CSCanada
Advances in Petroleum Exploration and Development
Vol. 17, No. 1, 2019, pp. 26-29
DOI:10.3968/11028

ISSN 1925-542X [Print]
ISSN 1925-5438 [Online]
www.cscanada.net
www.cscanada.org

Optimization Program for Difficult-to-Produce Reservoir in Bonan Oil Feild

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Received 26 September 2018; accepted 9 February 2019
Published online 22 April 2019

Abstract
After many years' development of oil reservoir in Shengli, tons of oil have been drilled out of reservoir and the condition of underground has been changed a lot. Nowadays, the quantity of oil production has been reduced rapidly, therefore, there is a new solution for old reservoir, to redevelop this reservoir with appropriate adjustment in drilling design and method. There are two main changes in this new solution, first one is to reduce the cost of wells in Yi 184 block. The second factor is optimizing parameters of the drilling design, such as casing program, drilling fluid system, drilling fluid material and etc. This paper is going to describe a solution for difficult-to-produce reservoir of Yi 184 block in Bonan oil field. It will be divided into 3 parts. The first part is introduction which is about the characteristics of formations and drilling difficulties in Yi 184 block. Second part is going to present the optimization of drilling design. Optimization of well construction and drilling fluid will be present in this part. The last part of this paper is a conclusion of the optimization program.

Key words: Optimization; Difficult-to-produce; Adjustment; Redevelop; Yi 184 block

Zhang, L. (2019). Optimization Program for Difficult-to-Produce Reservoir in Bonan Oil Feild. *Advances in Petroleum Exploration and Development*, *17*(1), 26-29. Available from: http://www.cscanada.net/index.php/aped/article/view/11028
DOI: http://dx.doi.org/10.3968/11028

INTRODUCTION

Formation Characteristic of Yi 184 Block
This block is between two reservoir-control faults, and the faults inside Yi block are also complicated. Oil bear formation are No.3 and No.4 sand set of Shahejie group. No.3 sand set is mainly sandstone and siltstone, No.4 sand set contains sandstone, siltstone and coarse-grained sandstone. Porosity of the formation is 11%, and Permeability of the reservoir is 5.5 millidarcy, therefore, this is low-porosity and extra-low permeability reservoir. Due to the reservoir pressure coefficient is 1.56, and geothermal gradient is 3.71℃/100m, so this reservoir is normal temperature and high pressure formation (Tang & Shao, 2007). There is a reservoir pressure statistical table of nearby blocks shows that adjacent blocks are generally belong to high pressure formation.

Table 1
Reservoir Pressure Statistical Table of Shasi Formation of Yi 176 Block

Well	Formation	Test top depth (m)	Test bottom depth (m)	Pressure coeffient
Yi 17	No.3 sand set	3586		1.54
Yi 170	No.3 sand set	3806.1	3829	1.48
Yi 171	No.3 and No.4 sand set	3480.5	3662.2	1.40
Yi 172	No.3 and No.4 sand set	3998.53	4021	1.55
Yi 173	No.4 sand set	4108	4124.5	1.63
Yi 176	No.4 sand set	3807.6	3824.6	1.68
Yi 178	No.4 sand set	3782	3812.8	1.53
Yi 184	No.4 sand set	4034	4044	1.68
Yi 186	No.3 sand set	3844.8	3847.5	1.54

Drilling Difficulties and Corresponding Technical Measures
There are 27 wells in this program, 18 wells are production well，9 wells are steamed well. Based on the data information we learned about the adjacent wells, the Table 2 indicates the drilling difficulties we met during those wells' drilling process.

