CSCanada
Advances in Petroleum Exploration and Development
Vol. 9, No. 1, 2015, pp. 115-118
DOI:10.3968/6639

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

Optimization of Drilling Engineering Design and Construction for Anshun 1 Well

LI Peili[a],*

[a] Drilling technology research institute, Shengli petroleum engineering Co., Ltd, Sinopec, Dongying, China.
* Corresponding author.

Received 6 February 2015; accepted 22 March 2015
Published online 30 March 2015

Abstract
Anshun 1 is a key risk exploration well. Based on the analysis of geological information, the engineering difficulties was confirmed and the drilling technology proposal on marine formation which is suitable for this block was formed through optimizing the well structure and selecting reasonable drilling method, drilling fluid system and matching drilling technologic measures. The well was successfully drilled to the objective interval with 5,478.91 m TD. The quality of well bore and cementing quality are qualified. The success of Anshun1 provides some guidance and reference for subsequent drilling operations in this block.

Key words: Risk exploration well; Well structure; Gas drilling; Vertical drilling; Anshun 1 well

Li, P. L. (2015). Optimization of drilling engineering design and construction for Anshun 1 well. *Advances in Petroleum Exploration and Development*, *9*(1), 115-118. Available from: URL: http://www.cscanada.net/index.php/aped/article/view/6639
DOI: http://dx.doi.org/10.3968/6639

INTRODUCTION
Anshun 1, located in Houzhai village of Chengguan Town in Puding County, Guizhou Province, is an important risk exploration of SINOPEC. The exploration results have an important significance to the exploration of natural gas and shale gas in Guizhou area. During the drilling process, many problems occurred including great uncertainty of geological factors, difficult prediction of the reef flat facies reservoir, poor formation drillability and well leakage in many formations. In the drilling engineering design, rational drilling methods were selected, design content was systematically optimized, and the matching techniquematching technology was innovatively applied, these provides the technical support for this well matching technique. matching technique

1. GEOLOGICAL SITUATION
Anshun 1 well was drilled from the upper formation of Guanling group, Triassic to the completed strata Shujiaping group, Lower Devonian. The drilling formation from top to bottom are as follows: The Triassic, Permian, Carboniferous and Devonian. The main target zone is reef flat facies reservoir of the Middle Devonian, and the Dolomite reservoir in Carboniferous and coal bearing strata in the Permian are also explored. Formation pressure coefficient is that the Guanling group - basalt group is 1.00-1.05, Maokou group - Da Tang group is 1.05-1.10, Rongxian group - Shujiaping group is 1.10-1.15. The lost circulation is relatively common in the structure of Anshun and its adjacent area, mud loss occurs in almost all the layers. Based on the statistics, the leakage layers exists in better reservoir and the lithology is mainly sandstone, limestone and dolomite.

2. DRILLING DIFFICULTIES AND TECHNICAL MEASURES

2.1 Drilling Difficulties
(a) ROP is very slow. The underground formations are featured by high hardness, high abrasive property, heterogeneity and serious bit bouncing in the drilling process, which could cause the damage of drilling tool and drilling bit and seriously affect the ROP. In addition, the formation has a strong natural deflecting ability, the

formation dip angle is up to 75 degrees and well deviation may easily take place. So when drilling in this formation, smaller WOB must be applied to avoid well deviation, which could result in low ROP.

(b) Due to the developed fractures and pores in Maping group, Huanglong group, Rongxian group and Dushan group, the rock is easily broken and the lost circulation is likely to happen.

(c) Due to the long open hole of the second and the third well section, it is very difficult to make a successful cementing operation.

(d) Multiple sets of coal seam, which is easily to collapse, will be drilled in Longtan formation of second spud, the sticking accident is likely to occur. In addition, the coal bed methane shows good, there is a certain risk of well control.

(e) The hole enlargement and complex lithology exist in the well interval of second spud. The wellbore stability and the control of hole deviation are very difficult when foam drilling technology is used to improve the drilling speed.

2.2 The Solution

(a) Two complex situation (circulation loss and wellbore instability) could be avoided through optimization of hole structure aiming to isolate well intervals that is easy to collapse and leak.

(b) Air drilling and air foam drilling technology were used to improve drilling efficiency and reduce the occurrence of well leakage.

