Analysis on the effect of comprehensive adjustments measures for the Second Type Reservoir in the Eastern Block of Beierxi

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Abstract. The second type reservoirs in the Eastern Block of Beierxi were put into production in December 2005 and October 2009. The block, a total of three production stages: the first stage (September 2009 - January 2015) for the production of initial water flooding production stage, perforated SII1- SII15+16 reservoir groups, and product some series adjustments in November 2014, blocking SII1-9 reservoir group, opening SIII reservoir group; The second stage (From January 1, 2015 to May 8, 2015) is the pre-slug stage of polymer injection; The third stage (From May 8, 2015 to the present stage) is the ternary main slug stage, entering the effective period. This article based on the fine reservoir geological characteristics of anatomy, using fine geologic research results, combined with the notes in the process of ternary dynamic reflection, and we also targeted comprehensive measures in order to adjust the work, control water cut increase rate, improve the block effect situation, and ultimately maximize recovery.

Keyword: Comprehensive measures; maximize recovery; ternary flooding.

1. Introduction
The second type of reservoir in the Eastern Block of Beierxi was put into production in December 2005 and October 2009. The target reservoir SII10+11-SIII10 was developed with $796 \times 10^4$ t geological reserve and $1411 \times 10^4$ m$^3$ pore volume. A total of 276 injection and production Wells were distributed, including 139 production Wells and 137 injection Wells[1-2]. At present, the injection rate is 0.17 PV/A, the concentration is 2021mg/ L, the concentration of alkali is 1.2%, the surfactant is 0.3%, the cumulative injection solution is $2513.4 \times 10^4$ m$^3$, the cumulative injection pore volume is 0.2825PV, the polymer dosage is $529.7PV \cdot mg/L$, the cumulative injection and production ratio is 0.86, the cumulative liquid production is $2881.3 \times 10^4$ t, the cumulative oil production is $202.29 \times 10^4$ t, the geological reserve recovery degree is 48.11%[3-5].

The eastern block developed 18 sedimentary units, higher than that of the west block, and channel sand drill encounter rate was 24.98%, below the brigade north west block oil and trials, high flooded thickness ratio 77.65%, higher than that of the west block, before injecting polymer the water cut is 94.55% , center shaft well number ratio of 52.9%, higher than that of the west block.
2. The analysis of the main problems and causes of block development

2.1. After the injection of ternary, some produced Wells did not see obvious displacement effect
By the end of 2015, there were 101 effective Wells in the block, 38 Wells with no obvious effect, accounting for 27% in the whole region. The average daily production of liquid was 51.4t per well, the daily production of oil was 2.4t, the water cut was 95.4%, and the concentration of accumulation was 325mg/L. Compared with that before the effective date, the daily production of liquid decreased by 10.8t, the daily production of oil decreased by 0.9t, and the water cut increased by 0.6%. Combined with dynamic and static data analysis, it is concluded that the main reasons for the effect are less remaining oil, low degree of injection and production system, and poor reservoir development.

2.1.1. The development of reservoir affects the development effect. From the point of view of each sedimentary unit, the poorly affected Wells are mainly concentrated in the parts with relatively narrow channel development and relatively poor continuity of sand body. The average sandstone thickness, effective thickness and formation coefficient are 12.1m,5.9m, and 1.604 m²·m, which are 4.1m, 4.8m and 2.57 m²·m lower respectively than that of the whole region (average sandstone thickness is 16.2m, effective thickness is 10.7 m, formation coefficient is 4.178 m²·m). After injecting ternary, the average daily production of liquid per well was 30t, and the average daily production of oil per well was 1.2t, 10.8t lower than that of the whole region [6-8].

2.1.2. The high degree of water flooding affects the development effect. 16 Wells did not see obvious effects due to high water flooding degree. The water-flooded thickness ratio of these Wells was 11%. After ternary injection, the average liquid production per well was 72t/d, oil production was 3t/d and water cut was 95.83%.

