Research on Investment and Daily Production Limit of Large-scale Fracturing Productivity Project of New Vertical Well

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Abstract. Large-scale fracturing technology is a new type of fracturing technology developed in recent years along with the fracturing theory research of natural fractured reservoirs. The application of large-scale fracturing in vertical wells has achieved good production results. However, due to the short application time of new technology in oilfields and the low regularity of development indexes, there is no economic evaluation method for shaping. This paper evaluates the development effect of large-scale fracturing in Daqing Oilfield, clarifies the variation law of its development index, and establishes the index prediction method in the evaluation period. Through sorting out the various depreciation calculation methods used in economic evaluation, the appropriate modified production method is selected as the method of calculating depreciation. Based on the relevant data and results of economic evaluation of oilfield development, the economic evaluation method of large-scale fracturing technology productivity project has been formed, and the calculation program has been compiled. The program is used to calculate the investment boundaries of large-scale fracturing blocks with different single well daily production under the condition of multiple oil prices, draw the maps of single well investment and single well daily production boundaries under different oil prices in large-scale fracturing blocks, and analyze the sensitivity of investment boundaries. The research results will be applied in proven reserves submission, unused reserves evaluation and oilfield development planning. Using this method for reference, the boundary maps of conventional water flooding development and large-scale volume fracturing can be drawn, and the research results can be applied to a greater extent.

1. Application of Large-scale Fracturing Technology in Daqing Oilfield
Large-scale fracturing technology was applied in 85 wells in Daqing peripheral oilfields from 2013 to 2015, and good development results were achieved. The investment of large-scale fracturing is relatively larger than that of ordinary fracturing, which is 5 times that of ordinary fracturing. The change of index after fracturing is different from that of ordinary fracturing. Therefore, it is necessary to analyze the development effect of large-scale fracturing, clarify the development index change law, and establish the index prediction method in the evaluation period. In order to provide methodological support for economic evaluation of subsequent implementation blocks.
Table 1 Annual oil production changes after large-scale fracturing wells are implemented

| Implementation time (year) | Number of wells (wells) | Production in 2012 (10,000 tons) | Production in 2013 (10,000 tons) | Production in 2014 (10,000 tons) | Production in 2015 (10,000 tons) | Production in 2016 (10,000 tons) | Production in 2017 (10,000 tons) | Multiplier of production increase |
|---------------------------|------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|-------------------------------|
| 2013                      | 37                     | 0.6599                          | 1.4057                          | 2.4055                          | 2.2078                          | 1.7891                          | 1.2555                          | 3.64                          |
| 2014                      | 27                     | 0.5187                          | 1.8736                          | 1.9462                          | 1.223                           | 0.8897                          | 3.75                            |                               |
| 2015                      | 21                     | 0.452                           | 0.9264                          | 1.5599                          | 1.1658                          |                                 |                                 | 3.45                          |

From the middle-year oil production in Table 1, the production multiples in 2013, 2014 and 2015 after large-scale fracturing are 3.64, 3.75 and 3.45, respectively, which are more than 3.5 times as high as before. According to the situation of well implementation in 2013, the production rate after 4 years of fracturing is 1.9 times that before implementation, and the effective period of large-scale fracturing can last for more than 8 years according to this rule.

The time of two batches of fracturing wells implemented in 2013 and 2014 will be aligned, and the number of sample wells will reach 64 wells, which can better reflect the law of decline. After the implementation of large-scale fracturing, the decline rate will increase by about 8 percentage points, and the initial decline rate will be more than 20%. The daily production of a single well can be stabilized at 2.27 tons by 300 days in the first year after implementation, the water content increases by 10%, and the liquid production rate is 4.75 times as much as that in the first year before implementation. The development effect is better, and it has a good application prospect. According to the development characteristics of Daqing peripheral oilfields, it is clear that the decline law of large-scale fracture net fracturing is hyperbolic decline, the initial decline rate is 35%, the first year is 33% of the production capacity, the second year is designed production capacity, and the third year is converted to 23%. This rule is used as a prediction method of oil production in the evaluation period.

2. Introduction of Economic Evaluation Method for Block Productivity

The relationship between economic evaluation methods and parameters should be straightened out, and the methods and parameters should be issued separately. Economic evaluation methods are mainly to standardize the contents and methods of economic evaluation specialty in the early stage of investment decision-making, clarify the concepts of relevant parameters, and have certain stability. The specific value of economic evaluation parameters has a strong timeliness. It needs to be adjusted according to the internal and external situation and the company's development strategy. It is stipulated in the "Economic Evaluation Parameters of Investment Projects", which implements dynamic management and matching use of methods.

2.1. Total Investment of Oilfield Productivity Projects

In the initial stage of project construction, the total investment of the project is mainly the total investment of oil and gas development and construction projects, which should be used for drilling development and oil field capital construction of productivity investment.

2.2. Oil and Gas Operation Cost

Oil and gas operation cost can be divided into four parts: production, injection, treatment and management. The existence of these four parts enables us to carry out cost analysis according to the number of each part. The main expenses included in the process of production operation include production operation expenses. The main expenses included in the process of injection operation include oil displacement injection expenses, downhole operation expenses, well logging and testing expenses, maintenance and repair expenses and other auxiliary operation expenses. The main expenses included in the process of processing operation include oil and gas processing expenses, transportation expenses and management process. The main expenses included are the management fees of factories and mines.
2.3. Financial Profitability Analysis of Oilfield Productivity Projects

According to some economic indicators, we can calculate whether the financial profitability is feasible. Profitability analysis is an important part of economic evaluation. According to the conclusions, we can judge the project. The following three indicators are the most important indicators to be analyzed.

