Study on the applicability of sand control fracturing technology in Lamadian oilfield

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Abstract. At present, the proportion of water drive fractured wells is as high as 85.8%, and the proportion of repeated wells is as high as 47.7%. In view of this reality, the potential tapping objects are gradually transferred to isolated sand body, river channel edge and top of thick oil layer. Due to the limited fracture length ratio of conventional fracturing, the potential tapping effect is poor. Therefore, the sand body fracturing method is adopted for this section, that is, increasing the fracturing scale and improving the production degree of oil layer by increasing the fracture length ratio. According to the statistics of the effect of sand control fracturing well, combined with the sand body development characteristics, connectivity characteristics and injection production relationship, the influencing factors of sand control fracturing effect are analyzed, and the applicability of sand control fracturing technology in Lamadian oilfield is clarified.

1. Introduction

With the oilfield development entering into the late stage of ultra-high water cut, the water cut of small layers is further increased, and the remaining oil enrichment parts are gradually reduced. At the same time, the proportion of water drive fracturing wells has reached 85.8%, and the proportion of repeated wells has reached 47.7%. The potential tapping effect is declining year by year. The potential tapping objects are transferred to isolated sand bodies, the edge of river channels and the top of thick oil layers, but the conventional fracturing fracture length ratio is limited, and the potential tapping effect is poor[1].

In recent years, through theoretical and field experimental research, the high-efficiency fracturing technology of fracture controlled sand body has been initially formed, and the design method of fracturing technology for sand control body has been preliminarily established. On the basis of conventional fracturing technology, the fracturing penetration ratio has been optimized, the whole sand body has been controlled by fractures, the seepage distance has been reduced, and the fracturing fluid flowback efficiency and crude oil flow capacity have been improved, so as to realize the effective production of controlled reserves. In order to verify the effect of sand control fracturing technology in Lamadian oilfield, 11 wells were implemented in water flooding in 2019. Based on the quantitative results of remaining oil, this paper analyzes the influencing factors of sand control fracturing effect through statistics of sand body development characteristics, connectivity characteristics and injection production relationship, and makes clear the applicability of sand control fracturing technology in Lamadian oilfield.
2. Distribution characteristics of remaining oil in late stage of ultra-high water cut

2.1. Distribution characteristics of remaining oil
The remaining oil simulation results show that, vertically, the remaining oil is mainly distributed in the top of thick oil reservoir, with an average oil saturation of 44.8%; horizontally, the remaining oil is mainly distributed in isolated sand body and river channel edge, with an average oil saturation of 46.4% in isolated sand body and 45.2% in river channel edge.

| classification           | Statistics of wells | Average oil saturation(%) |
|--------------------------|---------------------|----------------------------|
| Top of thick oil reservoir | 29                  | 44.8                       |
| Isolated sand body       | 21                  | 46.4                       |
| Riverside                | 11                  | 45.2                       |

2.2. Effect of potential tapping measures
During 2016-2020, the number of fracturing wells is decreasing year by year, and the remaining oil enrichment parts are gradually decreasing. Through numerical simulation, the quantitative results of remaining oil are as follows: vertically, the proportion of low UN flooded thickness at the top of thick oil reservoir is reduced from 27% to 18%; horizontally, the remaining oil becomes more scattered, but the remaining oil in isolated sand body and the edge of river channel Oil is still rich, conventional fracturing can not form effective displacement due to the limitation of fracture length, this part of the well is the focus of our potential[2].

| year   | Number of wells | proportion (%) | Diurnal fluid (t) | Daily oil increase (t) | to contain water (%) |
|--------|-----------------|----------------|-------------------|------------------------|---------------------|
| 2016   | 32              | 39.0           | 41                | 4.0                    | -2.1                |
| 2017   | 84              | 56.4           | 48                | 4.1                    | -1.4                |
| 2018   | 52              | 40.3           | 43                | 3.4                    | -1.7                |
| 2019   | 16              | 13.1           | 48                | 4.6                    | -3.3                |
| 2020   | 7               | 10.6           | 45                | 5.1                    | -5.8                |

3. Well and layer selection for fracturing of sand control body and its implementation effect

3.1. Well and layer selection
According to the distribution characteristics of remaining oil and the effect of potential tapping measures, it is analyzed that the remaining oil is mainly concentrated in the isolated sand body and the edge of the river. Through investigation, the sand control fracturing technology is selected. Based on the conventional fracturing technology, it optimizes the fracturing penetration ratio, controls the whole sand body with fractures, reduces the seepage distance, improves the fracturing fluid flowback efficiency and crude oil flow capacity, and realizes the control of reserves Effective use[3].

For this reason, we selected 69 layers from 11 wells, 8 isolated sand bodies and 61 riverside layers.

