

Study on Development Limits of Tight Oil Economic Technology in Daqing Oilfield

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Abstract

The reserves of tight oil resources in China are very abundant. In recent years, the application of large-scale fracturing technology has made the production of tight oil better. However, at the same time, the engineering investment brought by large-scale fracturing technology is also doubled, and the comprehensive investment is about 2–3 times that of conventional oil. Affected by the low oil price in recent years, economic factors have become a key factor restricting the effective use of tight oil, and also a key indicator for optimizing the unutilized benefit reserves. In this paper, economic limit method is used to calculate the economic and technical limits of daily oil production, geological reserves and the economic lower limit of effective thickness of vertical and horizontal wells in the development of tight reservoirs in Fuyu oil layer, so as to guide the reserve optimization of tight reservoirs and the implementation of development potential.

Keywords

Fuyu Oil Layer; Tight Reservoir; Economic Limit; Development Potential.

1. Introduction

Nowadays, tight oil has become the focus of unconventional oil and gas exploration and development, with the reputation of 'black gold'^[1-2]. Different countries have successfully carried out commercial development of tight oil and achieved great political and economic benefits^[3-4].

Tight reservoir not only has the general characteristics of continental clastic reservoir, but also shows low porosity and low permeability. Because of the geological characteristics of fracture development and strong heterogeneity, the optimization design of well pattern in tight reservoir is proposed. Higher requirements^[5-6]. The optimization of well pattern is a very challenging problem. Selecting the appropriate well pattern, arranging wells in the appropriate position and optimizing and adjusting the effective well pattern in the later stage will improve the development effect of the reservoir and make the oilfield obtain great economic benefits^[7-8].

By investigating the current research status, it is found that reserves are mainly used in the early and middle stages of reservoir development. Abundance method, for the reservoir 'dessert' well location deployment and optimization. In the current situation of low oil prices, economic factors have gradually become the focus of research. While ensuring the development effect, how to achieve the maximum economic benefits is the top priority at present.

2. Economic limits of tight oil Fuyu reservoir development

2.1. Value of economic evaluation parameters

2.1.1. Investment parameters of tight oil development project

In order to achieve the economic and effective use of tight oil in Fuyu oil layer, a new mechanism and new system for the development of tight oil developed to achieve the goal of reducing

investment and cost. The single well investment has decreased from CNY 9.17 million to CNY 5.63 million, with a decrease of 38.6%.

(1) Functional orientation of “five modernizations”: flattening, marketization, specialization, standardization;

(2) “11” self-management rights: 11 rights such as the right of organization establishment, the right of investment plan approval, the right of market operation, the right of bidding management, and the right of material procurement;

(3) “3unified” management measures: unified organization, unified management, unified operation, implement the whole life cycle management of production and business indicators;

(4) “2” organizational guarantee : oilfield company level set up management support group to provide policy and macro coordination support; The research institutes form a technical support group to support the design and rolling evaluation.

Table 1. Ta 21-4 test area five main project investment control situation table

Serial number	Item	Work load (well)	Related party transaction price (CNY 10,000)	Control objective		Actual performanc	
				Decrease (%)	Investment (CNY 10,000)	Decrease (%)	Investment (CNY 10,000)
1	Well drilling	160	308	40	185	40	184.40
2	Perforation	160	35	40	21	19.0	28.36
3	Fracturing	173	420	40	251	41.1	247.30
4	Oil producing equipment	157	24.3	20	19	-	7.38
5	Capital construction	173	129.6	20	103	26.2	95.70
Total			917		579		563.1

2.1.2. Economic evaluation parameters and cost estimation

(1) Economic evaluation parameters

1. Evaluation period : calculation period 10-15 years ;

2. Financial benchmark internal rate of return : 6% ;

3. Crude oil prices : US \$55, US \$60 and US \$70 per barrel from 2018 to 2020 ;

4. Crude oil commodity rate : 99.47% ;

5. Taxes :

1) Income tax : 25% ;

2) Crude oil VAT : 16 per cent ;

3) Natural gas VAT : 13% ;

4) Resource tax : 5.22% ;

5) Urban construction maintenance tax : 7% ;

6) Additional education fee : 5% ;

7) Special benefits for oil : the five-level excess progressive ad valorem rate is adopted, calculated monthly and paid quarterly. The levy ratio is determined by the monthly weighted average price of crude oil sold by oil mining enterprises (Fig.1).

