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ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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THE INFLUENCE OF WELLBORE AND BIT DIAMETER RATIO ON MINIMUM RADIUS PARAMETERS AND CHANGES IN WELLBORE DEVIATION ANGLE

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Abstract. This study investigates the influence of the wellbore and bit diameter ratio on parameters of wellbore deviation, such as the minimum curvature radius and the angle of deviation change. The application of refined mathematical models allowed for detailing the impact of wellbore diameter changes with an accuracy up to 15% and 43% more than predicted by standard models. Errors in modeling deviation parameters can lead to serious consequences, including increased drilling costs and decreased production efficiency. New models accounting for real conditions will help reduce the likelihood of such errors.

The aim of the article is to develop a refined mathematical model for accurately predicting the minimum bending radius and bending angle of wells, taking into account the measured well dimensions and specific drilling conditions. The methodology involves analyzing data on curvature radius and deviation angle depending on changes in wellbore diameter. The models were validated on two wells with different conditions. For well A (with a diameter Dc=235 mm, D=214 mm) and well B (with a diameter Dc=235 mm, D=190 mm), the following values were obtained: minimum curvature radii were 3024 m and 3752 m respectively, significantly exceeding values obtained by the standard model (2615 m). Results and Conclusions: Enhanced models allowed for more accurate determination of wellbore minimum curvature radii: 3024 m for well A and 3752 m for well B, representing a 15% and 43% increase compared to predicted standard models (2615 m). The deviation angle for well A was 19°, 13% less than predicted by the standard model (219°).

Keywords: minimum curvature radius, deviation angle, wellbore diameter, drill bit, turbodrill, enlargement coefficient.

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ҰҢҒЫМА МЕН БҰРҒЫЛАУ ҚҰРАЛЫНЫҢ ДИАМЕТРІ АРАҚАТЫНАСЫНЫҢ ЕҢ АЗ РАДИУС ПАРАМЕТРЛЕРІНЕ ЖӘНЕ ҰҢҒЫМА ОҚПАНЫНЫҢ АУЫТҚУ БҰРЫШЫНЫҢ ӨЗГЕРУІНЕ ӘСЕРІ

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Аннотация. Бұл зерттеуде ұңғыма диаметрі мен қашаудың қатынасының ұңғыма оқпанының қисаю параметрлеріне, атап айтқанда, минималды қисаю радиусы мен қисаю бұрышының өзгеруіне әсері қарастырылды. Нақты математикалық модельдерді қолдану ұңғыма диаметрінің өзгеруінің әсерін 15%-ға және 43%-ға дәлірек анықтауға мүмкіндік берді, бұл стандартты модельдермен салыстырғанда айтарлықтай жоғары көрсеткіш. Қисаю параметрлерін модельдеудегі қателіктер бұрғылау құнының артуына және өндіру тиімділігінің төмендеуіне әкелуі мүмкін. Нақты жағдайларды ескеретін жаңа модельдер мұндай қателіктердің ықтималдығын азайтуға көмектеседі.

Мақаланың мақсаты ұңғыманың нақты өлшемдері мен бұрғылау жағдайларын ескере отырып, минималды қисаю радиусы мен қисаю бұрышын дәл болжауға арналған нақты математикалық модель әзірлеу болып табылады. Әдіс ұңғыма диаметрінің өзгеруіне байланысты қисаю радиусы мен қисаю бұрышының өзгерүі туралы деректерді талдауды қамтиды. Модельдер әртүрлі жағдайлары бар екі ұңғымада сынақтан өтті. Ұңғыма A (Dc=235 мм, D=214 мм) және ұңғыма B (Dc=235 мм, қашау 190 мм) үшін келесі нәтижелер алынды: минималды қисаю радиусы тиісінше 3024 м және 3752 м құрады, бұл стандартты модельдер бойынша алынған көрсеткіштерден (2615 м) едәуір жоғары. Жақсартылған модельдер ұңғымалардың минималды қисаю радиустарын дәлірек анықтауға мүмкіндік берді: ұңғыма A үшін 3024 м, ал ұңғыма B үшін 3752 м, бұл стандартты модельдермен салыстырғанда 15%-ға және 43%-ға жоғары (2615 м). Ұңғыма A үшін қисаю бұрышы 19° болды, бұл стандартты модельдер болжағаннан 13%-ға төмен екенін көрсетті, бұл әртүрлі бұрғылау жағдайларында қарастырылып отырған әсердің маңыздылығын растайды.

