Analysis on fracturing effect of polymer flooding oil layer III1-9 in North Region I

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Abstract-Fracturing, as an important means to tap potential remaining oil and alleviate three contradictions, has a great contribution to the completion of production. Since the implementation of measures to increase oil and create efficiency project in 2017, the fracturing effect has been greatly improved. This paper analyzes the development characteristics and production status of the reservoir, and expounds the necessity of fracturing in this block. Taking a single well as an example, this paper analyzes two types of Wells with the purpose of low-efficiency well treatment and thick-layer well fracturing effect from the aspects of well selection conditions, development status, measure technology, measure effect and post-pressure protection, etc. providing reference for the implementation of the whole process fracturing measures in the block of the second-class reservoir.

1. Introduction
Due to high production pressure in recent years, the number of fracturing wells has been high, especially from 2013 to 2016, with the average number of fracturing Wells approaching 100 each year. However, due to the increasing water cut year by year, the influence of casing loss on injection-production relationship, and the limitation of well selection and layer selection, the oil increase rate at the initial stage of fracturing is still not ideal. Since the implementation of the measures to increase oil and create efficiency project at the end of 2016, we adhere to the problem-oriented, fracturing effect has been improved. The first is the amount of sand added by fracturing. The average amount of sand added by single seam has increased from about 7m³ to 16.5m³. Especially in the transition zone with poor reservoir development, large amount of sand fracturing technology has been applied. In addition, in the polymer block, the well of the type II reservoir in the block B with better whole-process adjustment has broken the boundary of the injection stage, and for the type II reservoir in the block A, the boundary of well selection and layer selection has been broken. Through this series of targeted methods, the fracturing effect has been greatly improved, and the average oil increase per well at the beginning of fracturing is the highest in recent years.

Since 2019, as type II oil layers in the block A and B have gradually entered the later stage of water cut recovery, the fracturing focus has gradually shifted to the other injection. The fracturing effect of the other blocks is analyzed below.

2. Geological overview
The block A is located in the north of Sazhong Development Zone. The block starts from the middle 11 row in the north, extends to the middle 3 row in the south, reaches the Well G and Well H in the west, and reaches the Transition Zone in the east. The oil-bearing area of the second type reservoir block is
7.34km², among which the pure oil area is 6.13km² and the first and second strips are 1.21km². Mining oil layers II1 ~ 9, 150 x 150 m injection-production well spacing, five-point area well pattern. A total of 258 oil and water Wells, including 106 injection Wells and 152 production Wells. The average sandstone thickness of the mining oil layers is 11.7m, the effective thickness is 7.1m, the average effective permeability is 0.530 μm². The geological reserves are 639.6×10⁴t.

3. The necessary of fracture

3.1. The transition zone is poorly developed and requires fracturing

The no. 4 station in the transition zone and its adjacent no. 3 stations are relatively poorly developed. The sandstone thickness, effective thickness and permeability are all lower than the average Wells in the whole region. (see table 1)

| Areas            | Injection station | Injection wells | Production wells | Sand thickness (m) | Effective thickness (m) | Effective permeability (μm²) |
|------------------|-------------------|-----------------|------------------|-------------------|-------------------------|-----------------------------|
| Pure oil areas   | 1#                | 34              | 37               | 14.0              | 9.1                     | 0.674                       |
|                  | 2#                | 39              | 46               | 12.0              | 7.3                     | 0.550                       |
|                  | 3#                | 33              | 37               | 10.5              | 5.8                     | 0.447                       |
| Transition zone  | 4#                | 30              | 32               | 9.7               | 6.1                     | 0.425                       |
| whole region     |                   | 136             | 152              | 11.7              | 7.1                     | 0.530                       |

3.2. The proportion of effective Wells in pure oil area is low, and the demand fracturing improves the development effect

The block was officially injected with polymer solution on August 15, 2017. By the end of 2017, polymer solution 0.06PV had been injected. There were 13 effective Wells in the pure oil area, and the effective well proportion was 10.2%, which was lower than the level of other type II polymer flooding blocks, and the fracturing efficiency was required to be improved.

4. Analysis of fracturing measures in Duandong of North No.1 Area

Since polymer injection, fracturing measures have been taken to comprehensively treat the two types of Wells and improve the connectivity of oil reservoirs in order to promote the balanced effect in the block. First, for Wells with low fluid yield and poor effect, full-well fracturing or thin-layer fracturing is implemented to treat low-efficiency wells. The second, it is to carry out fracturing transformation for Wells with effective trend to promote effective results.

4.1. Low efficiency well treatment

4.1.1. Production overview

Taking Well E as an example, the well is located in the transition zone and is a side well on the south side of the block. The reservoir is poorly developed and the permeability is only 0.42 m². Since the injection of polymer, the liquid volume of production has been decreasing gradually, the daily production fluid and flow pressure are obviously lower than the average level in the whole area, the water cut fluctuates, and there is no obvious effect trend. The connected well has good injection condition, and the ratio of injection volume and production volume is relatively high, so the low-efficiency well treatment is implemented for this well.

