UDK 622.243.23

DESIGNING OF AN OPTIMIZED S-SHAPED PROFILE IN CONTROLLED DIRECTIONAL WELLS

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Presented article describes a new approach to designing and projecting of profiles in controlled directional wells. The article deals with a new designing method of an optimized S-shaped profile in controlled directional wells with minimal length (expansion) of the wellbore.

Keywords: *designing of profiles in controlled directional wells, optimized S-shaped profile of a controlled directional well, well profile with maximal length (expansion) of the wellbore*

Traditional designing method of profiles in controlled directional wells is described in [1 - 8]. Input data used for calculation of elements of an S-shaped profile in controlled directional wells are as follows:

1. Kickoff depth in vertical direction, meters.

2. Depth to the top of the target subsurface object in vertical direction, meters.

3. Horizontal shift to the entry point into the subsurface target object, meters.

4. Wellbore deviation intensity at the kickoff point of the zenith degree, degrees/ 10-meters.

5. Deviation intensity within the wellbore section, characterized by reduction of the zenith angle, degrees/10-m.

6. Entry angle into the target object, degrees.

Calculation model of the aforementioned profile described in [1 - 6], is as follows. One sets the fixed value of the zenith angle within the angle kickoff section of the wellbore. Using the above value, we are able to calculate the residual parameters of the profile. Sections [7, 8] represent a calculation model of the S-shaped wellbore profile in a controlled directional well, characterized by the entry angle into the subsurface target object equal to zero; this case describes a simplified model of a S-shaped profile used in controlled directional wells. The LLC "Smith Production Technology" has developed

and curr4ently uses a unique strategy called “ideal well”. One of inalienable elements of the above strategy refers to the optimal wellbore profile. In view of the above, the think tank engaged by the LLC “Smith Production Technology” successfully addressed and resolved a tough task – designing of an optimized profile used in S-shaped controlled directional wells. Optimized profile used in controlled directional wells represents a wellbore profile distinguished by minimal length (expansion) of the wellbore. This profile of the wellbore is determined by mathematical solution of plotted curve, completely meeting the requirements and the conditions of aforementioned paragraphs [1 - 8]. Enclosed Fig. 1 represents the scheme of proposed S-shaped profile to be used in controlled directional wells.