Түйін сөздер: минималды қисаю радиусы, қисаю бұрышы, ұңғыма диаметрі, қашау, турбобур, кеңею коэффициенті.

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ВЛИЯНИЕ СООТНОШЕНИЯ ДИАМЕТРА СКВАЖИНЫ И ДОЛОТА НА ПАРАМЕТРЫ МИНИМАЛЬНОГО РАДИУСА И ИЗМЕНЕНИЯ УГЛА ИСКРИВЛЕНИЯ СТВОЛА СКВАЖИНЫ

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Аннотация. В данном исследовании рассмотрено влияние соотношения диаметра скважины и долота на параметры искривления ствола скважины, такие как минимальный радиус искривления и угол изменения искривления. Применение уточненных математических моделей позволило детализировать влияние изменения диаметра скважины с точностью до 15% и 43% больше, чем показывали стандартные модели. Ошибки в моделировании параметров искривления могут привести к серьезным последствиям, включая увеличение стоимости бурения и снижение эффективности добычи. Новые модели, учитывающие реальные условия, помогут снизить вероятность таких ошибок.

Целью статьи является разработка уточненной математические модели для точного прогнозирования минимального радиуса искривления и угла искривления скважин, учитывая измеренные размеры скважин и специфические условия бурения. Методика включает анализ данных о радиусе искривления и угле изменения искривления в зависимости от изменения диаметра скважины. Модели были апробированы на двух скважинах с различными условиями. Для скважины А (с диаметром Dc=235 мм, D=214 мм) и скважины В (с диаметром Dc=235 мм, долото 190 мм) были получены следующие значения: минимальные радиусы искривления составили 3024 м и 3752 м соответственно, что значительно превышает значения, полученные по стандартной модели (2615 м). Результаты и выводы. Улучшенные модели позволили точнее определить минимальные радиусы искривления скважин: 3024 м для скважины А и 3752 м для скважины В, что на 15% и 43% больше по сравнению с прогнозируемыми стандартными моделями (2615 м). Угол изменения искривления для скважины А составил 19°, что на 13% меньше, чем предсказывала стандартная модель, что подтверждает значимость рассматриваемого эффекта в различных условиях бурения.

Ключевые слова: минимальный радиус искривления, угол искривления, диаметр скважины, долото, турбобур, коэффициент уширения.

Introduction. The process of directional drilling of wells entails the implementation of measures to effectively manage both natural and artificial curvature, in addition to the control of the wellbore along a predefined trajectory. Deviation control during drilling is the process of maintaining the trajectory of the wellbore within specified limits, which may include the permissible inclination angle, the distance from the planned trajectory, or a combination of both factors. The methods described in the studies (Marland, et al., 2022; Barajas, et al., 2023; Carpenter, 2023; Ma, et al., 2016) reveal significant challenges in accurately predicting the drilling trajectory and the angle of curvature. While process automation has been shown to reduce the frequency of bottom-hole assembly (BHA) failures and improve drilling rig management, it does not always adequately adapt to nonlinear and unforeseen changes in geological conditions. These changes can unexpectedly impact the angle of curvature and trajectory, increasing the risk of failures instead of reducing them. Consequently, there is a pressing need to develop more flexible and adaptive control systems capable of effectively handling both standard and exceptional operational scenarios.

The necessity for exact control of the curvature angle in the design of the bottom-hole assembly (BHA) is demonstrated by a series of studies (Grechin, et al., 2018). It is of the utmost importance to consider the management of the drilling trajectory and the optimisation of the deflection radius of the wellbore. The impact of drill string configurations on the precision of the curvature angle and the integrity of the well trajectory has been elucidated by research (Willerth, et al., 2022; Wang, et al., 2017; Wang, et al., 2018). This highlights the importance of selecting appropriate equipment in order to minimise errors. The application of machine learning algorithms (Hegde, et al., 2019) enables the optimisation of processes and the prevention of slippage, thereby enhancing the control of the curvature angle and drilling trajectory.