3.2. Implementation effect

3.2.1. Initial effect analysis
From the results of 11 sand control fracturing measures implemented in 2019, the average daily fluid increase of single well is 59T, daily oil increase is 7.7t, and water cut is decreased by 4.6%. Compared with conventional fracturing, single well increases fluid by 19T, oil increase is 3.9t, and water cut is decreased by 2.9%. One well is less than 3T, accounting for 9.1%, and six wells are more than 8t,
accounting for 54.5%. The potential tapping effect of sand control fracturing is better than conventional fracturing[4].

### Table 3: Initial fracturing effect classification of water drive sand control body in 2019

| Classification | Number of Wells | Proportion (%) | Before Measures | Initial Stage of Measures | Difference |
|----------------|----------------|----------------|-----------------|---------------------------|------------|
|                |                |                | Nissan liquid (t) | Daily oil production (t) | to contain water (%) | Nissan liquid (t) | Daily oil production (t) | to contain water (%) | Nissan liquid (t) | Daily oil production (t) | to contain water (%) |
| Under 3t       | 1              | 9.1            | 28              | 0.7                        | 97.5       | 61              | 1.3                        | 97.9       | 33              | 0.6                        | 97.9       |
| 3t~5t          | 1              | 9.1            | 32              | 3.5                        | 89.1       | 58              | 6.8                        | 88.3       | 26              | 3.3                        | 88.3       |
| 5t~8t          | 3              | 27.3           | 40              | 1.8                        | 95.4       | 81              | 8.6                        | 89.4       | 41              | 6.8                        | 89.4       |
| Above 8t       | 6              | 54.5           | 24              | 1.7                        | 92.8       | 101             | 11.8                       | 88.4       | 78              | 10.1                       | 88.4       |
| Total          | 11             | 100.0          | 29              | 1.8                        | 93.8       | 88              | 9.5                        | 89.2       | 59              | 7.7                        | 89.2       |

3.2.2 Validity analysis

From the effective period of the measures, as of June 2020, 1 well with the effective period of sand control fracturing less than 200 days, accounting for 9.1%, daily fluid increase of 33 T, daily oil increase of 0.6 T and water cut increase of 0.6 percentage point at the initial stage of single well, water cut begins to rise after well opening, and the effective period is 48 days; 3 wells with the effective period more than 400 days, accounting for 27.3%, daily fluid increase of 69 T, daily oil increase of 10.1 T and water cut decrease of 2.0 percentage point at the initial stage of single well After 273 days, the water content began to rise, and the effective period was 483 days.

### Table 4: Classification of fracturing validity period of water drive sand control body

| Validity classification (days) | Number of wells | Proportion (%) | Increasing liquid strength (t/d.m) | Reducing water cut (%) | Connected thickness ratio (%) | Formation pressure (MPa) | Well spacing (m) | Number of water injection wells | Sand addition (m³) |
|------------------------------|----------------|----------------|-----------------------------------|-----------------------|-----------------------------|--------------------------|-----------------|---------------------------------|------------------|
| Under 200                    | 1              | 9.1            | 3.5                               | 0.4                   | 39                          | 10.8                     | 300             | 1.0                             | 200              |
| 200-400                      | 3              | 27.3           | 4.5                               | -3.9                  | 42                          | 11.5                     | 225             | 2.3                             | 165              |
| 300-400                      | 4              | 36.4           | 9.4                               | -5.7                  | 37                          | 11.3                     | 177             | 2.7                             | 193              |
| Above 400                    | 3              | 27.3           | 8.7                               | -4.5                  | 36                          | 11.6                     | 158             | 2.3                             | 99               |
| Total                        | 11             | 100.0          | 7.3                               | -4.6                  | 38                          | 11.9                     | 196             | 2.4                             | 160              |

There were 7 wells with a validity period of more than 300 days, of which 6 wells were mainly located at the edge of the river, accounting for 85.7%. This kind of reservoir has a certain connection relationship and poor seepage capacity. The application of sand control fracturing technology can optimize the fracturing penetration ratio, expand the sweep range of fracture control sand body and form effective displacement.

For example, in the early stage of well L2-3820 after fracturing, the daily fluid increase is 137t, the daily oil increase is 3.7t, the water cut decreases by 3.3 percentage points, and the current daily oil increase is 14.9t.
The effective period of the measures is related to the connected thickness, the number of water injection wells, formation pressure and other factors. It can be seen from table 2-2 that the wells with the effective period of less than 200 days have low formation pressure, insufficient formation energy,
less connected water injection wells around, large well spacing, low fluid enhancement intensity and short effective period; the wells with the effective period of more than 300 days have formation pressure near the original formation pressure, sufficient formation energy and short effective period. There are 2-3 connected water injection wells with high liquid increasing intensity, long effective period and good potential tapping effect[5].

