Optimization of Trajectory Design for Highly Deviated Directional Wells

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Abstract. Highly deviated directional well technology has the advantages of drilling through longer shale gas reservoir section, detecting and controlling gas bearing area in a large range, and greatly improving gas production of single well. Based on the preliminary work of vertical well and pre exploration well, through the optimization design of well bore structure, well trajectory, BHA, drill string mechanics, drilling fluid, cementing and other technologies, the drilling engineering design scheme of high angle directional well in accordance with shale gas exploration in high steep structural area is optimized, and the formation pressure profile and bit selection scheme are established to form a set of drilling technology for efficient development of shale gas. The technology system can be used for reference for the exploration and development of shale gas and coalbed methane in other areas in the future.

Keywords: Trajectory Design, Highly Deviated, Directional Wells

1. Introduction
As a clean energy, shale gas exploitation has been listed in the development strategy of China’s oil and gas resources. Since the breakthrough of shale gas obtained by CNPC in Well-Wei-201, Weiyuan, Sichuan Province in 2010, China’s shale gas development has entered a period of rapid development. In order to increase efforts to promote the sustainable development of shale gas [1], the former Ministry of land and resources has successively carried out two rounds of shale gas blocks in 2011 and 2013 Bidding and selling are mainly concentrated in Southwest Sichuan Basin, North Yunnan Guizhou, Western Hunan and northwest Or-dos Basin. Due to the uneven distribution of shale gas in China, most of them are located in the southwestern mountainous area and the northwest hilly area[2]. Shale gas exploration and development is difficult. In order to obtain the single well productivity, the project needs to drill high angle directional wells or horizontal wells to achieve the drilling purpose. It is particularly important to improve the scientific nature of drilling design and the success rate of one-time drilling[3].
2. Case Analysis of Well-BY-3XF and Well-BY-4XF

The shale gas drilling process in Baojing block can be divided into three stages: the first stage is 2013, because the geological conditions and formation pressure system are unclear after entering the work area, lack of experience in drilling shale gas wells, the nature of drilling is parameter wells, and the core drilling rig is used for construction, which belongs to the experience drilling stage, and the drilling is Well-CY-1 and Well-CY-2; the second stage is 2014, starting to use the oil drilling rig for construction, which is drilling performance The quality is a pre exploration well. Due to the limited data, the accuracy of drilling design is affected. The well bore structure design and construction scheme are still not reasonable. Drilling accidents happen frequently and the drilling cycle is long. All the wells are Well-BS-3, Well-BY-1 and Well-BY-2. The third stage is after 2015, I am familiar with the geological conditions of the work area. The drilling property is an evaluation well and the well type is a highly deviated directional well. Through the scheme With optimized design and scientific drilling, the drilling speed has been greatly improved and the drilling cost has been reduced. The wells to be drilled are Well-BY-3XF and Well-BY-4XF (As Fig. 1).

![Drilling site map of Baojing Block](image)

Figure 1. Drilling site map of Baojing Block

3. Optimization Design of Drilling Engineering

Due to large deviation (usually 55 ° ~ 86 °), large horizontal displacement and high friction torque, the wellbore is easy to lose its stability, causing collapse, lost circulation, sticking and other accidents; therefore, in the design of high angle directional wells, it is necessary to select a reasonable wellbore structure, optimize the well trajectory as much as possible, give priority to the profile type of smooth borehole, less footage and small friction torque, and reduce the drilling fluid in the open hole section. It is proved that the optimization design of drilling engineering scheme and drilling simulation are the basis of the completion of highly deviated directional wells.

3.1. BHA design and bit optimization

The BHA can be optimized and designed according to the drilling purpose. The BHA should be simplified as much as possible to avoid excessive centralizers and collars. The design of the pilot hole adopts the tower type BHA to prevent deviation. BHA: 9660.4mm tricone + 0279.4mm large drill collar + vibration eliminator.
In the first spud, the pendulum drilling assembly is used to cooperate with the roller bit for anti-deviation and straightening. BHA: 0444.5mm cone bit + 0279.4mm drill collar x 3 + 444mm centralizer + 229mm shock absorber + 0228.6mm drill collar x 2 + 0203mm non-magnetic drill collar + 0203mm drill collar x 2 + 0177.8mm drill collar x 1 + g127mm drill pipe.

In the second inclined section, "PDC bit + curved screw + MWD" is used to carry out composite drilling to minimize sliding drilling and improve the ROP. The designed BHA is 0311.15mm PDC bit + o216mm1.25 ° single bend + 0203mmndc + gam + MWD + 0203mmndc + + o177.8mmdc + 0127mmhwdpx15 + o127mmdp. In the directional process, each single inclinometer is used once, and the BHA is adjusted in time according to the actual drilling situation to control the borehole Track to ensure smooth hole.

In the third section of the target formation, rotary steering drilling is adopted to improve the drilling speed and the drilling rate of the reservoir. The BHA design is: 0215.9mm PDC bit + rotary steering tool + flexible nipple + ONTRAK MWD + 6127mm non-magnetic pressure bearing drill pipe + o127mmhwdpx3 + flexible nipple + while drilling jar + ρ 127mmhwdpx9 + 0127mmdp. It is required to closely monitor the formation change during drilling and adjust the borehole at any time according to the instructions of the geological director Trajectory to ensure the drilling rate of reservoir and reduce the risk of drag pressure and sticking. While drilling jar + σ 127mmhwdpx9 + σ 127mmdp, it is required to closely monitor the formation change during the drilling process, adjust the well trajectory at any time according to the instructions of the geological guide, ensure the drilling rate of the reservoir, and reduce the risk of drag pressure and sticking.

Figure 2. Trajectory Projection of Well-BY-3XF at 93.17°

3.2. Simulation of 5 Drill String Mechanics and Wellbore Cleaning

The fine analysis of drill string mechanics can provide the basis for the feasibility analysis of highly deviated directional wells, and can better guide the drilling design and construction. Taking Baoye 3xf well as an example, the friction torque is predicted by using the drilling design software, and the simulated conditions are rotary / sliding drilling, tripping out, tripping in, etc.

The software uses the triaxial stress method to check the tensile strength, torsion resistance and buckling analysis of the drilling tool. During normal tripping, the maximum tensile force of 127mmg105 drill pipe is 773.4kn, and the friction is 227.8kn. In case of downhole complex situation, the maximum tensile force of the drill pipe will reach 1301.2kn, which is smaller than the yield strength of the drill pipe. 1970kn. Under the rotating / sliding drilling condition The actual axial load...
line is larger than the critical load line of positive rotation bending without bending, and the WOB can be effectively transmitted to the drill bit (Fig. 3); the maximum torque during reverse reaming is 19.29kn · m, which is less than the torsional strength of the drilling tool body of 28kn · m, so there will be no accident of breaking the drilling tool (Fig. 4).

4. Summary
1) It is the precondition for the success of highly deviated directional well to fully collect seismic, geological, logging, logging and other data, and to use computer drilling software to optimize the design and analysis of well bore structure, well trajectory, drill string mechanics, hydraulic parameters, drilling fluid and cementing.
2) Through the optimization design of high angle directional drilling program and scientific drilling, the drilling cycle can be effectively shortened and accidents can be reduced.
3) The key to the success of high angle directional well is to introduce advanced and mature drilling
technology, organize construction carefully, and carry out the application of new technologies such as rotary steering drilling, new PDC bit and oil-based drilling fluid.

4) Actively carry out the application of drilling speed-up and optimized drilling, improve the development efficiency of shale gas wells, reduce the operation cost and create economic benefits.

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