Research on Comprehensive Treatment Method of Low-Production and Low-efficiency Well

Xu An *

Geological Brigade of the Second Oil Production Plant of Daqing Oilfield Co., Ltd.,
163000, China

*Corresponding author Email: c2anxu@petrochina.com.cn

Abstract. In recent years, low-yield and low-efficiency wells are increasing year by year, which seriously affects the overall development effect of the development zone. On the basis of field investigation, combined with the actual situation, this paper deeply analyzes the causes of low-yield and low-efficiency wells, studies the treatment methods of different types of low-yield and low-efficiency wells, and summarizes the treatment method of "focusing on adjusting water injection wells and using pressure to supplement and plug production wells". At the same time, combined with a series of supporting measures to tap the potential, the method of tapping the potential is continuously optimized, and the treatment scheme of single well measures is formulated one by one.

Keywords: Low yield and low efficiency, Causes, Governance.

1. Questions raised
Since the S Development Zone was put into production, with the gradual deepening of oilfield development and the successive production of infill adjustment wells, the recovery degree of the oilfield has been increasing and the distribution of remaining oil has become increasingly scattered. In different development periods, affected by formation conditions, technological level and ground conditions, a number of low-yield and low-efficiency wells appeared one after another, which seriously affected the development effect of water flooding. In 2020, on the basis of implementing the low efficiency causes and remaining oil potential of existing low production wells, combined with a series of supporting potential tapping measures, continuously optimize the potential tapping methods, and formulate single well measures treatment plan by well.

2. Cause analysis of low production and low efficiency wells

2.1. Current situation of low efficiency production wells
By the end of December 2019, there are 697 oil production wells with daily oil production less than 0.5T for six consecutive months, accounting for 12.9% of the total number of water drive wells in the region. Average single well perforated sandstone thickness is 20.5m, effective thickness is 6.2m, daily liquid production is 8.8t, daily oil production is 0.3t, comprehensive water cut is 96.56%, and cumulative oil production is 2.5013×10^4t.
According to well pattern distribution, there are 60 inefficient wells in basic well pattern, 104 inefficient wells in primary infill adjustment, 366 inefficient wells in secondary infill adjustment, 90 inefficient wells in tertiary infill adjustment and 77 inefficient wells in Gaotaizi well pattern.

### Table 1. Distribution of inefficient wells in 2019

| Classification | Series of strata                     | Number of wells (wells) | Penetration thickness | Current situation |
|----------------|--------------------------------------|-------------------------|-----------------------|-------------------|
|                |                                      |                         | Sandstone (m) | Active (m) | Daily liquid production (t) | Daily oil production (t) | Water content (%) | Sinking degree (m) | Accumulated oil quantity (×10⁴ t) |
| Pure oil area  | Basic well pattern                   | 60                      | 25.8          | 12.2       | 11.0 | 0.3 | 97.19 | 253.7 | 11.1302 |
|                | Primary encryption adjustment well    | 104                     | 23.8          | 8.9        | 9.4  | 0.3 | 96.69 | 190.5 | 5.1698  |
|                | Secondary encryption adjustment well  | 173                     | 20.38         | 5.16       | 8.3  | 0.3 | 96.39 | 230.8 | 1.2227  |
|                | Tertiary infill adjustment well      | 90                      | 16.3          | 2.9        | 8.3  | 0.3 | 96.66 | 192.6 | 0.4929  |
|                | Gaotaizi                             | 77                      | 30.6          | 9.5        | 7.5  | 0.3 | 96.06 | 331.0 | 1.8883  |
| Transition zone| Basic well pattern                   | 43                      | 20            | 9.2        | 12   | 0.3 | 97.50 | 254.3 | 1.4258  |
|                | Primary encryption adjustment well    | 193                     | 15            | 4.1        | 9    | 0.32| 96.44 | 221.3 | 0.6678  |
|                | Total                                 | 697                     | 20.5          | 6.2        | 8.8  | 0.3 | 95.66 | 230.3 | 2.5013  |

### 2.2. Cause analysis of low efficiency well

Based on the fine geological research results, combined with the dynamic and static data of oil and water wells and various monitoring data, a comprehensive analysis of 697 long shut-in wells in the whole region was made. The analysis results show that there are seven main reasons for the long-term inefficiency of oil production wells:

1. Due to the high water cut of oil production wells caused by multi-layer flooding, there are 50 such wells, with an average perforated sandstone thickness of 20.7m, an effective thickness of 7.4m, a daily liquid production of 21.9t, a daily oil production of 0.37t, a comprehensive water cut of 98.29%, and a cumulative oil production of 43021t, which have little potential for tapping.