3.2.3. Water cut analysis
From the perspective of potential tapping effect of different remaining oil types, the best water cut reduction effect is mainly in two wells with isolated sandbodies, accounting for 18.2%, with an average daily fluid increase of 41t, daily oil increase of 9.0t and water cut decrease of 12.8% at the initial stage of a single well; nine wells with river side potential tapping, accounting for 81.8%, with daily fluid increase of 63T, daily oil increase of 7.4t and water cut decrease of 3.5% at the initial stage of a single well. In 2019, the initial water cut of conventional fracturing will decrease by 1.7%, and the initial water cut of sand control fracturing will decrease by 4.6%.

Table 5. statistical table of fracturing effect of different types of remaining oil controlled sand body

| classification                  | Number of wells | proportion (%) | Before measures | Initial stage of measures | Difference |
|--------------------------------|----------------|---------------|----------------|--------------------------|------------|
|                                |                |               | Nissan liquid (t) | Daily oil production (t) | to contain water (%) | Nissan liquid (t) | Daily oil production (t) | to contain water (%) | Nissan liquid (t) | Daily oil production (t) | to contain water (%) |
| Riverside                      | 9              | 81.8          | 32              | 2.1                      | 93.5        | 95              | 9.5                      | 90.0        | 63              | 7.4                      | -3.5               |
| Isolated sand body             | 2              | 18.2          | 19              | 0.7                      | 96.5        | 59              | 9.6                      | 83.7        | 41              | 9.0                      | -12.8              |
| total                          | 11             | 100.0         | 29              | 1.8                      | 93.8        | 88              | 9.5                      | 89.2        | 59              | 7.7                      | -4.6               |

3.2.4. Economic benefit evaluation
By December 2020, the cumulative oil production of 11 sand control fracturing wells is 38997t, and the average cumulative oil production of single well is 3545t. The crude oil price is 2600 yuan / T (US $50 / barrel), the implementation cost is 1.8 million yuan / well, and the crude oil operation cost is 450 yuan / T. the input-output ratio is 1:4.2. Nine wells are mainly located at the edge of the channel, and the average cumulative oil production of single well is 3819t, and the input-output ratio is 1:4.6 High. In 2019, the input-output ratio of conventional fracturing is 1:1.7, and the economic benefit of sand control fracturing is better than that of conventional fracturing.

3.2.5. Application
According to the above analysis, well and layer selection is carried out. The wells with large well spacing, large controllable reserves, relatively rich remaining oil, isolated sand body and channel edge, more than 2 connected wells and formation pressure near the original formation pressure are selected regionally. In 2020, six sand control fracturing wells are selected, with daily fluid increase of 59T and oil increase of 6.7t at the initial stage, and water cut reduction of 3.5%.

Table 6. single well table of fracturing effect of sand control body in 2020

| Serial number | Well number | Before measures | Initial stage of measures | Difference |
|---------------|-------------|----------------|--------------------------|------------|
|               |             | Nissan liquid (t) | Daily oil production (t) | to contain water (%) | Nissan liquid (t) | Daily oil production (t) | to contain water (%) | Nissan liquid (t) | Daily oil production (t) | to contain water (%) |
| 1             | L1-S3910    | 31              | 2.4                      | 92.4        | 88              | 8.6                      | 90.3        | 57              | 6.2                      | -2.1               |
| 2             | L5-S3031    | 71              | 1.8                      | 97.4        | 146             | 9.0                      | 93.9        | 74              | 7.1                      | -3.6               |
4. Conclusions

(1) In the later stage of ultra-high water cut, the distribution of remaining oil is more complex. Vertically, the remaining oil is mainly distributed on the top of thick oil layer. However, due to the potential tapping year by year, the properties of interlayer become worse, and the potential layers of location balanced fracturing are less and less; horizontally, the remaining oil is mainly distributed in isolated sand body and river channel edge, which is the main potential tapping object at present.

(2) According to the field test analysis, it is concluded that: the formation pressure is near the original formation pressure, the formation energy is sufficient, and the validity period of the wells connected with 2-3 water injection wells is long; the water cut effect of the wells mainly tapping the potential isolated sand body is the best, and the cumulative oil increase of the wells mainly tapping the potential at the edge of the river channel is the most, and the economic benefit is the highest.

(3) By comparing the effects of conventional fracturing and sand control fracturing, it is found that sand control fracturing is superior to conventional fracturing in terms of initial daily oil increase, effective period, water cut reduction and economic benefits, which can be used as the main measure to tap potential in the future.

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