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Research Article

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Design of detouring obstacle horizontal wells

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ABSTRACT

The design of horizontal well in dense well pattern or offshore oilfield, the underground obstacles well constraints become more and more difficult. Based on the disturbance well describing the position and shape of, after coordinate transformation, established suitable for the design of dual graph design method to model 3D horizontal well design. The characteristic of this method is that the combined use of vertical profiles and horizontal projection of obstacles, respectively to the interval of the obstacles and the feasible region. This method takes into account the number, shape and location of the obstacle, is a universal method. The method of calculation of 3D horizontal well, good effect of design.

Keywords: detouring; horizontal well; design; barrier

INTRODUCTION

With the increasing development of oil exploration, at high water cut stage and enters the encryption stage, infill wells increasing, type of well trajectory is complex, well spacing is more and more small, or offshore oil platform constraints, the design of horizontal well and some may be around anti-collision, and probably need around the complex type an obstacle of horizontal wells. Previous detouring 3-D horizontal well are single obstacle, many obstacles for straight wells [1~5], among which are typically used for slope design method of correcting 3D directional wells and can be cylindrical method correcting design, can be around design barrier wells. For horizontal wells with complex well, multi barrier around obstacles seldom study design.

EXPERIMENTAL SECTION

METHOD AND THEORETICAL EQUATION

1 BARRIER WELL DESCRIPTION

This model takes into account the complex situation of drilling, using three spline method and the cylinder helix method of inclinometer data calculation, coordinates well trajectory in space coordinates. The three coordinate directions of the coordinates are the north, East and the vertical downward direction, the coordinate system origin area to take in the wellhead. As shown in Figure 1 $O_i' - N_i'E_i'H_i'$ coordinate system.

Between the well and barrier well designed minimum distance of not less than a limit value R, or in the actual drilling might crash drilling accidents, Therefore, the hole diameter ϕ of the disorder as well can be described as axis is well trajectory, Spatial tubular shape radius of $R+\phi$, the outer surface is a cylindrical surface. If the obstacles well trajectory coordinates function $X_i' = (N_i', E_i', H_i')$, then the surface representation into the following equation:

$$F(X_i') = 0 \quad (1)$$

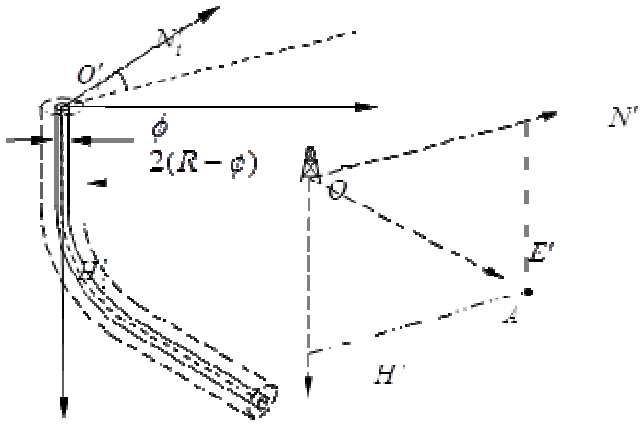

Figure 1 Space coordinate system diagram

2 COORDINATE CONVERSION

The disorder may not only a well, in order to better trajectory design and trajectory description, we need to coordinate each obstacle well where the coordinates are transformed into the new well design coordinate system, the coordinate system is based on the new design of well head point O as the origin of coordinates, vertical and horizontal to the plumb line the axis, positive vertical downward, to OA' (point A' to target point A in the horizontal plane projection point O) linear axis N', from O to A' , this time from up to down, the shaft clockwise π /2, the axis E' as the axis N' , the same direction as the axis N' direction. As shown in Figure 2.

Coordinate conversion formula which can have any export barriers well:

$$X_i = K_i(X_i' - X_{i0}') \quad (2)$$

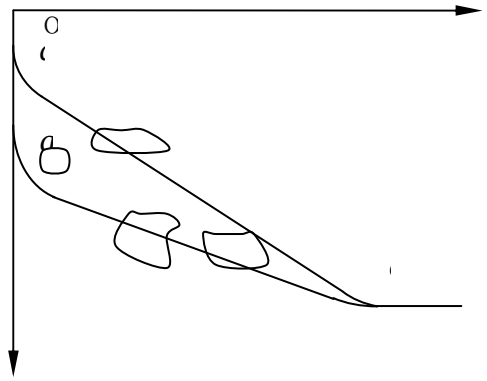

Figure 2 Feasible region and obstacle range diagram

Where: X_i To coordinate the i obstacles in well under the new coordinate; K_i For converting the i barrier well matrix; X_i' For the i barrier well a point coordinates in the original coordinates; θ_i Angle of the i barrier well the original coordinate system of N_i' axis and N' axis in the coordinate system between the horizontal projection plane. Then the function equation of the i obstacle well appearance curved surface as $F(X_i) = 0$.

3 THE THEORETICAL MODEL OF DETOURING DUAL GRAPH METHOD

As with cylindrical graph description of well trajectory, here is to design track by two charts, a picture is the vertical profile, another is disorder's horizontal projection.

3.1 VERTICAL PROFILE DESIGN

The same as trajectory design in general, before the design must know some design conditions, such as the target point, head position, deflecting interval tool whip stock range[$K_{1\min}$, $K_{1\max}$], drop angle section of the tool whip stock range[$K_{2\min}$, $K_{2\max}$], and the position of the Kop [$H_{\min}$, $H_{\max}$] and so on. The five section of horizontal well as examples to illustrate the dual graph method.

