3D Horizontal Well Fast Drilling Technology in X Gas Field

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Abstract. The design trajectory parameters of 3D horizontal wells in X gas field are not uniform, the construction is random, and the lack of standardization is not enough to achieve rapid drilling. Based on the analysis of the construction data and construction difficulties of the completed 3D horizontal well, according to the different design trajectory parameters and types, by standardizing the drilling tool assembly and well trajectory design, making full use of the characteristics of the drilling tool assembly and the formation law, and using the supporting tools to control the sand carrying and lubricity of the mud, control the solid content, and reduce the friction and torque of the 3D horizontal well, this paper studies and summarizes the 3D horizontal well rapid drilling technology. The field application shows that the 3D horizontal well rapid drilling technology can effectively reduce downhole faults, greatly improve the drilling speed, and achieve the effect of increasing speed and efficiency and saving costs. The 3D horizontal well rapid drilling technology plays a very good technical guarantee for the development of the gas field, and also provides a certain reference for peers.

Keywords: Horizontal well, rapid drilling, trajectory parameters, collision prevention and obstacle avoidance, supporting tools

1. Introduction

With the promotion and application of "industrialization", 3D horizontal wells have become the main development mode of horizontal wells in X gas field. Three-dimensional horizontal well project can reduce the number of well pads, effectively save land resources, and has significant advantages in improving construction efficiency and development efficiency, convenient for centralized management and maintenance in the later stage, efficient use of resources and other advantages.

In the aspect of trajectory design, 3D horizontal wells introduce trajectory parameters, some of which are different from conventional (2D) horizontal wells. These trajectory parameters are used to quantify the well trajectory and evaluate the difficulty of drilling construction.

Target front distance: the target front distance of 3D horizontal well refers to the apparent translation, that is, the projection of the well trajectory in front of the target on the target azimuth line, which can also be defined as the distance from the vertical intersection point of the vertical line of the wellhead to the extension line of the horizontal section to the target point A, and also refers to the effective target front distance. Closure distance: the vertical distance from the target point A to the vertical line where the wellhead is located, that is, the displacement in front of the target.

2. Analysis of construction difficulties

In order to ensure the safety of the well trajectory construction, the anti-collision and obstacle avoidance construction must be given priority, so the anti-collision section construction cannot be designed and constructed according to the established standardized trajectory.The design track parameters are not uniform, the construction mode is diversified, the main track parameters in the design of X gas field project are different, the site construction is random, and the construction mode is difficult to achieve standardization.The deviated well section includes the deviation correction section, the twist direction section and the inclined window section. The length of the controlled well section, the number of layers drilled through, the formation regularity is not uniform, and the trajectory control is difficult.Due to the existence of offset, it is difficult to establish the friction and torque model of 3D horizontal wells, and it is difficult to accurately analyze the stress of drill string and casing; In the later stage, the friction torque of the well section construction is large, the directional drilling of the

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downhole power drilling tool is difficult, and the construction efficiency is low.

3. Standardized construction of three-dimensional horizontal well

3.1 3D horizontal well classification

According to the difference in the design offset of 3D horizontal wells, 3D horizontal wells can be divided into three types: small, medium and large. Another case is to design 3D horizontal wells with small apparent translation of target points, that is, 3D horizontal wells with short target front distance. The horizontal projection is shown in Figure 1.

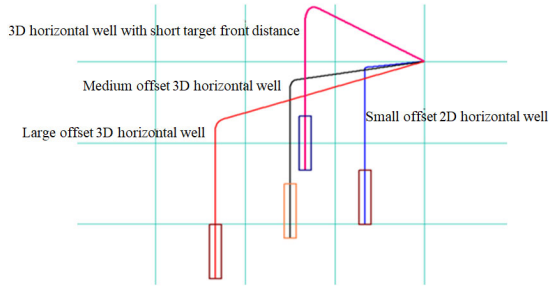

Figure 1. Schematic diagram of horizontal projection of various types of 3D horizontal wells

Small offset horizontal wells are classified as conventional two-dimensional horizontal wells due to their small offset, which is usually within 200 meters. Medium offset 3D horizontal well refers to the design offset within the range of 200-600 meters, which occupies the leading position of 3D horizontal well. The large offset 3D horizontal well refers to the design offset greater than 600m. This type of well has a low occupancy rate and is difficult to construct. The design target front distance (apparent translation) of the short target front distance 3D horizontal well finger is far less than the offset distance, and the ratio of the two is even less than 0.5 in actual construction, the track control requirements must be met by correcting the deviation and moving negative.

3.2 Programmed construction

3.2.1 Stratigraphic law analysis

X gas field involves a wide range of areas, and the formation rules of each block are different. It is difficult to standardize the specific construction of 3D horizontal wells of each block type by using a unified construction mode. The construction mode can only be standardized according to the corresponding different types of wells in the block. Through the analysis and statistics of a large number of construction well data on site, it can provide qualitative reference for each geological layer of X Gas Field, but it cannot be relied on quantitatively. The track trend of each geological horizon in the deviation correction well section of X Gas Field is shown in Table 1.

