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The Feasibility Analysis of Single [1]Curved Screw Drill through the Mouth of the Well Casing

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Abstract

With the development of drilling technology and the needs of the larger Bulit-up, the screw drill with larger structure corner is used more widely in drilling field. Because the existence of single curved screw drill tool with larger structure corner, it have larger friction during the bend PDM in the process of internal casing, so we often need to use the wellhead adjuvant into the well. In order to understand the single bent screw drill into the state in the wellhead diameter of casing, and how the angle of screw structure impact the feasibility, This paper analysis the stress of the single curved screw drilling tools in the well, and the condition it can safely through the mouth of the well conditions, establish the single bend PDM in the calculation wellhead down model. and the finite element model is established combined with the specific parameters of a well which is in the western of SiChuan depression. Using ansys analysis a particular casing inside diameter, under wellhead vertical segment into different structure when the turn of the screw drilling tools down into characteristics and stress distribution characteristics, it is concluded how large of the structure corners and how depth that the bend PDM can rely on gravity well down into the inside diameter of 250.19 mm casing, concluded the relationship between reaction force, friction force, and maximum stress with the well depth and the change of structure corners from 1.5°to 2.75°, provide a basis for drilling site selection of the appropriate combinations of screw drill and how to regulate the radial force of the device while into the well.

Keywords: *single curved screw; assembly; feasibility; frictional force; strength requirement*

1. Introduction

The exploitation of many domestic and foreign large oil field entered the middle and later period since the 21st century. Single curved screw assembly widely used in the worksite with the development of drilling technology, the needs of the new exploration of special reservoirs and the deflection demand of drilling field. [1-3] Because the dimension of the casing is small, the annulus space between single curved screw assembly and pipe is small in the vertical part of the wellhead. Single curved screw assembly usually needs big structure corner in order to deflecting, this result in the big corner single curved screw assembly has larger transformation and bear larger stress. So the initial process of single curved screw assembly down into the wellhead is difficult [4-6].

In the actual drilling worksite, the press-in device has not been applied interiorly. Therefore it is more meaningful to make single curved screw assembly down into the wellhead smoothly. In order to let single curved screw assembly down into the wellhead

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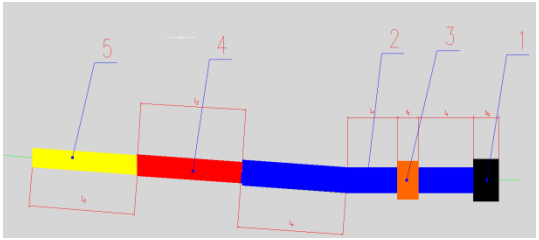
smoothly, it requires the drilling tool's weight is bigger than the friction produced between the drilling tool and the casing and deformation and strength of the drilling assembly shall satisfy the corresponding conditions. Meanwhile contact force produced by drilling tool and casing wall cannot be a devastating impact on casing, so as not to affect the subsequent production. [7-10] Based on these, this paper will establish the analysis model of the single curved screw assembly down into the wellhead and use the finite element method analysis this model.

2. Geometric Structure of Single Curved Screw Assembly



1-Bit 2- Single Curved Screw 3- Stabilizer 4- Non-Magnetic Drill collar 5- HWDP

Figure 1. Main Component of Single Curved Screw Assembly

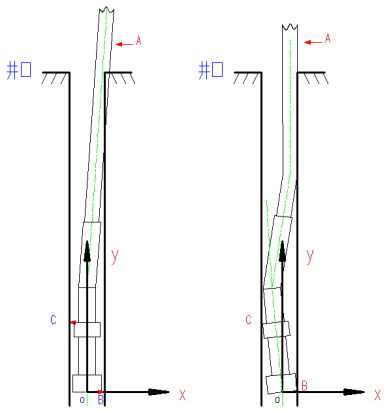
As shown in Figure 1 a schematic model of a single curved screw BHA (with a stabilizer), in which the diameter of the bit is D_0, the height is h_0; The diameter of the screw drill tool is d_{s1}, the overall length is L_m; the diameter of the stabilizer is D_1; the structure angle of single curved screw is γ; The diameter of the non-magnetic drill pipe is d_{s2}, the length is L_2; the diameter of HWDP is d_{s3}, the length is L_3.