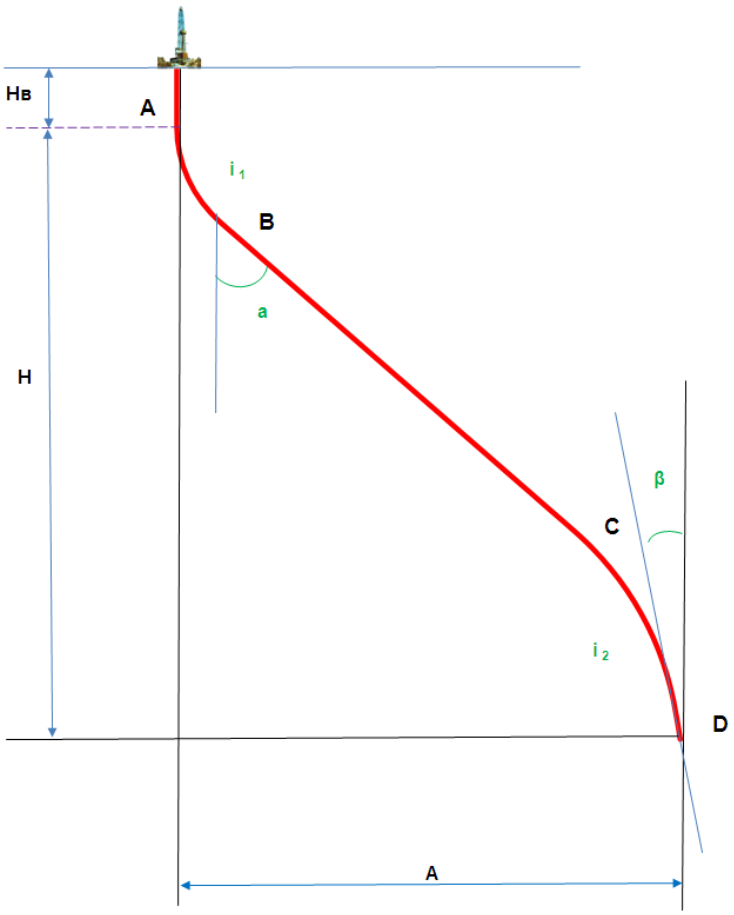

Figure 1. Proposed scheme of the S-shaped profile in controlled directional well

This enclosed figure incorporates plotted originally set values:

1. Нв – depth to the kickoff point of the angle (depth of vertical wellbore section), meters;

2. H – depth of the subsurface target object from the angular kickoff point, meters;

3. A – shift (deviation) in lateral outstretch until the entry point into the subsurface target object, meters;

4. β – entry angle into the subsurface target object, degrees.

5. i_1 – deviation intensity within the kickoff section of the zenith angle , degrees/ 10 m;

6. i_2 – deviation intensity within the reduction section of the zenith angle, degrees/10 m.

Fig. 1 encloses unknown values:

1. a – zenith angle, degrees;

2. Line AB – rickoff length of the angle, meters;

3. line BC = L – length of dipping (tangential) wellbore section, meters.

4. Line CD – length of the wellbore section characterized by reducing angle , meters.

Bearing in mind calculation of the wellbore profile, we use the curvature radius R. R = 573/i, degrees/10 m. Desired calculations call for generation of a design model (refer to Fig. 2). The design model shows that:

$< AFB = a; \ < CEG = a; \ < CEG = \beta.$

Longitudinal sections are equal to:

$У_1 = R_1 \sin a; \ У_3 = R_2 \sin a - R_2 \sin \beta;$

$У_2 = H - У_1 - У_2 = H - R_1 \sin a - (R_2 \sin a - R_2 \sin \beta) =$

$= H - R_1 \sin a - R_2 \sin a + R_2 \sin \beta.$

Latitudinal sections are equal to:

$X_1 = R_1 - R_1 \cos a;$

$X_3 = R_2 \cos \beta - R_2 \cos a;$

$X_2 = A - X_1 - X_3 = A - (R_1 - R_1 \cos a) - (R_2 \cos \beta - R_2 \cos a) =$

$= A - R_1 + R_1 \cos a - R_2 \cos \beta + R_2 \cos a.$

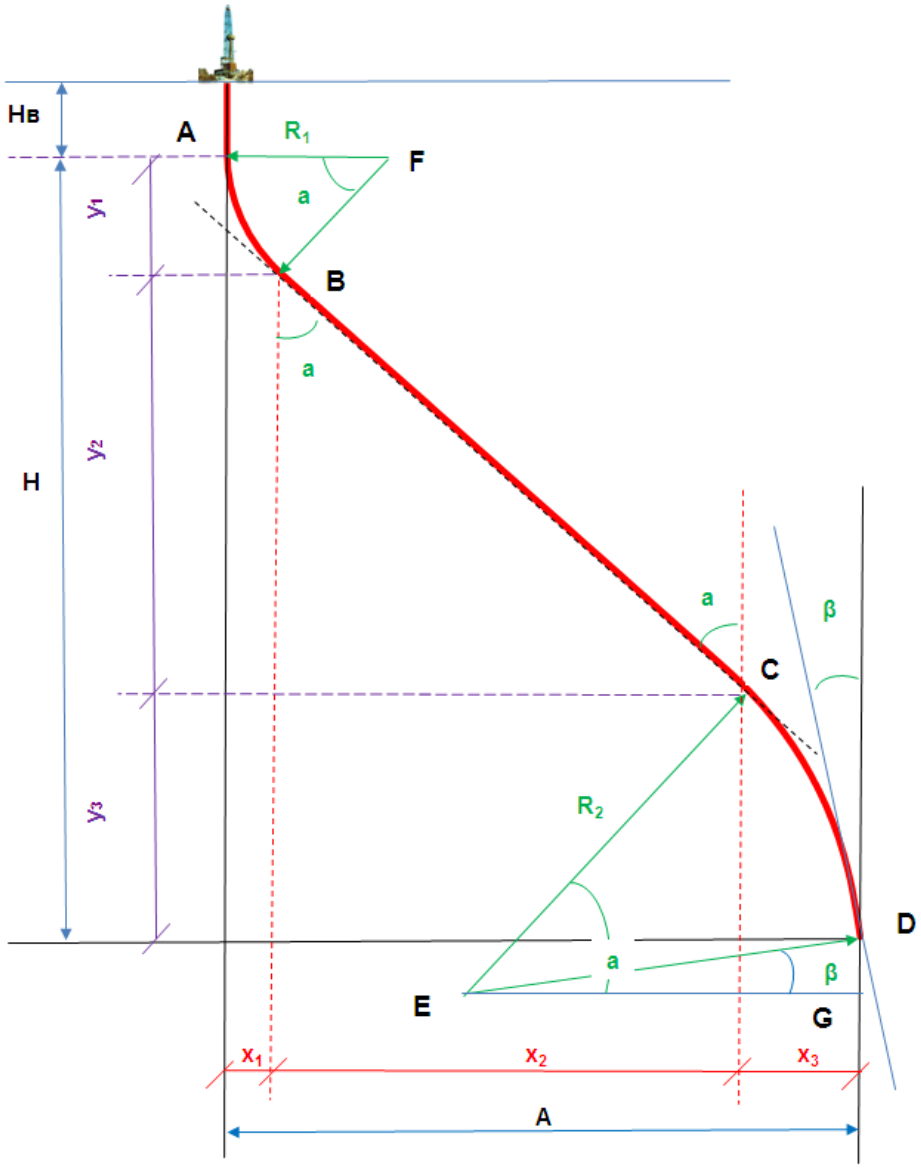

Figure 2. Design scheme of the S-shaped profile in controlled directional wells.

Length of the dipping wellbore section is equal to:

$L = X_2 / \sin a$; $L = У_2 / \cos a$; или $X_2 \cos a = У_2 \sin a$.

Having substituted X_2 and $У_2$ by above calculated values, we finally get:

$$(A - R_1 + R_1\cos a - R_2\cos \beta + R_2\cos a)\cos a = (H - R_1\sin a - R_2\sin a + R_2\sin \beta)\sin a.$$

After required transformations, we get:

$$(H + R_2\sin \beta)\sin a + (R_1 + R_2\cos \beta - A)\cos a = (R_1 + R_2).$$

Assuming that $(H + R_2\sin \beta) = a$; $(R_1 + R_2\cos \beta - A) = b$; $(R_1 + R_2) = c$, we generate the following equation:

$$\mathbf{a \sin a + b \cos a = c .}$$

Working on solution of the above equation (applying the auxiliary angle), we finally calculate the value of the *optimal zenith angle a.*

Calculated optimal value of the zenith angle enables us to determine the residual parameters of the optimized profile in S-shaped controlled directional wells. Hence, length of the kickoff angle section is equal to $L_{AB} = R_1 a$; length of the reducing angle section is equal to $L_{CD} = R_2 a$ (a – angular values in radians). Calculation equations assigned for determination of residual parameters of the S-shaped profile are mentioned above.

Conclusions

1. Engaged staffers developed the designing method of an optimized profile used in S-shaped controlled directional wells.

2. Optimized profile used in S-shaped controlled directional wells represents a wellbore profile, distinguished by minimal length (expansion) of the wellbore.

3. Profile used in S-shaped controlled directional wells, distinguished by minimal length (expansion) of the wellbore, enables us to minimize the well drilling costs.

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