2. For some oil production wells in basic well pattern and primary infill well pattern, due to the long production time, the cumulative oil production of oil wells is close to the controllable recoverable reserves of single well, with high recovery degree, reduced remaining recoverable reserves and decreased daily oil production level, resulting in inefficient wells. There are 54 such wells, with average drilled sandstone thickness of 26.7m, effective thickness of 10.2m, daily liquid production of 9.2t, daily oil production of 0.35t, comprehensive water cut of 96.25%, and cumulative oil production of 105940t, so the potential of such wells is small.

3. Lack of water injection wells or poor injection-production adaptability of well pattern due to fault shielding and casing damage of water injection wells, resulting in imperfect injection-production in well areas, resulting in insufficient liquid supply in production wells, resulting in inefficient wells. There are 250 such wells, with average perforated sandstone thickness of 16.4m, effective thickness of 4.8m, daily liquid production of 8.5t, daily oil production of 0.3t, comprehensive water cut of 96.41% and cumulative oil production of 24206t. This kind of well mainly combines the adjustment of block injection-production system, overhaul or renewal of water injection wells and other methods to improve the post-treatment of injection-production relationship.

4. Due to the serious longitudinal heterogeneity of multi-reservoir development, the single layer has high water cut, the other reservoirs are in poor production condition, and the interlayer contradiction is prominent, resulting in low-efficiency wells. There are 57 such wells, with an average perforated sandstone thickness of 18.8m, an effective thickness of 5.0m, a daily liquid production of 8.6t, a daily oil production of 0.3t, a comprehensive water cut of 96.51% and a cumulative oil production of 11703t. This kind of low-efficiency well has low recovery degree and great potential for tapping remaining oil, which is mainly treated by fracturing and other stimulation measures.
(5) The perforated thickness of oil wells is small, and the controllable reserves of single wells are small. At present, the remaining recoverable reserves of perforated oil layers are small, resulting in inefficient wells. There are 89 such wells, with an average perforated sandstone thickness of 13.6m, effective thickness of 1.7m, daily liquid production of 7.7t, daily oil production of 0.26t, comprehensive water cut of 96.61% and cumulative oil production of 6288t. At present, this kind of well has little potential for drilling remaining oil in oil layer, and it is difficult to treat it, so it can be considered to replenish new oil layer.

(6) The physical properties of oil layers in the transitional zone are poor, the water absorption capacity of some water injection wells is poor, and the production level of oil production wells is low. In particular, due to the small number of injection wells and poor water absorption capacity in the four strip areas, the single well productivity of oil wells is low. There are 164 such wells, with an average drilled sandstone thickness of 16.4m, effective thickness of 4.7m, daily liquid production of 8.5t, daily oil production of 0.31t, comprehensive water cut of 96.41% and cumulative oil production of 8133t. Such wells can be comprehensively treated in combination with block encryption adjustment, and tap potential under the condition of improving injection-production relationship.

(7) Due to the serious casing change, it is difficult to control, which leads to low efficiency of oil production wells. There are 30 such wells, with an average perforated sandstone thickness of 22.0m, an effective thickness of 6.5m, a daily liquid production of 8.3t, a daily oil production of 0.32t, a comprehensive water cut of 96.14% and an accumulated oil production of 16408t.