The study (Inyang, et al., 2017) proposes an approach to tool orientation control in directional drilling using a constant build rate controller, which enhances the stability and efficiency of operations. The work (Prasetyo, et al., 2019) examines the impact of drill pipe stiffness on drilling dynamics and emphasises the necessity of optimising their design to reduce vibrations and improve drilling performance, particularly in horizontal drilling. Furthermore, the article (Inyang, et al., 2017) identifies a significant limitation of measurement-while-drilling systems, namely their susceptibility to failure.

The utilisation of particular methodologies and technologies facilitates a more exact adherence to the intended trajectory. Nevertheless, despite meticulous planning, wells may deviate from the intended trajectory due to geological factors, thereby increasing the risk of failing to access hydrocarbon-bearing formations and achieving the desired project outcomes. The accumulation of data on natural curvature and the development of theoretical foundations for artificial curvature have enabled researchers to identify common patterns, as evidenced by the literature. Nevertheless, the actual trajectory of the well often deviates from the planned one due to factors that cannot always be predicted or accounted for in mathematical models of wellbore formation.

The appropriate selection of the BHA is of critical importance to the success of drilling operations. In onshore drilling operations in Kazakhstan, the selection of BHA is frequently based on local heuristic methods rather than a comprehensive analysis. In a drilling system comprising a bit, a turbodrill and a deflector, each component serves a specific function in controlling the drilling direction. The key factors to be considered are the dimensions of all BHA components, their condition, and the diameter of the well. When the bit and deflector are in effective synchronisation, they exert pressure on specific sections of the wellbore wall, thereby enabling control over the well's curvature angle. This, in turn, constrains the curvature angle to the requisite level, thereby guaranteeing the precision of the drilling process and averting unanticipated deviations from the intended trajectory (Voevidko, 2013).

In directional drilling in anisotropic environments, a variety of equations are employed to describe the rate of well curvature when non-oriented BHAs are utilised, with gravity identified as the primary influencing factor (Gadzhiev, et al., 2014; Khnychkin, et al., 2012; Buglov, et al., 2022). The fundamental premise of all mathematical models is that the curvature is a consequence of the formation of an angle of trajectory between the tangent to the wellbore axis and the direction of the drilling velocity vector. However, a significant number of these models are either not universally applicable or based on imperfect computational frameworks containing simplifications that are not always well-justified.

In the course of practical drilling operations, the necessity of grasping the patterns of wellbore curvature has been repeatedly demonstrated as a crucial factor in the successful placement of well trajectories within complex geological structures. The analysis of field data is of great importance in identifying these patterns and determining the primary causes of curvature under specific geological conditions (Nazarov, 2021; Neskoromnykh, 2015; Zholbassarova, et al., 2024). However, the existing mathematical models are unable to provide sufficient accuracy for a quantitative assessment of the curvature process, resulting in significant discrepancies between the planned and actual well profiles (Nikulshin, et al., 2010; Ivanov, et al., 2017). It can be reasonably deduced that the implementation of an appropriately selected and configured bottom-hole assembly (BHA) will not only enhance the efficiency of the drilling process but will also assist the drilling company in achieving its desired outcomes by reducing the potential for risk and cost. Consequently, more accurate and predictable drilling outcomes can be achieved, which is of particular importance in challenging geological environments.

The objective of the study is to identify and rectify errors in the application of M.P. Gulizade's formulas in situations where the wellbore diameter exceeds that of the bit diameter. This scenario is typical of drilling operations in soft to medium-hard formations, where deflectors are commonly employed. The objective is to develop a more precise mathematical modification of the existing formula, taking into account the geometric dimensions of the bit-turbodrill system and real drilling conditions, in order to ensure accurate control over the wellbore curvature trajectory.

Materials and basic methods

The curvature angle of the wellbore is constrained when drilling wells with a deflector, dependent on the degree to which the "bit–turbodrill–deflector" system is compatible within the well. This takes into account the geometric dimensions, the condition of the system, and the diameter of the well itself. Provided that the bit is capable of sufficient cutting and that the deflecting force is elastic, the turbodrill body will exert pressure on the convex section of the wellbore wall in the direction where the curvature forms. This consequently restricts the curvature angle of the wellbore.