(2) Cost estimation

The estimated range of total cost includes oil and gas production cost, management cost, financial cost and operating cost, among which oil and gas production cost includes oil and gas operation cost and depreciation.

1. Operating cost parameters

The operation cost items mainly include : production operation cost, oil displacement injection cost, oil and gas processing cost, downhole operation cost, logging test cost, maintenance and repair cost, transportation cost, other auxiliary operation cost and plant and mine management cost. The project specific operating cost calculation parameters are shown in Table 2.

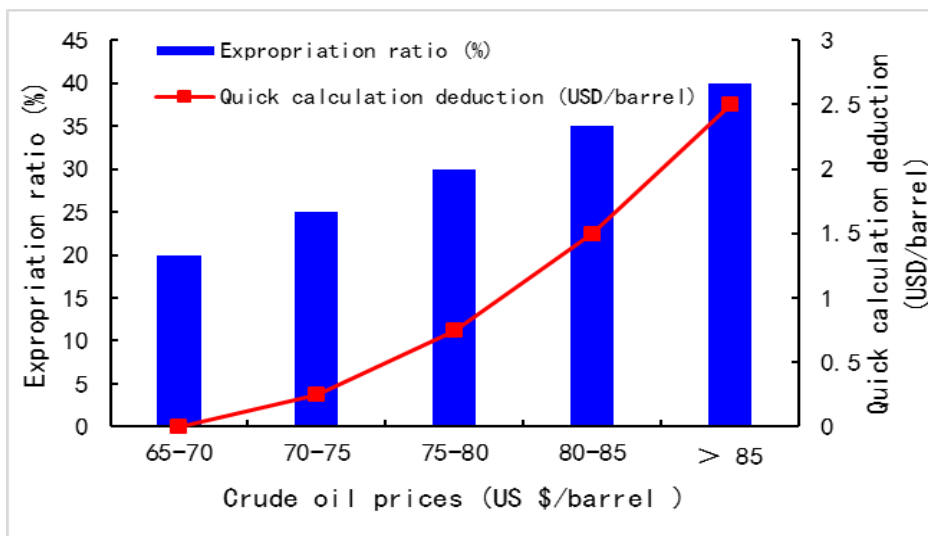


Fig. 1 Oil Special Revenue Collection Ratio

Table 2. Operation Cost Parameter Table

Serial number	Item	Unit	Routine	De-sharing
1	Operational costs incurred	Ten thousand yuan per well	5.7	3.0
2	Oil displacement injection fee	Yuan/m ³ (water)	7.7	6.3
3	Oil and gas processing fee	Yuan/t (liquid)	20.3	18.4
4	Workover cost of well	Ten thousand yuan per well	4.6	4.3
5	Logging Well Test Fees	Ten thousand yuan per well	1.1	0.7
6	Maintenance and repair costs	Ten thousand yuan per well	2.2	1.7
7	Transportation	Ten thousand yuan/total well number	0.2	0.2
8	Other auxiliary operating expenses	Ten thousand yuan/total well number	1.9	1.9
9	Plant and mine management fee	Ten thousand yuan/total well number	2.2	0.9

2. Management costs

Management costs mainly include amortization fees, safety production costs and other management costs.

Other management costs : 352.31 yuan/ ton oil (conventional), 185.31 yuan/ton oil (to share).

3. Operating expenses

Operating expenses are calculated by 0.5% of operating income.