3. Basic Assumption

In order to establish the analysis model of the BHA through the mouth of the well casing, BHA in the casing of the situation can be simplified and make the following assumptions [11-13]:

1. Before the screw assembly contacting with the casing wall, the central axis of drill bit, stabilizer and the front end of the screw bending point contact with the axis of casing wall.
2. The BHA screw lower bending point is rigid and the upper part (HWDP) in the bending point of the BHA is in continuous contact with the casing above the point of contact;
3. The inner wall of the casing is rigid;
4. Ignore the effect of dynamic load caused by the process of BHA down into casing;

4. Analysis the Down into Process of the BHA



a) Before Bending b) After Bending

Figure 2. The State Before and After Bending of Assembly

Assumption that BHA along the center line into the casing, due to the inner diameter of the casing is fixed and screw drill tool exists a certain corner when down to a certain depth, BHA theoretically in contact with the wall(shown as Figure 2-a). To make BHA smoothly down into the casing, a large radial load is often required .After down into a certain depth, due to the force at the wellhead, the bottom B of the drill sides to the right and contacts with the casing, while the upper end of the stabilizer to the left and in contact with the casing. As shown in Figure 2–b, after continued to fall into, the contact area between BHA and casing wall is increased. When the BHA gravity is less than the friction between the BHA and the casing wall, it is required to provide the device with the axial force until the BHA able to down to rely on their own gravity.

5. The Finite Element Model of Assembly

To establish the model, ignore the non-magnetic drill collar part, assuming that non-magnetic drill collar diameter consistent with compound pipe diameter; In the early period of the assembly under the casing into, Assume that casing axis and Z axis screw drill bit axis coincide, as shown in Figure 3.

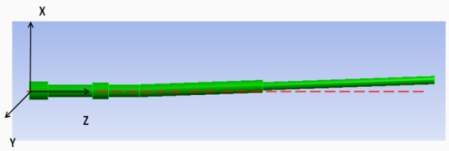


Figure 3. The Finite Element Model of the Single Curved Screw Assembly into the Well

6. The Location of the Critical Point

In the initial stage of single bending screw into the Casing ,Single bending screw drilling tool and casing without contact. The critical state will appear with the increase of the depth. That means the bottom of the screw drill assembly, the upper end of the stabilizer, and the screw at the wellhead are the first time in contact with the inner wall of the casing. The rotation of the drill string along the central axis of the shaft.

$$\theta = \arcsin\frac{d_{s0}}{|BC|} - \arcsin\frac{D_0 + D_1}{2|BC|}$$

$$|BC| = \sqrt{(h_0 + L_1 + h_1)^2 + (\frac{D_0 + D_1}{2})^2}$$

We can draw from the geometric relationship.

$$(L_0 - L_b + h_0)\sin\theta + \frac{D_0}{2}\cos\theta$$

$$= (\mathrm{L}_b + x)\sin(\gamma - \theta) + \frac{d_1}{2}\cos(\gamma - \theta)$$

It is known that the assembly must meet the following conditions at the same time.

7. Conditions for the BHA down into Casing

7.1. Friction

Due to the structural angle of single curved screw BHA, When the single curved screw BHA in the process of downing to the casing in straight well, will be in contact with the casing and produce larger friction. The friction force is the important factor to decide whether single curved screw BHA well down into the well. Since the casing located vertical section, the direction of frictional is along the center of the casing and the formula14 for calculating total friction force is:

$$f = u \times \sum F_i$$

Where u is the friction coefficient; $\sum F_i$ is the total contact force (N) of the lower BHA and casing.