Table 2
Drilling Difficulties of Adjacent Wells

Well	Density of drilling fluid (g/cm3)	Complex situation
Yi 17	1.15~1.79	Mud loss happened in Shasi section which is about 3685m,and the amount of loss is 4m3
Yi 170	1.06~1.80	Sticking occurred during third spud, and the position is 2965m
Yi 193	1.08~1.80	Sticking occurred when drilled to Dongying group about 2003m
Yi 184-1	1.08~1.78	Mud loss happened when drilled to3948.20m, and the amount of loss is 20m3

According to the complex situation happened during the drilling process of adjacent wells, the difficulties of Yi 184 block's optimization program are:

• Lots of wells in the same block, anti-collision is difficult.

• Sloughing and sticking happen easily due to the soft formation of the upper part of Guantao group.

• High pressure exists in Shasi section, apply drilling fluid with high density may lead to mud loss.

• Drilling rate is low at Shasi formation.

• When it drills to 4418.64m, the well depth of second spud is too long to cementing.

• H_2S was detected during drilling process of adjacent well.

The Corresponding technical measures are:

• Make the drilling order reasonable based on the maximum anti-collision distance between wells.

• Apply suitable drilling system. Using Calcium-treated-polymer drilling fluid for Dongying formation to improve the support and inhibitive ability. Using multiple salts-plugging and anti-collapse drilling fluid system for easily collapsing and leaking formation, to hold well steady, and in the meanwhile this drilling fluid system provides good protection for reservoir (Guan, Li, & Zhou, 2001).

• Enhance monitoring on field and prepare enough sulfur removal agent(basic zinc carbonate)for the possibility of H_2S in Shasi formation.

• Using cone and PDC bits in preference to other bits.

• Optimizing cementing method. Apply double density cementing while cementing with long sealing section and apply plastic micro expansion cement slurry system above reservoir.

1. THE OPTIMIZATION OF DRILLING DESIGN

1.1 Well Construction

1.1.1 Principle of Well Construction Design

The design of well construction is directly to the benefits of drilling and oilfield development. According to current drilling technology and the characteristics and pressure of this formation, the well construction should be designed under the principle of safe, high-efficiency drilling and protection of oil and gas reservoir (Ouyang, Liu, & Wang, 2011). There are some basic requests for the well construction design (Guan, Li, & Zhou, 2001):

• It could effectively protect oil and gas zones, so that oil and gas reservoirs with different pressure systems would not be damaged by drilling fluid.

• It could avoid blowout, collapse and sticking, especially lost circulation, and it can create good conditions for rapid, safe, high quality and economical drilling.

• It should minimize the difficulty of construction work and ensure safe drilling.

• It would improve drilling speed, shorten well construction period, and achieve higher technical and economic benefits.

• It should meet the requirements of oil production engineering.

• It should be beneficial to well trajectory control, and be conducive to accurate targeting.

1.1.2 Casing Program of This Block

Table 3
Casing Program for Production Well

Spud	Bit size(mm)	Drilling depth(m)	Casing OD (mm)	Casing setting depth(m)	Top of cement(m)
First spud	346.1	401	273.1	400	Surface
Second spud	241.3	Drilling to middle part of Shasan formation	177.8	Directional well 3450(VD) Vertical well 3450	Surface
Third spud	149.2	Drilling to target reservoir	114.3	Liner (3350～)	

Table 4
Casing Program for Steamed Well

Spud	Bit size(mm)	Drilling depth(m)	Casing OD(mm)	Casing setting depth(m)	Top of cement(m)
First spud	346.1	401	273.1	400	Surface
Second spud	241.3	Drilling to the middle part of Shasan formation	193.7	Directional well 3450(VD) Vertical well 3450	Return to upper oil and gas layer 200m, or 200m above the deflection point
Third spud	165.1	Drilling to target reservoir	127	To the bottom of well	Surface

There are 27 wells of Yi 184 block. 18 wells are production well and the rest wells are steamed well. Different well type using different casing program. For the production and steamed well, the purpose of surface casing is to sealing the unconsolidated formation and shallow water layer and to setting wellhead. The function of technical casing is to sealing the layer with low pressure-bearing capacity and creating suitable conditions for high pressure formation of third spud. See the detailed content in Table 3 and 4.