The research conducted by M.P. Gulizade (Gulizade, et al., 1982) demonstrated that the curvature of a wellbore when utilising a deflector follows a parabolic trajectory. In light of the fact that this study is concerned with the evaluation of the maximum deflecting capability of the bottom-hole assembly with a deflector, it can be assumed with sufficient practical accuracy that within the length of the "bit–turbodrill" system, the curvature occurs along the arc of a circle.

The radius of curvature of the wellbore resulting from unequal destruction of the bottom hole without milling the wellbore walls, in the presence of a deflecting force on the bit, is determined by the following formula:

$$R = \frac{0.171 L_T^2}{D - d_T}, \qquad (1)$$

where: L_T - length of the turbodrill with the bit, D-diameter of the bit, d_T-diameter of the turbodrill.

Formula (1) is applicable to the specific case where the wellbore diameter is equal to the bit diameter (Gulizade, et al., 1982). Nevertheless, in instances where the wellbore diameter is marginally larger than the bit diameter, which is typical when drilling soft to medium-hard formations – where deflectors are primarily employed – the application of formula (1) to ascertain R is not feasible. Nevertheless, it is common practice to erroneously employ formula (1) and the derived formula for calculating potential alterations in the wellbore curvature angle in instances where the wellbore diameter exceeds the bit diameter. This is typically achieved by substituting the wellbore diameter, *D*, into Formula (1) in place of the bit diameter, *D* (or, equivalently, by utilising a borehole enlargement coefficient for *D*). As a consequence of this modification, the expression is no longer capable of accounting for the geometric dimensions of the system composed of the bit and the turbodrill. This indicates that when utilising the same turbodrill and wellbore diameter, the minimum radius of curvature and potential alterations to the curvature angle would remain consistent, irrespective of the bit diameter.

A proper assessment of the deflecting capability of the bottom-hole assembly can only be made by considering the geometric dimensions of the bit–turbodrill system and the actual wellbore diameter. Let us examine the impact of an increased wellbore diameter relative to the bit diameter on the curvature process of the wellbore in the presence of an elastic deflecting force. Subsequently, we will derive generalized formulas (2–4) for determining the minimum radius of curvature and the maximum possible change in the wellbore curvature angle.

Figure 1 illustrates the position of the turbodrill within the wellbore, whose diameter is *t* times larger than the bit diameter (*t*>1). It is evident that, in this case, the radius of curvature will be the smallest, while the change in the curvature angle will be the largest. This is because the turbodrill body, pressing against the upper wall of the wellbore, limits the potential for more intense wellbore curvature.

According to Figure 1, the following can be calculated:

$$R = \frac{a_1^2 + h_1^2}{2h_1}, \tag{2}$$

$$R = \frac{a_2^2 + h_2^2}{2h_2}, \tag{3}$$

$$a_2 = L_T - a_1 \tag{4}$$

By simultaneously solving the three equations and considering that the values of h_1^2 and h_2^2 are negligible compared to other terms in the equations, we obtain the following simplified expressions:

$$4(h_2 - h_1)^2 R^2 - 4 L_T^2 (h_2 + h_1) R + L_T^4 = 0 \tag{5}$$

The smallest root of this equation:

$$R = \frac{L_T^2}{2(\sqrt{h_1} + \sqrt{h_2})^2} \tag{6}$$

The second root of equation (5) is excluded from consideration as it gives an infinitely large radius value.

From expression (6), it follows that the minimum radius of wellbore curvature is determined by the length of the bit-turbodrill system and the values of h_1 and h_2

According to figure 1, we have the following:

$$h_1 = D_c - d_T = mD - d_T; \quad h_2 = \frac{D - d_T}{2}$$

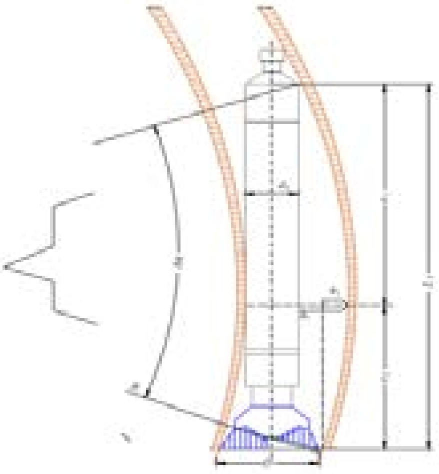

Fig. 1. Scheme of wellbore deviation due to uneven formation breakdown under the combined action of deflecting force considering wellbore enlargement.