7.2. Condition for Maximum Stress of BHA

Due to the structural angle of single curved screw BHA and the limitation of the casing wall, When the single curved screw BHA in the process of downing to the casing in straight well, it is required to provide the device with the axial force to make it downing to smoothly. The axial force can make the BHA down into the casing while it will also make BHA produce certain deformation. So this requires that he maximum stress in the process of BHA downing into the casing is less than the minimum allowable stress of each component of the BHA, to ensure the BHA fracture damage will not occur.

7.3. Geometrical Condition

The bending deformation of the lower part of the BHA should be less than the allowable deformation values of each part of the material, so as to ensure that the BHA damage do not occur and the normal work of the BHA.

7.4. Conditions for Contact Force

In the process of BHA down into casing, in order to ensure the scratches cased by BHA on the casing wall do not affect the subsequent oil recovery operation, the contact force of drill and stabilizer with the casing wall should be less than the allowable value.

8. Results and Discussion

8.1. The Distribution of Radial Thrust

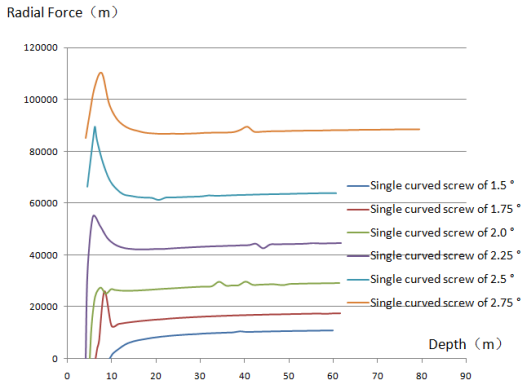
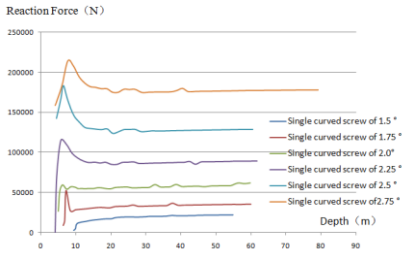


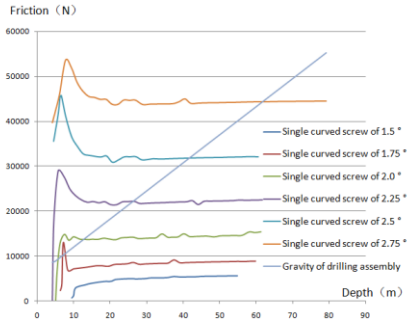
Figure 4. The Relationship Between the Radial Force of Auxiliary Device into the Well and the Well Depth

Figure 4 show the variation of radial force, which is provided by the device to tripping the single curved screw assembly into the casing. According to Figure 4, we know that the radial force needed for the single curved screw assembly increases rapidly with the increase of the depth at the beginning, and then decrease gradually after its increase to the largest. At last, its stability to a certain area with a small change. We can learn that the corners of single curved screw had a greater influence on the radial force, the radial force increased along with the increase of single curved screw drill screw structure corner.

8.2. The Tripability Analysis of the Different Structure Corners



a) The Relationship between the Reaction Force with the Well Depth



b) The Relationship between the Friction with the Well Depth

Figure 5. The Relationship between the Reaction Force and Friction with the Well Depth

From Figure 5-a, we know that the reaction force in the casing during the tripping increased gradually with the increasing of depth, and the reaction increased to the largest between 5 m to 15 m, then the reaction force decreases gradually and finally tends to be stable. The reaction force increases with the increase of, and the largest reaction force and the structure corner almost linear relationship.