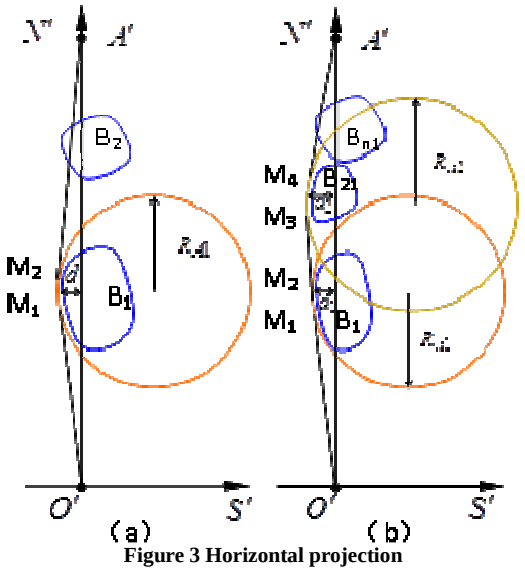

Figure 3 Horizontal projection

In the design of detouring well, the obstacle avoiding well section are generally inclined well section. According to the characteristics of well trajectory design, the underground rock structure and site construction tools, technology and other conditions, underground for borehole through space is limited, it does not consider the obstacles borehole cross space called the feasible region of the wellbore. If the design show in the vertical profile, $abcAc'b'a'a$ area surrounded the feasible domain is shown in Figure 3, B1~B4 for all obstacles in the profile on the boundary. Obviously , the obstacles wellbore out of the feasible domain is no effect on the design , only the obstacle involved in feasible constitute the obstacle to the design for a new well, barrier interval is introduced to aid in the design. Its definition is: in the feasible region, in vertical direction according to certain principles, the feasible region by 0 to 1 from top to bottom to describe, that interval [0, 1], then put a barrier in the feasible region covered by characterization of interval recorded, called the obstacles' obstacle range, as shown in figure 3. The obstacles in the feasible region is not the same, some may be part of the barrier, some is all the barrier, blocking the situation is different. Here is the obstacles interval, and also gives the design interval of design well. If the barrier interval of the barrier B1 is [0, m], then left to the design interval is [m, 1], so all the obstacles barrier interval from Union, then its complement set, get the feasible interval of design. If the feasible region is not empty, then design calculation is in this interval, given the design trajectory. If the feasible region is empty, as shown in Figure 3, the obstacles B4 blocking the feasible path for all, then only the changes to the design barrier level projection, detouring design again.

3.2 THE HORIZONTAL PROJECTION DESIGN

This obstacles horizontal projection is defined as the barrier well in the feasible region where vertical depth within the scope of section of the well the horizontal projection to the graphics. Design of horizontal projection of the obstacles to avoid change alternately range, it is best to increase stability range design or stability reduction azimuth design. In the design of obstacles horizontal projection, if need detouring, first to determine which need around an obstacle. The general choice of the feasible region of obstacle degree is the biggest barrier. In addition, in the design process, are likely to encounter only detouring once and cannot complete the design, then we must consider the second time detouring. As shown in Figure 3 (a) shows, here is a selection of obstacle B_1 detouring, the horizontal length of target A in the vertical profile of S_A is linear OM_1, M_2A and M_1, M_2 curve, then linear OM_1, M_2A and M_1, the new surface between M_2 are together. Each point on the curve of the plumb line formation is a new vertical profile. Then considering the vertical profiles of cataract new obstacle situation, to find a feasible interval, the design of well trajectory. If the feasible region in the vertical profile of the new chart is still not feasible interval, then based on the design of the on looking for an obstacle detouring, as shown in Figure 3 (b), until find a feasible trajectory design of the well. Otherwise you will reconsider this design is feasible. There is a need to explain, in the design process, the situation is very complex, is likely to face in the given design conditions not required by

the design of the track condition. For example the whip stock deflecting ability makes the design trajectory can not around obstacles.

RESULTS AND DISCUSSION

According to the above theory, using Delphi language and visual OpenGL write 3D detouring software. The combined results of software design and gives an example to illustrate the dense well detouring with the two side method. Figure 3 is a 3D well trajectory design of the different viewpoint of the diagram, as shown in Figure 3 (a) shows, there are 4 wells in the vicinity of the design wellhead with the target , horizontal length 354.81m wellhead target distance, vertical depth 2114.4m, whip stock maximum build-up rate is 8 ° /30m, have a greater impact on the design data of two wells are as follows: Barrier well 2 is a straight well, coordinate the wellhead in the new coordinate system is (167.2, 3.7, 4, -3) barrier well 4 is a directional well. Because the safety radius limit, this example obstacle well 3 will completely block the design wellhead and target (Figure 3(b) shows), can't be the vertical profile chart at the wellhead and target point line the plane of developed into a complete design, so to make detouring design, need to bypass obstacles well 2. That is to say, the design of two dimensional detouring cannot be solved, the need for 3D detouring design. After around the barrier well 3 formed in vertical profile, and discovery the barrier well 4 effect the design, this is because of the formation of a barrier in the feasible region of the vertical profile, the design in the feasible region is limited, but this restriction is limited, and the space design, also that is to say the obstacles interval not [0, 1], that feasible interval is not empty, so only the design as shown in Figure 3.

CONCLUSION

(1) A new method for 3D detouring horizontal well design using double figure method was presented for the first time, the three-dimensional detouring horizontal well can design directly, without first trial and then scanning anti-collision, avoids the uncertainty of design, reduce the design workload.
(2) Model of the method proposed in this paper, without number, obstacles well shape and position limits, and put forward the concept of the "domain" and "barrier interval", which makes the design of 3D horizontal well visual and accurate.
(3) In the actual calculation, some restricted conditions (such as tools to build angle capability, the actual position of the obstacle etc.) to consider, trying to avoid in the current conditions can not be designed well trajectory.
(4) Using Delphi language and OpenGL write 3D detouring software, software application effect is good.

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