Therefore, the value of h_1 represents the relationship between the diameters of the wellbore and the turbodrill. In other words, h_1 is a measure of the displacement of the turbodrill in relation to the wellbore axis. It is precisely because h_1 and h_2 account for the relationships between various parameters that equation (1) cannot be used by substituting Dc in place of D for cases where the wellbore diameter is larger than the bit diameter. Upon substituting the values of h_1 and h_2 into equation (6), the following result is obtained:

$$R = \frac{0{,}25L_T^2}{(0.5m+0.25)D-0.75d_T+0.71\sqrt{(\mathrm{m}D-d_T)(D-d_T)}} \qquad (7)$$

The value of R can be used to determine the possible change in the curvature angle

$$\Delta\alpha = \frac{\ell}{R}\frac{180}{\pi},$$

Where:Δα is the possible change in the curvature angle of the wellbore over a penetration length *l*, measured in meters.

Assuming l=10m and substituting the value of R into the above expression, we obtain the formula for determining the possible change in the curvature angle over 10 meters of penetration, taking into account the wellbore enlargement:

$$\Delta\alpha_{10} = 40\frac{180}{\pi}\frac{(0{,}5m+0{,}25)D-0{,}75d_T+0{,}71\sqrt{(\mathrm{mD}-d_T)(D-d_T)}}{L_T^2} \qquad (8)$$

Expressions (7) and (8) for determining the values of R and Δα, respectively, can be significantly simplified for certain values of the borehole enlargement coefficient *t*, while maintaining sufficient accuracy for practical calculations.

For this purpose, expression (7) can be rewritten as:

$$R = \frac{0{,}25L_T^2}{(0{,}5m+0{,}25)D-0{,}75d_T+0{,}71\sqrt{\mathrm{mD}^2-(m+1)\mathrm{D}\mathrm{d}_T+d_T^2)}}$$

When the borehole enlargement coefficient *t*=1.2, with an accuracy of 2.85%, it can be assumed that $m = \left(\frac{m+1}{2}\right)^2$ holds true (for *t*=1.5, the accuracy differs by 4.1%). Substituting $m = \left(\frac{m+1}{2}\right)^2$ in place of t in the first term of the square root expression, we finally obtain:

$$R = \frac{0{,}171L_T^2}{(0{,}586m+0{,}414)D-d_T} \qquad (9)$$

If the wellbore diameter equals the bit diameter, i.e., *t*=1, then formulas (7) and (9) reduce to formula (1). Consequently, these formulas are more generalized.

The simplified formula for determining $\Delta\alpha_{10}$, the curvature angle change over 10 meters of penetration limited by the turbodrill body, becomes:

$$\Delta\alpha_{10} = 58,6\frac{180}{\pi}\frac{(0,586m+0,414)D-d_T}{L_T^2} \qquad (10)$$

Expressions (9) and (10) can also be represented in the following form:

$$R = \frac{0,171\cdot L_T^2}{0,586D+0,414D-d_T} \qquad (11')$$

$$\Delta\alpha_{10} = 58,6\frac{180}{\pi}\frac{0,586D_C+0,414D-d_T}{L_T^2} \qquad (12)$$

Formulas (11) and (12) evaluate the impact of the ratio between the wellbore diameter and the bit diameter on the radius of curvature and the possible change in the wellbore curvature angle.

Results

The developed formulas demonstrate that when wellbore curvature is formed due to asymmetric bottom-hole destruction and wall milling, the maximum possible values of the radius of curvature and the change in the curvature angle, limited by the turbodrill body, depend not only on the dimensions of the bit-turbodrill assembly but also on the actual wellbore diameter. Formulas (9) and (11) indicate that the actual increase in wellbore diameter relative to the bit diameter has a lesser effect on the minimum possible radius of curvature than predicted by formula (1), where the bit diameter is replaced by the wellbore diameter. For the purposes of this discussion, we will assume that two wells, designated A and B, have been drilled using a turbodrill TPO-6 ⅝" with a diameter of d_T=170mm and a length of L_T=10m. It is further assumed that both wells have the same diameter, D_s=235mm.