Table 1. Trajectory trend of each geological horizon in the deviation correction well section of XX Gas Field

No.	Formation	Lenth（m）	Deviation change rate (°/100m)
1	ZL	230	1～2
2	YA	270	1～2
3	YC	500	0～1
		300	-1～-4
4	ZF	248	0～1
5	HSG	100	0～2
6	LJG	310	1～3
7	SQF	252	-1～1

The second spud of horizontal well in X gas field enters ZL group. According to the above table, the upper strata of ZL group, YA group and YC group increase the slope, and the lower and middle strata of YC group decrease the slope with a large range. It enters ZF group, until the upper strata of SQF group (micro) increase the slope, and then enters the inclined section construction at the lower part of SQF group.

3.2.2 Determination of drilling tool assembly

According to the design requirements and in combination with the formation rules, the "four in one" drilling tool assembly is selected for the second spud of the 3D horizontal well in X gas field. The drilling tool assembly is as follows: Φ228PDC+7LZ185*1.25°+ Φ 177.8SDC+ Φ 224STAB+MWD（411x410）+ Φ 177.8NMDC + Φ 177.8DCx (9-15 pcs)+ Φ 127HWDP × 45 pieces+ Φ 127DP.

Select the length of short drill collar according to the type of block well. According to the qualitative analysis of the formation law, the length of the short drill collar of the "four in one" drilling tool assembly in the second spud of the 3D horizontal well in X gas field can be selected according to the following modes, as shown in Table 2.

Table 2. Selection reference of short drill collar length of "four in one" drilling tool assembly in each block of X gas field

No.	Block	Short DC length（m）
1	SLG	3
2	SX	4
3	T2	3
4	JZ	2
5	JN	4

The selection principle of centralizer: 1mm smaller than the screw centralizer. Small offset horizontal wells are constructed according to conventional two-dimensional horizontal wells, and short drill collars are not added in the second spud assembly.

3.2.3 Track design

(1) Track mode selection
According to the 3D horizontal well type of X gas field, the trajectory design is carried out by using the software of Yiheng Sunshine Navigator. The 3D horizontal well trajectory design model usually selects "horizontal well". Enter the horizontal well model, and select "increase stability and increase" for the trajectory description in the design parameters.

(2) Selection of skew point
The length of the initial section, that is, the skew point, can be adjusted according to the engineering design or the track requirements. In order to standardize the construction of 3D horizontal wells, we will conduct well depth and formation specifications for the deflection points according to the type of 3D horizontal wells, as shown in Table 3.

Table 3. Trajectory specifications of different types of 3D horizontal wells

No.	Type	Offset (m)	Inclination point (m)	Formation	Deviation correction well deviation (°)
1		0-50	None	None	≤2
2	Small offset	50-200		ZF	≤15
			2000-2300		
		200-300	1200-1400	YC top	≤10
3	Medium offset	300-600	800-1200	YC top	18-22
4	Large offset	≥600	600-800	YA	≤25
5	with short target front distance	200-400	1000-1200	YCtop	≤20

The middle and lower part of YC Formation is a declination formation, and the well section of this formation contains gravel interlayer, which has low sliding adjustment efficiency. Generally, 3-5 ° well deviation is reserved in advance in the middle and upper part of YC group.
(3) Trajectory design
After the initial segment length is determined, the trajectory is designed. The dogleg degree of the first increase is the dogleg degree of the initial directional section. Generally, 10-12 °/100m is selected based on the comprehensive deflecting ability and track smoothness of the screw drilling tool; The second increase of dog leg degree is the twisting direction section, usually 15 °/100m. The second added deviation is the deviation angle of the twisted azimuth well, usually the deviation correction well. You can also select the direction of increasing and decreasing the inclination according to the specific situation. The third increase of dog leg is the increase of dog leg in the window well section, which is designed to be 15 °/100m, leaving room for trajectory adjustment.

3.3 Technical measures

3.3.1 Give priority to barricade construction in anti-collision section

If there are anti-collision and obstacle avoidance wells, the construction specification can be set aside, and the anti-collision and obstacle avoidance construction can be carried out first. After the anti-collision section passes safely, the trajectory design or redesign can be carried out.

3.3.2 Reserved deviation lead angle in the middle of YC group

The deviation correction section of 3D horizontal well in X gas field is located in the middle and lower strata of YC group. The "four in one" drilling tool assembly has a strong composite deviation reduction, and the sliding adjustment is relatively difficult, and the construction efficiency is low. In order to achieve rapid drilling, the well deviation is reserved in the upper and middle strata of YC group in advance, and the specific reserved space depends on the size of deviation correction. According to the field construction experience, the deviation angle of the leading shaft is usually 25% - 30% of the deviation correction. Avoid track adjustment in the middle and lower part of YC group to improve the construction efficiency. After entering ZF group, adjust the track in time, and the well deviation angle is slightly less than the design deviation correction well deviation.