(c) The drilling fluid system with good anti-sloughing, leak protection and high temperature tolerance was optimized.

(d) Under the premise of ensuring the wellbore quality, the torque impulse generator with PDC bit and vertical drilling technology were designed to improve the ROP, shorten the drilling cycle and reduce the complex situation.

3. OPTIMIZATION OF CASING PROGRAM

The Well locates in Anshun lithologic trap of Anshun depression in Qiannan downwarping region. There are lots of unforeseen factors during the drilling process. The geological conditions in actual drilling may be different from the expected. The complicated situation including well leakage and well sloughing would exist. Therefore, in the process of well structure design, the change of formation and possible pressure should be considered. In order to ensure safety in drilling operation and complete the drilling task, the selection of casing program should leave an appropriate margin for unforeseen circumstances[3].

Due to the unstable formation on the top of this well, well leakage and collapse may occur. The surface casing should isolate the water zone and upper unstable formation easy to collapse, then the wellhead and blowout preventer stack were installed. The formation of Permian is unstable. It has a relatively low formation pressure and poor pressure bearing ability. The intermediate casing should isolate the hole sloughing-prone zone as much as possible. Based on the formation pressure prediction of this well and the actual drilling data of offset wells, through analysis and discussion, the casing program was determined.

The φ476.25 mm conductor seated at 30 m after the hole was drilled with φ558.8 mm bit. The φ339.7 mm surface casing with 800 m is to isolate the water layer. φ311.2 mm drill bit was used in second spud and the φ273.1 mm intermediate casing, used to seal Longtan group and above formations that is easy to collapse, seated at the top of basalt formation, around 2,706 m. In the third spud, φ241.3 mm bit was used to drill to the top of gas zone of Dushan group, then the Φ193.7 mm production liner was set from 2,502 to 5,267 m.

4. DRILLING FLUID OPTIMIZATION

The geological design of Anshun 1 well and offset wells data shows that the upper formation in Qiannan area is easy to leak, the coal seam in Longtan formation is easy to collapse, and coal layer in Maokou group, Liangshan group and Maping group and fracture zone are easy to cave in. So the drilling fluid is required to present a good anti -sloughing and anti –sticking ability. Considering the features of formation and the requirement of environmental protection, drilling fluid system was determined. To decrease well leakage, fresh water drilling technology was applied in conductor section and after air drilling in first spud. Polysulfonate non-invasive drilling fluid system was adopted after air drilling in second spud. Drilling fluid of the third spud was required to further strengthen anti-fouling, anti-sloughing, anti-high temperature and filtration control ability based on second spud drilling fluid system. Therefore, the high temperature anti-stick sulfonated strong inhibitive drilling fluid system was selected. Polysulfonate drilling fluid has the advantages of good stability, high temperature resistance and good wall building properties, could meet the needs of drilling in deep well section. The mud density was determined by adding 0.07-0.15 security value to the comprehensive prediction pressure coefficient. Adjusting mud density during operation must follow the principle of balancing pressure without circulation loss. Near balanced drilling should be achieved to discover and protect hydrocarbon reservoir.

5. THE MATCHING TECHNOLOGY

5.1 Air Foam Drilling

Air drilling can prevent the reservoir from pollution by drilling fluid. It helps to improve oil production capacity. Air drilling technology can make the bottom rock bulge by extrusion, produce tensile stress zone, contributes to the bit and rock contact. Thereby it is easier for the bit to drill into formation and improves the drilling efficiency effectively[1]. During the construction of second spud, air drilling section was from 804 to 1,128.87 m, drilling footage was 324.87 m, the average ROP was 5.6 m/h. Foam drilling section was from 1,128.87 to 2,100.25 m, drilling footage was 971.38 m, and the average ROP was 5.19 m/h. The average ROP of air drilling was two times higher than the conventional mud drilling.

