Computer High-precision Analysis Method for Economic Life of Oilfield Development

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Abstract. In the feasibility study of oilfield development projects and the management of oil reservoirs, it is necessary to calculate the economic life of oilfield development projects accurately, which is of certain guiding significance for the economic evaluation and decision of such projects. In this paper, the calculation method for the economic life of oil equipment is introduced. Examples of the specific application of the method to the equipment update decision system are illustrated. The backstage database is established to analyze the economic life of oilfield development.

Keywords: Economic Life, Inferior-converted Numeric Method, Minimum Annual Average Cost Method

1. Introduction

In the oilfield production capacity construction, it is necessary to highlight the benefits of production, investment, quality and duration management rather than merely chasing scale expansion, and pursue a rapid, high-quality and efficient development model [1-3]. As an oil company, how to determine the economic life of an oilfield development project based on market changes is crucial to the survival and development of oil companies [3-5].

Half of an oil and gas field development cycle can be divided into three stages: production, stable production, and decline; 1. Production stage: at the initial stage of oil and gas field development, half of the new well output is greater than the natural decline production, and the current oil field production is higher than the previous year; 2. Stable production stage: oil field In the mid-development period, the annual output of new wells is basically equal to the natural decline, and the output of the oil field in the current year is close to the output of the previous year; 3. Decline stage: In the later stage of the oil field development, the sum of the increase in old well measures and the output of the new well is less than the natural decline, the output of the oil field is low in the previous year [6-8]. With further exploitation of oil fields, the production costs of oil and gas fields in the middle and late stages of development will surely rise rapidly. When the production cost rises rapidly to affect the profit level of oil companies seriously, it is of considerable significance to study the economic life of oilfield development projects.

The economic life of oilfield development projects refers to the calculated maximum operating time of the oil development project under the same economical and technical conditions. Meanwhile, the highest economic limit crude oil output acceptable for the oilfield development project is the
operating cost less than the production of crude oil. The output of value, that is, the cost of crude oil produced by the oil and gas field (block) plus the target profit and tax of the enterprise during normal production, is less than the output of oil and gas sales revenue.

2. Economic Life

2.1. Decision System for Oilfield Equipment Update
The oilfield equipment update decision system is mainly a set of equipment management decision systems that integrates equipment management and evaluation developed for pumping unit, water injection pump, and oil pump. The system mainly includes equipment selection, decision analysis (update decision and update timing), cost statistics, system management, and other major modules. Decision analysis is the main module, and cost statistics and system management serve it. The main basis for updating decisions in decision analysis is the economic life of the equipment.

2.2. About Economic Life
The economic life of the equipment means that the equipment is subjected to tangible wear or invisible wear during use (or idle), or both, and the length of time that the equipment is economically unusable to continue to use is referred to as the economic life of equipment, which is the optimal life cycle of the equipment determined from the cost perspective.

For a piece of equipment (or a set of equipment) that has been purchased or is in use, all expenses in a life cycle need to maintain the normal operation of the equipment in addition to the procurement cost (including the original value of the equipment, transportation costs, installation and commissioning fees) Spending is the maintenance fee. For pumping units and injection pumps, this part of the cost mainly includes electricity, materials, and maintenance costs. With the more prolonged use of equipment, the annual maintenance fee required for the regular operation of the equipment will gradually increase, while the annual equipment procurement cost allocated will decrease as the service life increases. Both factors are combined to identify an appropriate period. When the equipment is used to this year, the sum of the annual equipment procurement cost and the annual average maintenance fee (also called the annual average cost of use) is the least, that is, the annual The lowest average cost of use indicates that the equipment is most suitable for this period of use, which is the economic life of the equipment.

2.3. Economic Limit Rate
How to determine the economic life span of an oilfield development project? Firstly, the economic limit rate of the project should be determined. The so-called economic concentrated output refers to the value of input and output balanced within a year when the output of a general oilfield development project reaches a certain stage, and the output reaches a certain value. The output at this time is called the economic limit rate. For oilfield development projects, the highest acceptable economic output of crude oil is the output whose operating cost is less than the value of the crude oil produced. That is, once the output of crude oil drops to a certain limit value, the output is equal to the input (that is, neither profit nor loss), this limit value is called the economic limit rate.

After determining the economic limit rate of the project, and then comparing the projected annual output of the project with the economic limit rate of the project, the economic life of the project can be determined. For oilfield development projects, the calculation of economic limit production involves many parameters, and the specific operation is also relatively complicated. Here is only a brief introduction to the calculation method model in the general theoretical sense. The basic principle is the principle of break-even.

3. Calculation Method for Economic Life

3.1. Inferior-converted Numeric Method
If the residual value of a piece of equipment after several years of use is zero, K is used to represent the equipment purchase fee, T is used to represent the number of years of use, then the equipment cost per year is $K/T$ (the annual amortization amount of the original value of the equipment K), which is related to the service life of the equipment. As the use age $T$ increases, $K/T$ decreases inversely. Conversely, the longer the equipment is used, the greater the overall wear loss of the equipment, and the maintenance cost of the equipment and fuel and power consumption increase. The performance of the equipment continues to decline, which is called low degradation of the equipment. If this low degradation increases by! Every year, the low degradation value in the $T$th year is $iT$, which increases in proportion to the increase in the number of years of use $T$, and after $T$ years of use, the average low degradation value is $\lambda T/2$.