| Table 2. Statistics on the causes of inefficient wells in 2019 |
|---------------------------------------------------------------|
| Reason classification          | Number of wells (wells) | Penetrate sandstone (m) | Open effective (m) | Daily liquid production (t) | Daily oil production (t) | Water content (%) | Sinking degree (m) | Accumulated oil production (t) |
|--------------------------------|-------------------------|-------------------------|--------------------|-----------------------------|-------------------------|------------------|------------------|-------------------------------|
| Multilayer high water cut     | 50                      | 20.74                   | 7.44               | 21.86                       | 0.37                    | 98.29            | 281.57           | 4.3021                        |
| Injection production is not perfect | 250                     | 24.33                   | 7.82               | 6.77                        | 0.29                    | 95.73            | 232.98           | 2.4206                        |
| Single layer high water cut   | 57                      | 20.74                   | 7.44               | 21.86                       | 0.37                    | 98.29            | 215.27           | 1.1703                        |
| The opening thickness is small | 89                      | 13.61                   | 1.75               | 7.73                        | 0.26                    | 96.61            | 205.40           | 0.6288                        |
| High recovery                 | 57                      | 25.89                   | 9.95               | 9.22                        | 0.35                    | 96.25            | 239.10           | 10.5940                       |
| The condition of transition zone is poor | 164                     | 16.44                   | 4.76               | 8.50                        | 0.31                    | 96.41            | 222.89           | 0.8133                        |
| Serious casing deformation    | 30                      | 22.03                   | 6.50               | 8.29                        | 0.32                    | 96.14            | 237.81           | 1.6409                        |
| total                         | 697                     | 20.45                   | 6.22               | 8.82                        | 0.30                    | 96.60            | 230.28           | 2.5102                        |

3. Study on treatment method of low efficiency oil recovery well

3.1. The principle of low efficiency well treatment
The treatment of inefficient wells should focus on economic benefits, adhere to the principle of staging in batches, from easy to difficult, and gradually optimize the treatment methods on the basis of gradually summing up experience. In 2020, we will carry out the long-term well shut in treatment technology, carry out the research on the technology integration method, and consider the surface and underground uniformly to ensure the effective development of the oilfield.

On the basis of careful analysis of the causes of inefficient wells, the production potential of oil production wells and the treatment potential of water injection wells in well areas are clearly defined. In addition, taking into account the improvement of the overall benefits of well groups and blocks, the treatment method of "focusing on adjusting water injection wells and using pressure to supplement and plug production wells" is summarized, with specific principles:

First, aiming at the infill adjustment oil production wells and Gaotaizi oil production wells with low single-layer water breakthrough recovery, optimize the fracturing technology, implement the fracturing transformation and improve the seepage conditions of thin and poor oil layers. At the same time, the
methods of fracturing, acidizing and subdividing water injection are adopted to improve the water absorption capacity of water injection wells.

Second, for low-efficiency oil production wells with small perforated thickness and less controlled remaining recoverable reserves, take supplementary hole measures to tap the potential.

Thirdly, according to the development plan of block polymer flooding, the thick oil layer is replenished for the inefficient wells with imperfect injection and production at the edge of fault or the remaining oil-rich area of fault block, and the injection-production relationship of polymer flooding sand body is improved.

Fourthly, aiming at the production wells with imperfect injection and production that lack of connected water injection wells, the methods of connecting water injection wells for overhaul, renewal, sidetracking, injection diversion or infill adjustment are adopted to improve the injection-production relationship and tap the remaining oil potential.

Fifthly, in order to solve the problems of poor water absorption and prominent interlayer contradictions in water injection wells in well areas, fracturing, acidizing, subdivision and heavy division of water injection wells are carried out to further optimize the water injection structure in well areas, thus improving the production capacity of oil production wells.

3.2. Field test study

In 2020, on the basis of the principle of inefficient well treatment, there are five main methods to treat oil production wells with treatment potential:

1) Production well fracturing

The fracturing potential of oil wells is mainly concentrated in the oil wells with rich residual oil, imperfect injection and production, and the production wells with thin and poor layers that are not used or with low production degree due to interlayer contradictions. According to the relationship between injection and production, sand body connectivity and formation energy, the specific fracturing methods are determined: for potential non energy production wells, pressure drive fracturing method is adopted; for relatively perfect injection production, thin injection thick production and insufficient formation energy, moderate scale fracturing method is adopted; for relatively perfect injection and production, small injection production well spacing or relatively good connection between oil and water wells, the specific fracturing method is determined Common fracturing method. We closely combine the fine geological research results with the new fracturing technology, continuously optimize the fracturing scheme design, optimize the fracturing construction scale and construction technology, improve the individualized design of the scheme, and ensure the oil increase effect of fracturing. In 2020, a total of 30 fracturing wells were implemented. After fracturing, the single well increased liquid by 34.8t, increased oil by 2.9t and increased oil by $1.78 \times 10^4$ t annually.