4.1.2. Reservoir development situation

According to the planar sedimentary facies map and longitudinal grid diagram, channel sand is developed in SIII1 unit, while non-channel sand is developed in other sedimentary units, and it is mostly
located at the edge of channel sand, and the communication between the well and the well is mostly of the third type. So this well has greater remaining oil potential. (see figure 1)

**Figure 1** Grid diagram and sedimentary facies belt diagram in Well E

### 4.1.3. Fracturing technology
According to the properties of different layers, multiple fracturing techniques are optimized to carry out fracturing reconstruction of the well. The SII 1 oil layer developed by channel sand was fractured to release the productivity power near the well zone. Multi-fracture fracturing is performed on SII 2 and SII 7-8 with many thin oil layers; Selective fracturing is performed on the highly heterogeneous SII 3-4 and SII 8-9 oil layers. With SII 3-4, for example, the oil layer developed thin-and-poor sand I, at the same time its connected water well developed poorer oil layer and the degree of perfection of it is low. Sand body below, located in the edge of the channel sand, can improve the connectivity between oil and water Wells after fracturing, mining the remaining oil of phase transformation zone. So we use selective fracturing techniques, temporary plugging in the upper part of thin-and-poor sand I, pressure the lower part of thin-and-poor sand body II. In addition to the SII 1 oil layer, the amount of sand added to the single seam of the other thin-and-poor oil layers is 11-15m³. The amount of sand is increased and the conductivity of the fluid of fracture is improved.

### 4.1.4. Fracturing effect and post-pressure protection
At the initial stage of fracturing, 45t was added and the liquid level was located at the wellhead, which significantly improved the low efficiency. Aiming at the situation of high submersion after pressure, the stroke was increased and the liquid production was further increased. At the same time, The injection volume of the two connected Wells was increased by 20m³ to ensure the liquid supply capacity of the well group. With the effect of polymer injection, water cut further decreased.

### 4.2. Increased development efficiency by fracturing

#### 4.2.1. Production overview
Take well F as an example. This well is located in the pure oil region and the reservoir is poorly developed. Since the polymer injection, the water cut in this well shows a downward trend, but the liquid
production level also drops greatly. At the same time, the fluid production and flow pressure are obviously lower than the average level in the whole area. The injection capacity of injection Wells around is better and the ratio of the injection and production is relatively high. Therefore, the well was fractured to increase efficiency.

4.2.2. Reservoir development situation
The development status of each unit can be judged by the sedimentary facies map. Except for SII2a unit located inside the channel sand, other sedimentary units are mostly located in phase transition areas such as the edge of banded sand body, which has the remaining oil potential. (see figure 2)

![Figure 2 Grid diagram and sedimentary facies belt diagram in Well F](image)

4.2.3. Fracturing technology
In terms of optimal design, fracturing technology is optimized according to the development characteristics of different layers. Taking the selective multi-fracture fracturing process implemented in the first oil layers as an example, the well-developed high aquifer section above is temporarily blocked, and then the multi-fracture fracturing is performed at the bottom of the oil layers, so as to achieve the purpose of exploiting the remaining oil in the thin layer. The average amount of sand added per layer in this well reaches 15m3, and the fracture length reaches 35m.

4.2.4. Fracturing effect and post-pressure protection
In the initial fracturing stage of this well, the increase of fluid was 24t, the increase of oil was 5.3t, and the water cut decreased by 7.72%. With the progress of polymer injection, the water cut showed a trend of continuous decrease. At present, the oil production level is still above 2t, and the accumulated oil increase is over 1900t.

Up to now, a total of 69 fracturing Wells have been fractured in the block, including 24 Wells with increased fracturing efficiency. The average daily fluid increase of a single well at the initial stage of fracturing was 47t, the daily oil increase was 4.53t, and the water cut decreased by 2.4%. In addition, 45
low-efficiency Wells were treated. At the initial stage of fracturing, the average daily increase fluid of a single well was 51t, the daily increase oil was 2.97t, and the water cut decreased by 2.6%. The fracturing efficiency of the block is positively correlated with the development of the reservoir, that is, the response condition of the well-developed area is better, while the number of response Wells in the relatively poorly developed station is closely related to the number of fracturing Wells.

5. Conclusions
(1) The oil layers development of the block A gradually deteriorates from west to east, and the effective Wells are mainly concentrated in the well-developed no. 1 and no. 2 stations and the measures have a high proportion in the No.4 station.
   (2) Appropriately increasing sand volume is helpful to improve fracturing effect.
   (3) Full well fracturing should be the main treatment for low efficiency Wells. After the liquid production level is improved, water cut can be further reduced with the progress of polymer injection.

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