3.2. Minimum Annual Average Cost Method

To calculate the economic life of equipment, we use the annual average cost of equipment to calculate the $T$ years first. Then, the year $T_0$ with the lowest annual average cost can be identified. The annual average operating cost of equipment in year $t$ can be expressed by equation (1)

$$AC_t = K/t + \sum_{j=1}^i M_j/t$$

(1)

Where $t$ - the service life of the equipment;

$K$-equipment purchase fee;

$M_j$ - the maintenance fee used in the $j$th year of the equipment.

If the residual value at the end of the $t$-th year is considered, the equation (1) is changed to

$$AC_t = (K - L_t)/t + \sum_{j=1}^i M_j/t$$

(2)

Where $L_t$ represents the residual value at the end of the $t$ year.

If the time value of funds is considered, equation (1) can be changed to

$$= K \frac{(1+i)^t}{(1+i)^t - 1} - \frac{i}{(1+i)^t - 1} \sum_{j=1}^i M_j \frac{(1+i)^i}{(1+i)^i - 1}$$

(3)

Where $i$ represents the discount rate, which can be determined after referring to the bank loan interest rate and considering the risk factor and other factors.

Substitute the actual data of equipment usage into (3), calculate $AC_t$ in each year of use, and find the $t$ value $t_0$ corresponding to the minimum value from it is the economic life of the equipment.

4. Case Analysis

During oilfield production management, to informatize the production process and related business, it is necessary to convert the business process into a data stream that can be executed, and at the same time, establish an appropriate data model and store these data effectively. In this process, only a reasonable design of the model is allowed. Hence, the underlying data of the basic entity can be stored reasonably and effectively through the effective channel.

4.1. Data Processing

To endow a universal significance to the research, we comprehensively classified and saved massive data and information collected. Discounted calculations are conducted to make the data comparable, addable, and reasonable. The data processing algorithm is implemented in the database using stored procedures, as shown in Figure 1 below.
The oil pumping unit is used as an example for a detailed introduction. The total volume of sample data is 2423 units; sample distribution: 186 Xinglongtai Oil Production Plants, 618 Shuguang Oil Production Plants, 583 Jinzhou Oil Production Plants, 5 Ciyutuo Oil Production Plants, 314 Huanxiling Oil Production Plants, 314 Shenyang Oil Production Plants; the production date is 112 2003−2018.

Due to the incomplete historical data records of a single device in the actual case, the 2018 data of devices of the same model with different production dates are taken, and the average of the data of each device on the date of production is taken as the data of each useful life of the device of the model, equipment procurement cost The discount method is converted to 2003 values.

4.2. Life Calculation

As multiple devices are used to fit a model equipment, the equipment cost is shown in Table 1.

The procurement cost in the above table is calculated from the average of the procurement cost of equipment for each production date. The purchase fee is discounted to the value in 2018, and the discount factor is 2.25%. The average value of the discounted data is taken as the procurement cost of the model equipment. After conversion, the purchase fee is 172011.64 yuan.

Table 1. Model equipment cost table (unit: yuan).

| Production date | Equivalent useful life | Maintenance fee | Purchase fee | Purchase fee after discount | Year-end residual value | Average annual cost |
|-----------------|------------------------|-----------------|--------------|-----------------------------|------------------------|---------------------|
| 2017            | 1                      | 62 476.9        | 142 501.15   | 145 707.43                  | 107 490.63             | 100 693.7           |
| 2016            | 2                      | 68 229.43       | 144 768      | 151 355.85                  | 67 171.24              | 107 445.47          |
| 2015            | 3                      | 78 035.55       | 146 872.36   | 157 010.98                  | 41 975.53              | 107 925.78          |
| 2014            | 4                      | 71 870.77       | 149 101.88   | 162 980.78                  | 26 230.64              | 104 340.7           |
| 2013            | 5                      | 75 784.84       | 171 564.63   | 191 753.96                  | 16 391.61              | 106 351.97          |
| 2012            | 6                      | 80 277.94       | 158 906.62   | 181 602.53                  | 10 243.17              | 101 339.13          |
| 2011            | 7                      | 86 693.13       | 138 088.56   | 161 361.87                  | 6 400.99               | 96 904.21           |
| 2010            | 8                      | 97 610.55       | 145 065.82   | 173 329.16                  | 4 000                  | 98 788.53           |
| 2009            | 9                      | 87 329.9        | 137 611.43   | 168 121.93                  | 2 499.61               | 97 103.48           |
| 2008            | 10                     | 89 411.22       | 136 987.9    | 171 125.75                  | 1 562.02               | 96 728.4            |
| 2007            | 11                     | 93 684.46       | 134 412.92   | 171 687.03                  | 976.11                 | 96 555.96           |
| 2006            | 12                     | 101 725.92      | 136 871.72   | 178 761.31                  | 609.97                 | 97 606.83           |
| 2005            | 13                     | 106 037.7       | 138 835.62   | 185 406.1                   | 381.17                 | 98 784.1            |
| 2004            | 14                     | 105 943.93      | 140 394.58   | 191 706.47                  | 238.2                  | 99 755.75           |
| 2003            | 15                     | 106 744.64      | 134 839.19   | 188 263.39                  | 148.85                 | 99 998.09           |