2.2. Calculation results of development economic and technical limits

According to the selection criteria and methods of economic evaluation parameters of Daqing Oilfield Company Limited in 2019, the economic limit production, economic limit geological reserves and economic limit well spacing density (economic limit well spacing) of single well corresponding to different crude oil prices during the evaluation period are calculated by using the following formula^[9-10].

$$q_{min} = \frac{(I_D + I_B)(1 + R)^{T/2} \times \beta}{0.0365 \times \tau_o \times d_o \times T \times (P_o - O)(1 - D_c)^{T/2}}$$

$$N_{min\ k} = \frac{(I_D + I_B)(1 + R)^{T/2}}{d_o \times (P_o - O) \times W_i \times E_R}$$

$$f_{min} = \frac{d_o \times (P_o - O) \times N \times E_R}{(I_D + I_B)(1 + R)^{T/2} \times A_o}$$

In the formula:

I_D —The average drilling investment of a well (including perforation, fracturing, etc.), ten thousand yuan/well;

I_B —The average ground investment of a well (including system engineering and mining construction, etc.), ten thousand yuan/well;
 R —Investment loan interest rate, decimal;
 T —Development evaluation years, years;
 β —Oil well coefficient, namely the ratio of the total number of oil wells to the number of oil wells, decimal;
 τ_0 —Oil production rate, decimal;
 d_0 —Crude oil commodity rate, decimal;
 P_0 —Crude oil sales price, yuan/t;
 O —Crude oil cost, yuan/t;
 0.0365—Annual time unit conversion;
 D_c —Annual comprehensive decline rate of oil field, decimal;
 W_i —Degree of recovery of crude oil geological reserves within the development evaluation period, decimal;
 E_R —Oil recovery ; decimal;
 N —Geological reserves of crude oil, t;
 A_0 —Oil-bearing area, km².

According to the actual economic parameters of tight oil development in Daqing Oilfield, combined with the production law of tight oil development, the lower limit of the minimum effective thickness of vertical well fracture network fracturing is 7.63m, and the value is 8.0m (Table 3). The minimum effective thickness limit (design 1000m horizontal section) of the main layer in horizontal well volume fracturing is 2.21m, and the value is 2.5m (Table 4). (Note : Tight oil can be used to calculate economic limits by reducing investment by 20%)

Table 3. Economic Limits of Vertical Well Fracturing in Fuyu Oil Layer

Crude oil sales price(\$/bbl)	Category	Lower limit of initial daily oil production(t/d)	Extreme recoverable reserves(10 ⁴ t)	Limit geological reserves(10 ⁴ t)	Effective thickness lower limit(m)
Echelon	Routine	2.90	0.41	5.13	11.60
	De-sharing	2.50	0.35	4.42	10.00
	Extension of evaluation period	2.38	0.35	4.41	9.53
	Reducing investment by 20 %	1.91	0.28	3.53	7.63

Table 4. Economic Limit of Horizontal Well Volume Fracturing in Fuyu Reservoir

Crude oil sales price(\$/bbl)	Category	Lower limit of initial daily oil production(t/d)	Extreme recoverable reserves(10 ⁴ t)	Crude oil sales price(\$/bbl)	Effective thickness lower limit(m)		
					1000	1200	1500
Echelon	Routine	9.79	1.12	12.48	3.14	2.77	2.34
	De-sharing	8.60	0.99	10.96	2.76	2.43	2.06
	Extension of evaluation period	8.44	0.99	10.96	2.76	2.43	2.06
	Reducing investment by 20 %	6.75	0.79	8.77	2.21	1.94	1.65

3. Conclusion

(1) Under low oil prices, economic factors have become an important factor restricting the effective development of tight oil. Determining the economic boundaries of tight oil development can effectively guide the reserve optimization and production planning of tight reservoirs.

(2) Under the new mechanism of reducing cost and increasing efficiency in tight oil development, the lower limit of economic effective thickness of tight reservoir in Fuyu oil layer is determined by economic limit method, that is, the lower limit of effective thickness of vertical well is 8.0m, and the lower limit of effective thickness of main layer of horizontal well is 2.5m (1000m horizontal section).

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