2.1.3. The low well pattern perfection degree influenced the development effect. A total of 9 Wells with no obvious effect were subjected to 2.7 effective direction on average, 0.4 of which were lower than that of the whole region. As can be seen from the effects of affected Wells in different locations, 69 central Wells, accounting for 53% of the number of affected Wells, decreased liquid production by 1806t/d, increased oil production by 352t/d, and decreased water content by 14.4 percent compared with that before ternary injection. There were 27 fault Wells, accounting for 20% of the number of affected Wells. Compared with the pre-injection period, liquid production decreased by 560t/d, oil production increased by 130t/d, and water content decreased by 9.7 percent. There were 34 fault Wells, accounting for 26% of the number of affected Wells. Compared with those before ternary injection, fluid production decreased by 1352t/d, oil production increased by 26t/d, and water content decreased by 8.2%. Therefore, the higher the degree of well pattern perfection, the better the development effect.

2.2. Water cut in some production Wells rises rapidly
After ternary injection, water cut in 49 Wells rose rapidly, accounting for 35% of the total number of Wells. The water cut increased from 81% to 82.8%, and the water cut increased by 1.8 percentage points. In the rising Wells, there were 36 Wells with stable rising fluid content, the water cut increased from 78.3% to 81.6%, and the water cut increased by 3.3 percentage points. There were 6 Wells with rising water cut and water cut increased by 2.5 percentage points. From the characteristics of the Wells with no obvious effect, the formation capacity is small, oil saturation is low, a kind of Wells with low connected thickness ratio and less effective direction have a fast rising rate of water cut and poor effective direction[9-10].

3. Analysis of the effect of comprehensive adjustment measures
The east block of reservoir, in order to solve above problems and contradictions, on the basis of fine geologic research results, find out reservoir watered-out degree, the use of state and degree of injection-production perfecting, find out the remaining oil distribution characteristic, through injection adjustment
and optimization of oil and water Wells measures and reasonably to adjust the pressure system, good development effect were obtained.

3.1. Carefully implement ternary flooding injection well adjustment and measures to promote block effectiveness

3.1.1. 148 Wells were adjusted in order to promote the effect of ternary flooding. After the adjustment, injection was increased from 7800m³/d to 7985m³/d and increased by 185m³/d. The injection pressure was increased from 9.9mpa to 10.3mpa and increased by 0.4mpa, the injection concentration was adjusted from 1695mg/L to 1814mg/L, and the injection viscosity was adjusted from 26mPa · S to 29mPa · S. 97 production Wells were connected around. After these adjustments, the fluid yield was 6524t/d, the oil yield was 418t/d, and the comprehensive water cut was 93.6%. Compared with before adjustments, the fluid yield increased by 34.6t/d, the oil yield increased by 74.3t/d, and the comprehensive water cut decreased by 1.11 percentage points.

3.1.2. 20 Wells with low injection pressure and prominent inter-layer and plane contradictions were selected for deep profile control. A profile control system combining water plugging agent CT -- 5 enhanced bulk particle water plugging agent and hlX-077 high strength profile control and sealing agent for oil production was adopted, and particles carried by medium molecular weight polymer solution were used for deep profile control. Profile control has been implemented since January 17, 2015. Profile control radius is 50m and average profile control thickness is 3.5m. After profile control, the average injection pressure increased by 3.5mpa compared with that before profile control, and the injection volume was adjusted to 1240m³/d at 655m³/d. Compared with the 56 surrounding production Wells, the current production fluid is 2770t/d, the production oil is 236.8t/d, and the comprehensive water content is 91.45%. Compared with before profile control, fluid yield decreased by 1355.7t/d, oil yield increased by 42.4t/d, and water content decreased by 3.8 percentage points.

3.1.3. 33 Wells were acidified and 8 Wells were fractured for injection Wells with poor reservoir development and suction conditions. The daily production fluid increased by 780t from 390t to 1169t, the daily production oil increased by 209t from 95t to 304t, and the water cut decreased rapidly from 76.6% to 74%, with a decrease of 2.6 percentage points.