Table 3. Fracturing effect statistics of low-efficiency oil production wells

| Fracturing mode          | Number of wells (wells) | Fracturing thickness | Production situation before pressing | Production after pressing |
|-------------------------|-------------------------|----------------------|--------------------------------------|--------------------------|
|                         |                         | Sandstone (m)        | Sandstone (m) | Daily liquid production (t) | Daily oil production (t) | Water content (%) | Sinking degree (m) | Daily liquid production (t) | Daily oil production (t) | Water content (%) | Sinking degree (m) |
| Ordinary fracturing      | 15                      | 4.2                  | 2          | 11.6 | 0.35 | 96.98 | 174.9 | 31.6 | 2.3 | 92.72 | 225.6 |
| Moderate scale fracturing| 10                      | 5.3                  | 1.8        | 7.7  | 0.32 | 95.84 | 199.7 | 42.7 | 3.3 | 92.27 | 224.7 |
| Pressure drive           | 5                       | 10.1                 | 4.5        | 7.4  | 0.36 | 95.14 | 141.8 | 86.4 | 5.4 | 93.75 | 314.5 |
| Total                   | 30                      | 5.5                  | 2.4        | 9.6  | 0.34 | 96.44 | 177.7 | 44.4 | 3.2 | 92.79 | 240.1 |

2) Hole repairing of production well

For the low efficiency oil production wells with small perforation thickness and less controlled remaining recoverable reserves, the measures of hole filling are adopted to tap the potential, combined
with the field test of profile control and flooding, and the hole filling at the fault edge. In 2020, a total of 10 wells will be supplemented, and the daily liquid production and oil production of single well will be 22.4t, 2.5t and $0.64 \times 10^4$t respectively.

3) Overhaul of water injection wells in well area

The recovery of water injection is carried out in the well area with low production and low efficiency due to the water injection well to be overhauled. There are 20 water injection wells in the production well area to be overhauled and shut in. According to the treatment plan in 2020 and the surface conditions, 17 water injection wells connected with 16 production wells were overhauled. After the overhaul, the daily water injection is 203m$^3$, and the annual cumulative oil production of 16 production wells is $0.32 \times 10^4$t.

4) Measures to increase injection in injection wells

In view of the low production and low efficiency of production wells due to poor water absorption of water injection wells, measures are taken to increase water injection in water injection wells. The principles to be followed in well selection are as follows: the difference between allowable pressure and injection pressure is not greater than 0.5MPa, the water nozzle of measure layer has been adjusted to the maximum, and the measure layer is in the direction of pressure relief. According to the reasons of water injection wells can not be allocated, sand body connectivity and reservoir production status, the specific measures are determined: for the water injection wells with poor reservoir development and unbalanced production, and the difference between injection allocation and actual injection is greater than 30m$^3$, fracturing of injection wells is implemented. Acidizing of water injection wells is carried out for the water injection wells with reservoir pollution and balanced production. In 2020, a total of 20 wells will be increased by water injection well measures. After the implementation, the daily water injection of single well will be increased by 30m$^3$, and the annual cumulative oil production of 10 production wells will be $0.1 \times 10^4$t.

5) Injection production system adjustment

In view of the low efficiency wells formed due to imperfect injection and production and poor perforation correspondence of oil-water wells, we improve the injection production relationship by converting oil production wells into injection wells, filling holes in water injection wells and updating, so as to further tap the potential of remaining oil. In 2020, a total of 2 production wells will be converted into injection, 3 renewal wells, 2 water injection wells will be re drilled, and 1 new well will be injected, with an annual increase of $11.68 \times 10^4$m$^3$, and the annual cumulative oil production of 10 low efficiency wells will be $0.2 \times 10^4$t. In 2020, 76 low efficiency wells will be treated and the annual cumulative oil production will be $3.04 \times 10^4$t.

4. Some understandings

1) Based on the fine geological research results, combined with the dynamic and static data of oil and water wells and various monitoring data, it is the key to control inefficient wells to accurately analyze the causes of low-yield and inefficient wells.

2) It is the most direct and effective way to control inefficient wells to implement stimulation measures for oil production wells. However, from the long-term effect, it is more economical to treat and adjust the water injection wells in the well area.

3) The degree of recovery can directly reflect whether the inefficient oil wells have the potential for further treatment.

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