1.2 The Optimization of Drilling Fluid Design

1.2.1 Analysis of Drilling Formation for Drilling Fluid

The formation of this block is composed of Shahejie group, Dongying group, Guantao group, Minghuazhen group and Quaternary layer. Based on the actual drilling information, using drilling fluid system should consider the following difficulties.

• Guantao group and upper formation have poor lithology, weak bonding, easily flushing, collapsing and leaking. It should be focused on anti-collapse and leakage control to improve well quality.

• The formation temperature of Shahejie group is high, mudstone is easily hydrated which could causing block collapse. Drilling fluid system should enhance wellbore protection, anti-collapse, anti-sticking and ensure the high temperature stability (Sun, Yang, & An, 2009).

1.2.2 Application of Drilling Fluid System

Table 5
Drilling Fluid System for Each Section

Spud	Drilling fluid system
First spud	Bentonite slurry
Vertical section of second spud	Calcium-treated-polymer drilling fluid
Direction section of second spud	Polymer anti-collapse drilling fluid
Third spud	Multiple salts-plugging and anti-collapse drilling fluid system

Using multiple salts-plugging and anti-collapse drilling fluid system for this block has lots of advantages (Guan, Li, & Zhou, 2001). Firstly, it would solve the difficulties of Shasan group which are high formation pressure, easily collapsing and reaming, and high degree of mineralization. Secondly, it would solve the problem caused by drilling mud couldn't fall which are no use of big mud pool for circulating, and less inhibitive ability. Thirdly, it is high-clean drilling mud, and it could achieve drill bit self-cleaning and improve the efficiency of breaking rock of PDC drill bit. Finally, this drilling fluid is reusable which could increase the production cost.

1.3 The Optimization of Cementing

1.3.1 Principles of Casing String Design

The design of casing string should follow the principles as below (Tang, 2005).

• Satisfied the technological requirement of drilling operation, reservoir development, formation pressure, oil production mode and reform of production layer.

• All the strings' steel grade and thickness have a wide range of options.

• Satisfied the requirement of drilling fluid property and cementing.

• The design of casing string should be economically fair, appropriate and resourceful.

• It should have high reliability, convenient craftwork and strong operatbility.

1.3.2 Casing Determine

According to the information of drilled wells, it will apply three spuds casing. For production well, it designed as Φ177.8mm intermediate casing and Φ114.3mm liner for production casing. For steamed well, it designed as Φ193.7mm intermediate casing and Φ127.0mm liner for production casing. Due to this block is ultra-low porosity and ultra-low permeability reservoir, use P110 steel grade liner for production casing to meet the requirements of later fracturing production. The casing accessories and tools used in cementing should be consistent with the strength of the casing string, and the buckle should match the casing buckle type. (Sun, Yang, & An, 2009)

1.3.3 Cementing Method

For production well, apply inner string cementing for surface casing, and the cement is required to return to the ground. Use primary cementing and variable density cement slurry system for intermediate casing, and the cement is required to return to the ground. Utilize liner cementing for production casing and use high-temperature with plastic and micro-expansive cement, weighting cement slurry, and the cement is required to return to the hanger bell mouth.

For steamed well, apply inner string cementing for surface casing, and the cement is required to return to the ground. Use primary cementing and conventional high-temperature cement slurry system for intermediate casing, and the cement is required to return to 2000m. Utilize primary cementing and variable density cement slurry system for production casing, and the cement is required to return to the ground.

CONCLUSION

Widespread use has likely been curtailed by the challenging commodity price environment that has forced operators to drill and complete wells faster to lower recovery costs and provide production to the market quicker. With the recent decline in oil and gas prices, operators are considering all possibilities to help reduce lifting costs. Optimization program for difficult-to-produce reservoir reduced the production cycle and lifting costs, therefor, this optimization program will be widespread use for difficult-to-produce reservoir.

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