3.1.4. Some injection Wells are adjusted to alleviate the contradiction between layers. After the adjustment of SII reservoirs in the eastern block, the development of SII group was significantly better than that of SIII group, with prominent inter-layer contradictions, which affected the ternary injection effect. In order to alleviate inter-layer conflicts and promote the equilibrium effect of ternary flooding, stratified adjustment was adopted for injection Wells. In December 2015, 90 Wells were completed, accounting for 65.7% of the total number of Wells. After the adjustment, the average injection pressure per well rose from 10.1mpa to 10.2mpa, the injection volume increased from 5385m³/d to 5405m³/d, and the actual injection volume increased from 5385m³/d to 5405m³/d. The 90 Wells were subdivided into 332 layers, including 212 control layers, with the injection strength of 2.1m³/d · m and 120 reinforcement layers, with the injection strength of 5.9 m³/d · m. With an average of 2 ~ 3 injection stages, the average permeability level difference decreased from 15.1 to 9.3.

3.2. Liquid extraction measures of production Wells ensure ternary flooding effect

So far, there have been 24 fracturing Wells. After fracturing, the fluid yield has been 1169t/d, the oil yield has been 304t/d, the comprehensive water content is 74%, and the flow pressure is 2.97mpa. Compared with before fracturing, the fluid yield has increased by 780t/d, the oil yield has increased by 209t/d, and the water cut has decreased by 2.6 percentage points.

After parameter adjustment, the fluid yield was 1222t/d, the oil yield was 174t/d, the comprehensive water cut was 85.7%, and the flow pressure was 4.7mpa. Compared with before parameter adjustment,
the fluid yield increased by 179t/d, the oil yield increased by 33t/d, the water cut decreased by 0.7%, and the flow pressure decreased by 0.83mpa.

86 times are complemented to reduce the parameter. After parameter adjustment, liquid yield was 3649t/d, oil yield was 504t/d, comprehensive water cut was 86.2%, and flow pressure was 2.4mpa. Compared with before parameter adjustment, liquid yield decreased by 565t/d, oil yield increased by 5t/d, water cut decreased by 2%, and flow pressure decreased by 0.29mpa (Table 1).

Table 1. Liquid extraction measures of production Wells

| Project       | Number of well | Liquid yield Before (t/d) | Oil yield Before (t/d) | Water cut Before (%) | Flow pressure Before (MPa) | Liquid yield After (t/d) | Oil yield After (t/d) | Water cut After (%) | Flow pressure After (MPa) |
|---------------|----------------|---------------------------|------------------------|-----------------------|---------------------------|-------------------------|---------------------|-----------------------|--------------------------|
| Fracture      | 24             | 390                       | 95                     | 76.6                  | 2.88                      | 1169                    | 304                 | 74                    | 2.97                     |
| Increase parameter | 23      | 1042                      | 141                    | 86.5                  | 5.53                      | 1222                    | 174                 | 85.7                  | 4.7                      |
| Reduce parameter | 86      | 4214                      | 499                    | 88.1                  | 2.11                      | 3649                    | 504                 | 86.2                  | 2.4                      |
| Sum           | 123           | 5468                      | 681                    | 87.5                  | 2.83                      | 5710                    | 885                 | 84.5                  | 2.89                     |

4. Achieving development effect

The blocks in the January 2015 began to firstly inject polymer slug, on May 8, 2015, the blocks went into ternary main slug injection, the injection speed is 0.17 pv/a, the concentration of 1930 mg/l, alkali concentration 1.2%, 0.3% surface active agent, cumulative injection solution 2513.4 x 10⁴ m³, cumulative injection pore volume 0.2825 pv, 529.7 mg/l polymer injection amount, accumulated injection-production ratio of 0.86, the cumulative produced fluid volume 2881.3 x 10⁴ t, the cumulative oil production 202.29 x 10⁴ t, geological reserves recovery degree of 48.11%.