5.2 Vertical Drilling

In drilling operation, deviation prevention and fast drilling is a common technical problem. Vertical drilling system can liberate WOB and improve ROP[4]. The formation of Anshun1 has a strong natural deflecting ability, so tapered drill collar string with big size and pendulum drill assembly were used to prevent well deviation in second spud, but the effect was very limited. Therefore vertical drilling was applied in section 2,436-2,518.37 m, drilling footage was 82.37 m, the average ROP was 1.02 m/h. The inclination changed from 6.25 degrees @ 2,436 m to 2.62 degrees @ 2,492.58 m. Drop off rate was about 6 degrees per 100 meters. The footage was 2,518.37-2,610.79 m with second set of vertical drilling tool, the average ROP was 1.03 m/h, the inclination changed from 2.5 degrees@ 2,508.55 m to 0.24 degrees @2,595.59 m, the drop off rate was about 4 degrees per 100 meters. The obvious well straightening effect of vertical drilling was obtained and the wellbore quality was ensured.

5.3 Application of Torque Generator in Anshun 1

When the screw drill with PDC was used in inhomogeneous formation, the PDC cutters were easy to damage because of the stick-slip effect and the high rotating speed of bit. In order to improve the PDC bit drilling efficiency and lifetime, the torque generator, shown in Figure 1, was used [2]. Torque generator along with PDC bit was applied in Maokou Formation of the third spud, the advantages were as follows:

(a) This tool provides impact crushing as a main force supplemented by rotary shear to break rock. So it can improve the drilling speed and ensure the borehole quality at the same time[5].

(b) The fluid energy of drilling fluid is converted to mechanical impact energy which is torsional, high frequency, even and stable. The energy passed directly to PDC bit, makes the bit and bottom maintain continuous.

(c) Stick-slip effect of bit is eliminated, the recoil torsion is reduced. It helps to improve the durability and prolong the service life of the bit.

(d) Torsional oscillation is reduced on drill stem, thereby the fatigue degree of BHA is decreased. Torque generator worked with PDC were applied in section of 2,757.5-2,843.71 m and 2,881.11-3,055.20 m in this well, the ROP was 3.92 m/h and 3.55 m/h. The ROP is much twice higher than conventional drilling.

The specification of BHA: Φ241.3 mm five blade PDC (nozzle: 16 mm × 3) + torque generator +430 ×410 float valve +Φ177.8 mm two-way shock absorber +Φ177.8 mm non-magnetic drill collar +Φ239 mm stabilizer +Φ177.8 mm drilling collar + flexion axis +Φ177.8 mm drilling jar +411 × 410 bypass valve +Φ127 mm drill pipe (7 blast joints).

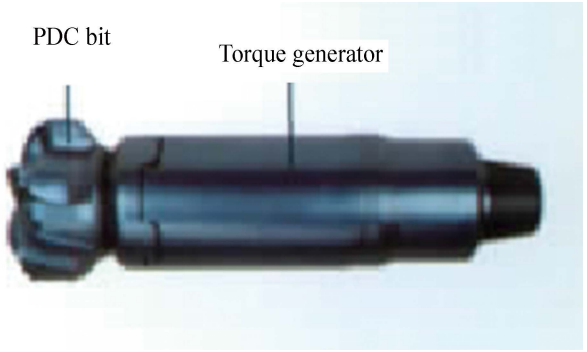

Figure 1
External View of Torsion Generator

CONCLUSION

In the construction of Anshun 1 well, new technology and new process were actively promoted. The work of speed up was achieved with certain effect.

(a) In the first spud of Anshun 1, fresh water drilling was used in Guanling group of Qiannan depression, of which the drilling footage was 399.5 m, the average ROP was 2.47 m/h. It provides precious experience for the fresh water drilling operation in this area.

(b) Air foam drilling technology was first used in the Anshun depression of Qiannan region. Air drilling were applied in second spud, drilling footage was 324.87 m. While the air foam drilling technology was applied, the footage of 971.38 m was obtained. Anshun 1 well was the deepest well that applied air foam drilling technology in this area.

(c) In second spud, vertical drilling tool was applied, deviation correction and prevention have been achieved with good effect. With the help of this tool, the problem that hole deviation was very hard to control in Guizhou area for a long time was solved.

(d) Lost circulation occurred many times during well construction, among which the seepage was in domination. Mud loss prevention and mud loss control technology were used to prevent the lost circulation through sealing leak path near wellbore and improving the bearing capacity of formation.

Through the construction of this well, we had a deeper understanding of the Qiannan area, some valuable experience were accumulated for the future operation.

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