3.3.3 Selection of twist orientation mode

The deviation angle of the correction well determines the speed of the offset elimination. When the deviation correction well deviation is small, resulting in the lack of offset, you can choose to increase the deviation and twist azimuth. In the process of twist azimuth, multiple offset points are eliminated, and the second increase dogleg degree takes the lower limit. When the trajectory is constructed according to the design trajectory, the stable skew direction can be selected to smoothly transition into the deviated section. When the deviation correction well deviation is large and the offset is too large, it is necessary to select the declination and twist direction, control the well deviation, reduce the declination speed, take the

upper limit of the second increase dogleg degree, and quickly twist the direction.

3.3.4 Timely design to be drilled, optimize the trajectory, and improve the construction efficiency of the second cleaning area.

According to the parabola principle and the force analysis of the drilling tool, it is relatively difficult to adjust the trajectory of the second cleaning area (well deviation 30-60 °). During the actual drilling construction, the residual offset and apparent translation are integrated. The overall trajectory of the twist section is to be designed for drilling. The twist direction mode and the size of the second increase in completion angle are to be determined, the dogleg degree of the second cleaning area is to be reduced, the sliding ratio is to be reduced, and the rapid drilling of the deviated section is to be realized.

3.3.5 Refine the landing control, and determine the well deviation into the window according to the horizontal section design and formation dip angle.

According to the trajectory design of horizontal section and formation structure, the deviation control of target entry is reasonably carried out. When the reservoir target is tilted upward, the gas reservoir is explored with a well inclination of 85-86 °, and the top of the reservoir is 88-90 ° into the window; When the reservoir target dips downward, control the well trajectory to explore the gas reservoir at 82-84 °, and enter the window at 86-88 ° in the middle of the reservoir.

4. Field application effect

The design deviation of J33-34H2 well is 667 meters, the apparent translation is 548 meters, and the directional deviation correction is 800 meters. The "stability increase" profile design is made by using the "horizontal well" model of Navigator software, as shown in Table 4.

Table 4. Node data of well J 33-34H2 design trajectory

Depth (m)	Inclination (deg)	Azmuth (deg)	Vertical depth (m)	Visual translation (m)	Dogleg (deg/100m)	Closing distance (m)	Closed azimuth (deg)
0	0	90.73	0	0	0	0	0
800	0	90.73	800	0	0	0	0
1010.76	21.08	90.73	1006.03	3.84	10	38.33	90.73
2631.29	21.08	90.73	2518.16	62.3	0	621.07	90.73
2901.31	19.63	174.97	2776.1	113.48	10	676.73	94.62
3428.66	89.94	174.97	3061.46	517.8	13.33	844.49	122.79
3828.19	89.94	174.97	3061.86	917.33	0	1134.24	138.95

In the selection of the second spud-in drilling tool assembly, 2.0m short drill collar is selected. During the construction, make full use of the law of lowering the deviation in the middle and lower parts of YC, reserve the well deviation in advance, correct the deviation by 21.08 °, reserve the well deviation in the middle and upper parts of YC in advance to 27 °, advance the well deviation by 6 °, and compound the natural deviation in the later stage to improve the construction efficiency, see Table 5.

Table 5. Actual Drilling Track Data of Well J33-34H2

No.	Depth(m)	Inclination(deg)	Grid orientation (deg)	No.	Depth(m)	Inclination(deg)	Grid orientation(deg)
1	1110.2	20.26	94.31	11	1465.15	25.76	87.36
2	1205.8	24.31	92.81	12	1494.02	25.1	85.96
3	1234.52	25.1	91.76	13	1522.84	24.18	84.55
4	1263.35	26.02	92.29	14	1551.63	23.65	83.06
5	1292.09	26.9	90.97	15	1638.11	22.15	81.3
6	1330.45	27.56	90.53	16	1666.72	21.23	81.23
7	1349.52	26.68	89.21	17	1695.46	20.44	82.18
8	1378.14	26.51	88.77	18	1753.01	19.82	86.75
9	1407.19	25.93	87.98	19	1781.59	19.65	85.25
10	1436.11	25.67	87.36	20	1810.32	19.34	84.9

5. Conclusion

(1) The standardized construction of 3D horizontal wells in X Gas Field only standardizes the design of drilling tool assembly and well trajectory from the type of 3D horizontal wells in the block. It also needs to be flexibly used in the field construction. The dead wrench and hard sleeve may lead to passive or out-of-control trajectory.
(2) The well trajectory of SX well pad is complex, and the anti-collision situation is still serious. The standardized construction of 3D horizontal wells (including 2D) is difficult to promote in a large area. The specific construction must also give priority to anti-collision and obstacle avoidance.
(3) The full utilization of the characteristics of the drilling tool assembly and the formation law is the key to fast drilling in the deviation correction section.
(4) The combined use of supporting tools can greatly improve the construction efficiency of inclined shaft section. Due to the limitation of service time, the composite bit should be selected in the deviated well section with a small distance in front of the target.
(5) To ensure the smoothness of the track, the sand-carrying property and the lubricity of the mud, and to control the solid content can effectively reduce the friction and torque of the three-dimensional horizontal well, and provide guarantee for the extension of the horizontal section.

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