4.1. The injection pressure rose steadily and the injection rate remained stable

At present, the injection pressure in block has been rising steadily, mainly in the range of 8-10mpa and 10-12mpa. Compared with blank water flooding stage and pre-polymer slug stage, the injection pressure has increased as well. The proportion of Wells which are less than 8MPa has decreased from 22.06% to 7.3%, and the proportion of Wells with 10-12mpa has increased from 25.0% to 45.26%.

4.2. Formation pressure shall be kept within a reasonable range

In 2015, there were 16 Wells with continuous pressure measurement data, formation pressure was 10.40mpa, total pressure difference was 0.15mpa, and annual pressure difference was -0.01mpa. Compared with 2014, the percentage of Wells with a total pressure difference which are greater than 1.0MPa declined from 31.3% to 25.0%, and those with a total pressure difference less than -1.0MPa declined from 31.3% to 18.7%. The number of Wells within the reasonable range of -0.5MPa to 0.5MPa increased by 25.0 percentage points from 12.5% to 37.5%. The proportion of the number of Wells in the high and low pressure well area decreased as well, and the pressure imbalance was effectively improved (Table 2).

Table 2. The differences of formation pressure in two years

| Time | Numbers of wells | Original pressure (MPa) | Static pressure (MPa) | Flow Pressure (MPa) | Total differential pressure (MPa) |
|------|-------------------|-------------------------|-----------------------|---------------------|----------------------------------|
| 2014 | 16                | 10.25                   | 10.41                 | 3.88                | 0.16                             |
| 2015 | 16                | 10.25                   | 10.4                  | 3.59                | 0.15                             |
| ratio|                   | -0.01                   | -0.29                 | -0.01               |                                   |
4.3. The water cut continues to decline, and the production Wells take effect successively
So far, 130 production Wells in class II reservoirs in the eastern block have been affected, accounting
for 94% of the total number of Wells. At present, the liquid yield is 5694t/d, the oil yield is 964t/d, and
the water cut is 83.1%. Compared with that before polymer injection, the liquid yield has decreased by
4344t/d, the oil yield has increased by 484t/d, and the water cut has decreased by 12%. At present, 28
Wells, accounting for 20% of the total number of Wells, have seen their water content drop by more
than 25%. Liquid yield was 1060t/d, oil yield was 373t/d, water content was 64.8%, liquid yield was
decreased by 1043t /d, oil yield was increased by 241t/d, water content decreased by 28.9%. 33 Wells,
accounting for 23% of the total number, saw water cut down by 15-25 percentage points, with fluid cut
down by 1160t/d and oil cut down by 257t/d, with water cut down by 77.8%. Compared with before the
effect, fluid cut down by 1083t, oil cut up by 137t and water cut down by 16.8%. There were 21 Wells,
accounting for 15% of the total number of Wells, with a water cut of 948t/d and 144t/d, with a water cut
of 84.9%. Compared with before the effect, the daily fluid cut of 648t, the daily oil cut of 74t and the
water cut of 10.7%. 27 Wells, accounting for 19% of the total number of Wells, had water cut of 1396t/d
and oil cut of 139t/d. Compared with before the effect, daily fluid cut of 576t, daily oil cut of 54t and
daily water cut of 5.6%. There were 21 Wells with a water cut of 3-5%, accounting for 15% of the total
number of Wells, producing 1128t/d fluid, producing 53t/d oil, with water cut 95.3%. Compared with
before the effect, the daily production fluid decreased 369t, the daily production oil increased 4t, and
the water cut decreased 1.5percentage points.

5. Conclusions and understanding
By combining the development characteristics, production dynamics and optimization of comprehensive
treatment measures of the second-class reservoirs in the Eastern Block of the second class reservoirs,
the reservoir potential is maximized and the underground situation of the whole block is in a benign
state.

Adhere to the principle of "frequent tracking, frequent adjustment and frequent combination", and
timely adjust the plan according to the dynamic change characteristics of the produced well, which can
effectively control the rising speed of water cut of the well.

Fracturing measures can effectively alleviate the contradictions of high injection pressure and low
oil well pressure and energy, so as to improve the recovery factor.

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