimentary unit in Block B by using this process, and the efficiency has been greatly improved.

Figure 3. Flow chart of potential pool of sedimentary unit level measures

The potential block B is selected as the object, and there are many faults in the northeast of this area, and there are fault-shielded remaining oil. Before encryption, it belongs to anti-nine-point mining, and there is residual oil with uncontrollable well pattern. Since 2014, a total of 11 oil and water wells have been shut down due to casing damage, accounting for 21.6% of the total number of wells in the whole
region, and there is residual oil with imperfect injection and production at well points. To sum up, it is considered that the remaining oil in this area is rich. The potential of 127 oil and water wells in this block is tapped by sedimentary units, and the potential pool of sedimentary unit-level measures is established.

At present, the new and old wells in Block B have been fully investigated, with 37,017 sedimentary units and 7,034 potential units of poor reservoir type, accounting for 19%. It can be recognized from Figure 4 that there are four remaining oil types of poor reservoir type in this block, namely, filling contiguous, edge bridging (thin injection and thick production), edge bridging (thick injection and thin production) and contiguous poor development type, without lump distribution. Among them, there were 3588 contiguous poorly developed types, accounting for 51.0%. Sorting according to different potential types and the proportion of units from high to low makes the well selection and layer selection of measures more detailed and provides guarantee for tapping the potential of measures.

![Figure 4. Distribution of potential types of poor reservoirs](image)

After classifying potential types, sum up all potential units of each well, and finally calculate the proportion of potential units to the total number of units of the whole well. Combining the proportion of single well potential units in Table 2 with the dynamic data, 10 fracturing wells are selected.

4. Application effect analysis

According to the above results, seven schemes have been designed, and two have been implemented, with an initial daily oil increase of 7.9 tons per single well. Taking well C as an example, it belongs to five-point Fab well, which is connected with three water wells. The interval sandstone thickness accounts for 34.13% of the whole well, and the interval effective thickness accounts for 39.68% of the whole well. The oil increase at the initial stage of the measures is 11.27 tons, which is 6 tons more than the scheme design, and the cumulative oil increase is 943.3 tons. Through timely cultivation and protection before and after the measures, and timely production release, the production level has obviously increased, and remarkable fracturing effect has been achieved.

On December 6, 2018, the connected water well D of Well C was cultured before pressure, and the injection allocation was increased from 70 cubic meters to 90 cubic meters. After the water was raised in the fractured zone, a certain injection-production pressure difference was increased, which could well improve the production and spread degree in a period of time.

After fracturing the well on March 19, 2019, the pump was changed to 44 mm → 70 mm. The reservoir energy is suddenly released, the bottom hole flowing pressure increases, and the production pressure difference is obviously reduced. In order to enlarge the production pressure difference, the oil well has been adjusted, and the flushing times have been adjusted twice, from 6n/min to 7n/min, and from 7n/min to 8n/min. After fracturing, 3 water wells are protected and adjusted, 80 cubic meters of water is pumped for fracturing target layer, and injection allocation of water wells in fracturing well area is adjusted in time to keep injection-production balance and extend the effective period of fracturing stimulation.
5. Summary

(1) In the later stage of development, it is more and more important to select wells and layers by fracturing technology. Fracturing the remaining oil of poor reservoir type can effectively improve the production degree and development effect.

(2) Fully combine the dynamic and static data, and know the potential of fine sedimentary unit level, so as to make the well and layer selection more accurate.

(3) Clearly implementing the potential distribution and applying it to all blocks in the whole region will greatly guarantee the effect of the measures and enhance the development level.

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