(1) Inferior-converted Numeric Method

It can be seen from the data in Table 1 that the value of low degradation is changing every year, and the average value of annual change is taken as the final value of low degradation and substituted into the equation. If the equipment maintenance fee for the i-th service life is \( C_i \),
\[ \lambda_i = C_{i_{nl}} - C_{i} \text{ (} i = 1,2,3,\cdots,14 \text{)} \text{ can be obtained, and } T_{\min} = 10 \text{ can be obtained by substituting} \]
\[ \lambda = \frac{1}{14} \left( \sum_{i=1}^{14} \lambda_i \right) \text{ into the equation.} \]

(2) Minimum Annual Average Cost Method
It can be seen from the data in Table 1 that the annual average cost of equipment put into operation in 2003 is the smallest. That is to say, the reasonable update period of the equipment is 11 years, which is basically consistent with the results obtained by the inferior-converted numeric method.

Economic life of oilfield development projects: the development process of oil and gas fields, the economic cost of oil and gas development are closely related to the production stage. With the increased utilization of oil field reserves and the gradual increase in the water content of the oil field, the operating costs of oil field development continue to rise. However, crude oil production has gradually declined after a certain period of stable production, resulting in a decline in sales revenue. The proportion of input and output changes constantly with the development of oil and gas, the input is getting bigger and bigger. However, the output is getting less and less. At some point, when the output is roughly equal to the input, it may not be profitable to continue production in the field. At this time, the economic life of the field has ended.

In addition, in the early stages of oilfield development, oil and gas are transported to the surface by bottom pressure. With the development of the oil field, the pressure at the bottom layer declines, making it increasingly difficult to move the oil and gas to the surface. Hence, it is a stage when oil and gas fields have the shortest time and the highest benefit. The recovery factor at this stage is about 10-

Around 20%. During the stable production stage of the oil field, specific technologies, such as water injection and oil recovery technology, are used to maintain the bottom pressure and enable crude oil to be recovered to the surface. The recovery factor at this stage is about 20-40%. To extract more details, we need to apply the specific oil recovery technology to extend the stable production period of oil and gas fields and slow down the decline rate to increase the recovery rate of oil and gas fields. The methods for improving the recovery factor can generally be divided into chemical flooding, gas-miscible flooding and thermal recovery. Among them, chemical flooding and miscible flooding are suitable for thin oil reservoirs developed by water injection; thermal recovery is mainly suitable for high viscosity heavy oil (heavy oil) reservoirs that cannot be water injected.

5. Conclusion
In the feasibility study of oilfield development projects and the management of oil reservoirs, it is necessary to calculate the economic life of oilfield development projects accurately, which is of certain guiding significance for the economic evaluation and decision of such projects. In the cases of this paper, the pumping unit is used as an example to calculate its economic life. With data integrity, the economic life of a single device can be calculated in strict accordance with the theoretical method to obtain higher precision and more accurate results.

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Brief analysis of several parameters in technical economic evaluation of oilfield development.

References
[1] Cobian Álvarez, José Armando, Resosudarmo B P . The cost of floods in developing countries' megacities: a hedonic price analysis of the Jakarta housing market, Indonesia[J]. Environmental Economics and Policy Studies, 2019,2(3):1-10.
[2] Tarhini A , Alalwan A A , Shammout A B , et al. An analysis of the factors affecting mobile commerce adoption in developing countries: Towards an integrated model[J]. Review of International Business & Strategy, 2019, 29(3):157-179.
[3] Ayesha, Ahmed, Ibrahim. Breast self-examination awareness and practices in young women in developing countries: A survey of female students in Karachi, Pakistan.[J]. Journal of
[4] Othman A A E, Elsaay H. Adaptive reuse: an innovative approach for generating sustainable values for historic buildings in developing countries[J]. Nephron Clinical Practice, 2018, 10(1):1704-1718.

[5] Paloma V, Escobar-Ballesta M, Blanca Galván-Vega, et al. Determinants of Life Satisfaction of Economic Migrants Coming from Developing Countries to Countries with Very High Human Development: a Systematic Review[J]. Applied Research in Quality of Life, 2020, 5(1):1-21.

[6] Zhang, Li, Tiara. Burden of cancer pain in developing countries: a narrative literature review.[J]. Clinicoeconomics & Outcomes Research Ceor, 2018, 6(1):1-7.

[7] Chaowanapong J, Jongwanich J, Ijomah W. The determinants of remanufacturing practices in developing countries: Evidence from Thai industries[J]. Journal of Cleaner Production, 2018, 170(1):369-378.

[8] Ye L, Zhang X. Nonlinear Granger Causality between Health Care Expenditure and Economic Growth in the OECD and Major Developing Countries[J]. International Journal of Environmental Research & Public Health, 2018, 15(9):104-112.