When calculating the friction, refer to the related literature data [15], take, The final results as shown in Figure 5-b .The figure shows that the friction increased gradually with the increase of depth, it increased to the largest between 5 m to 15 m, then the friction decreases gradually and finally tends to be stable. The friction increases with the increase of screw structure corners. While comparing the friction and its own gravity of assembly, we concluded that screw structure corners of 1.5° can tripping rely on its own gravity. The friction of 1.75 ° screw structure corners will be greater than gravity between 5-10 meters in the casing during the tripping, in this section, we need to use pressure device or increase the drill pipe to tripping. 2.0° and 2.5° screw structure corners all needs to use pressure device after creates friction during the tripping, 2.0° can rely on its own gravity of BHA after tripping 10 to 15 m, 2.5° is after 25 to 30m. Assembly of 2.5° can depends on its own gravity until tripping to 40-45 m, and 2.75° is after 60m.

Stress analysis

We can draw from Figure 6 that the change of the bending angle of the screw structure has a more obvious effect on the maximum equivalent stress of the drilling assembly. The influence of tripping depth is bigger also, the maximum stress increased as the depth increases at first, and then the maximum stress in a small fluctuations after a certain depth, but the absolute value in reducing. Combined with Table 1, when structure corner changed from 1. 5° to 2.75°, the maximum equivalent stress increased from 82 MPa to 544.44 05MPa.We can obtained that the maximum stress occurs generally at the end of the screw and increase a drill pipe diameter changes at the same time. Compared to the strength conditions of the assembly, that is, the maximum stress condition of 412 Mpa, We can learn that structure corner of 1.5°, 1.75°, 2.0° and 2.25° screw can satisfy the requirements of strength, stress concentration will appear in 2.5° and 2.75° during the tripping, which means has a certain risk.

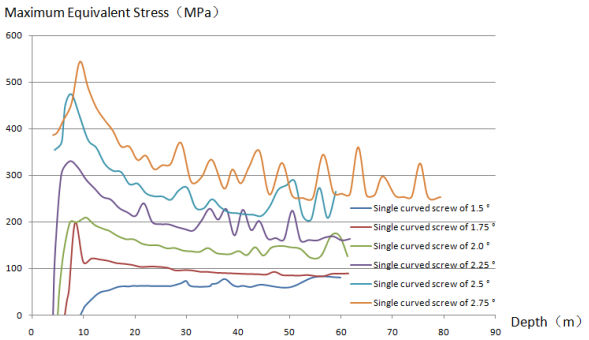


Figure 6. The Relationship Between the Maximum Stress of Assembly with the Well Depth

Table 1. The Maximum Parameters Related to the Different Structural Corner

Corner of Screw（/°）	Biggest Reaction（/N)	Biggest Friction（/N)	Biggest Radial Force（/N)	Largest Equivalent Stress（/Mpa）
1.5	22330.07	5582.5	11132	82.05
1.75	52307.7	13076.9	26154	199.7
2	61841.8	15460.5	29856	209.33
2.25	115563.9	28891.0	54737	330.3
2.5	182865.8	45716.5	89689	474.5
2.75	214159.6	53539.9	110200	544.44

9. Summary and Conclusion

1) Analysis the condition of single curved screw assembly down into the wellhead safely, calculate the down into process of the φ185mm screw with 1.5°, 1.75°, 2.0°, 2.25°, 2.5°, 2.75°structure corner. Obtained the radial force, the reacting force and the friction during the down into process. Obtained the relationship between the drilling assembly's maximum stress and the well depth.

2) By comparing the drilling tool's weight and the friction during the down into process, it can guide the ability of single curved screw assembly down into the wellhead. The analysis results show that: single curved screw assembly with 1.5°structure corner can down into the well depends on it's weight. For single curved screw assembly with 1.75°structure corner, the friction force is greater than it's weight between 5-10m, then it can down into the well with it's weight. Single curved screw assembly with 1.75°, 2.25°, 2.5° and 2.75° structure corner need press-in device within a well depth. After reach this well depth, it can down into the well with it's weight.

3) The analysis show that the maximum stress locate nearby the joint of screw and heavy weight drill pipe. The larger the structure corner is, the bigger the maximum stress will be. When the maximum stress is 412MPa, single curved screw assembly with 2.5° and 2.75° structure corner dissatisfy strength requirements.

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