3. Mapping of Economic Limits for Large-scale Fracturing

3.1. Establishment of a typical large-scale fracturing block model

To meet the needs of evaluation, a typical block model of large-scale fracturing is established. There are 20 vertical wells in the reservoir block, and no water injection wells are used for water injection. The depth of drilling wells is 2000m, and the productivity of the block is calculated according to 300 days. Because the implementation of large-scale fracturing multi-block internal rate of return is considered at 6%. The actual value of operation cost is 15 years.

3.2. Drawing of Boundary Layout

Using the integrated productivity evaluation program, the investment boundaries of different oil prices and single well daily production are calculated, and the investment boundaries of single well and single well daily production of large-scale fracturing technology development blocks under different oil prices are plotted. Taking $60 as an example, the investment boundaries of each single well under daily production conditions are calculated, and the boundaries are plotted using the calculated results and parameters. The specific data are shown in Table 2 below.

| Daily Single-Well Output (t) | oil well (wells) | Infrastructure well (wells) | Built capacity (10^4t) | Years of evaluation (Years) | Industry benchmark rate of return (%) | Investment Limits to Achieve Standards (10^4 yuan) |
|-----------------------------|-----------------|----------------------------|------------------------|----------------------------|--------------------------------------|--------------------------------------------------|
| 2                           | 20              | 20                         | 1.2                    | 15                         | 6%                                  | 363.4                                            |
| 2.1                         | 20              | 20                         | 1.26                   | 15                         | 6%                                  | 391.2                                            |
| 2.2                         | 20              | 20                         | 1.32                   | 15                         | 6%                                  | 419.1                                            |
| 2.3                         | 20              | 20                         | 1.38                   | 15                         | 6%                                  | 446.9                                            |
| 2.4                         | 20              | 20                         | 1.44                   | 15                         | 6%                                  | 474.8                                            |
| 2.5                         | 20              | 20                         | 1.5                    | 15                         | 6%                                  | 502.6                                            |
| 2.6                         | 20              | 20                         | 1.56                   | 15                         | 6%                                  | 530.5                                            |
| 2.7                         | 20              | 20                         | 1.62                   | 15                         | 6%                                  | 558.3                                            |
| 2.8                         | 20              | 20                         | 1.68                   | 15                         | 6%                                  | 586.2                                            |
| 2.9                         | 20              | 20                         | 1.74                   | 15                         | 6%                                  | 614.0                                            |
| 3                           | 20              | 20                         | 1.8                    | 15                         | 6%                                  | 641.9                                            |
| 3.1                         | 20              | 20                         | 1.86                   | 15                         | 6%                                  | 669.7                                            |
| 3.2                         | 20              | 20                         | 1.92                   | 15                         | 6%                                  | 697.6                                            |
| 3.3                         | 20              | 20                         | 1.98                   | 15                         | 6%                                  | 725.4                                            |
| 3.4                         | 20              | 20                         | 2.04                   | 15                         | 6%                                  | 753.3                                            |

When the international oil price is US$50, US$55, US$60, US$65, US$70, US$80, US$90 and US$100, respectively, the investment limits, development indexes and cost parameters of different single well daily production under the condition of 6% internal rate of return are calculated according to the basis of vertical well large-scale fracturing technology. Parameters are used to draw the boundaries of single well investment and single well daily production under different oil prices of large-scale fracturing technology.
At present, according to the current investment parameters of the oilfield, the total investment of drilling, infrastructure and fracturing for large-scale fracturing is estimated to be about 6.5 million yuan. The daily production limits of single well under different oil prices are calculated by chart as shown in Table 3. The $70 daily production limit is 2.8 tons.

Table 3. Daily production limits investment of 6.5 million yuan

| Oil price (US dollar/barrel) | 50  | 55  | 60  | 65  | 70  | 80  | 90  | 100 |
|-----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Daily production limit of single well (ton) | 4.2 | 3.8 | 3.4 | 3.0 | 2.8 | 2.5 | 2.3 | 2.2 |

Based on the evaluation results of economic boundaries of large-scale fracturing blocks, the daily output of a single well increases by 0.1 tons at the same oil price, and the change of boundaries investment is shown in table 4. From the result, the higher the oil price is, the higher the increment of investment limit is for each 0.1 ton increase of daily production of single well. This shows that the higher the oil price is, the more sensitive the daily production of single well is to the evaluation results. In the stage of high oil price, increasing the daily production of single well plays a greater role in improving the economic benefits of the block.

Table 4. Oil Price Change of Investment Limit of 0.1t Increase Daily Production under the Same Development mode

| Development mode | 50  | 55  | 60  | 65  | 70  | 80  | 90  | 100 |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Investment Limit of Large-scale Fracturing Technology (RMB 10,000) | 19. | 22. | 24. | 27. | 29. | 33. | 36. | 38. |
|                  | 81  | 24  | 85  | 84  | 51  | 19  | 16  | 71  |

4. Conclusion

The boundary map can be applied to the submission of proven reserves, the evaluation of unutilized reserves and the formulation of oilfield development planning. It can preliminarily screen whether the blocks meet the economic benefits and reduce the evaluation workload. This method can be used to develop the boundary plates of conventional water flooding development and large-scale volume fracturing, enrich the application scope of the plates, and be applied to a greater extent. In the process of project evaluation, the cost, tax and fee parameters should be selected according to the actual situation of the unit. If the parameters are incomplete, the evaluation data of other similar blocks can also be borrowed.
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