The drilling of well A was conducted with a bit diameter of D=214mm, while well B was drilled with a bit diameter of D=190mm. In this instance, the borehole enlargement coefficient for well A is m=1.1, while for well B it is m=1.24.

The application of formula (1) yields the result that the minimum radii of curvature in both cases are identical, equalling 261.5 m. Consequently, the potential alterations in the curvature angle for both wells will also be identical, amounting to Δα10 = 2.19°.

In practice, however, the minimum radii of curvature for wells A and B will differ from each other and also be significantly larger than the value of R=261.5m obtained from formula (1). Accordingly, the potential alterations in the curvature angle for both wells will also diverge, with their values being considerably smaller than the previously mentioned 2.19°. In particular, the following values were obtained for wells A and B: R=302.4m for well A and R=375.2m for well B. The corresponding $\Delta\alpha_{10}$ values were 1.9° for well A and 1.52° for well B. Therefore, the actual minimum radii of curvature for wells A and B are 1.15 and 1.43 times larger, respectively, than those predicted by formula (1). The calculated data indicate that under the aforementioned conditions, the potential change in curvature angle when drilling with a 190mm bit (well B) will be 1.25 times smaller than when drilling with a 214mm bit (well A).

This is due to the fact that the milling capacity of the assembly when drilling with a 190mm bit (i.e. the value of h_2) is less than when drilling with a 214mm bit, despite the influence of the overturning moment (i.e. the value of h_1) being the same for both wells.

This also elucidates the reason for the diminished curvature build rate when the diameter of inclined wells is reduced.

Figure 2 illustrates the relationship between the potential alteration in the curvature angle and the ratio of the wellbore diameter to the bit diameter for a range of bit and turbodrill combinations.

From figure 2, it follows that an increase in the ratio of wellbore diameter to bit diameter leads to an increase in the possible change in the curvature angle. Furthermore, the relative growth of the possible curvature angle change $m = \frac{D_c}{D}$ for reduced-diameter wells with compact turbodrills is greater than for normal-diameter wells.

For example: When drilling with bits No. 11 and 10 using turbodrills TPO-9” and TPO-8”, increasing t from 1.0 to 1.2 results in a growth of the possible curvature angle change by 1.92 and 2.0 times, respectively. When drilling with 214 mm and 8” bits using turbodrills TPO-7½ and TPO-6⅝, the same increase in t leads to a rise in Aa_w by 2.36 and 2.25 times, respectively.

As the length of the bottom-hole motor with the bit increases, the curvature intensity of the wellbore significantly decreases and, under certain conditions, may approach zero (Figure 2). This graph is constructed based on the maximum elastic moment (M_y), calculated as the product of the moment of resistance (W) and the yield strength of the deflector material (σ_t).

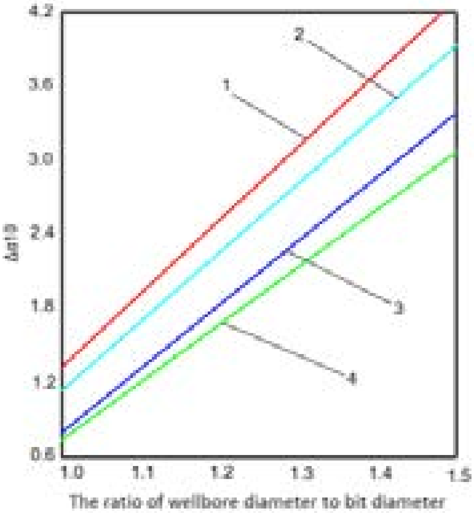

Fig. 2. Change in potential deviation angle variation due to the ratio of wellbore and bit diameters: 1 - bit 295.3 mm, turbodrill TPO-240 mm; 2 - bit 243 turbodrill TPO-215 mm; 3 - bit 215.9 turbodrill TPO-195 mm; 4 - bit 190 mm turbodrill TPO-172.

Figure 3 shows the dependence of the wellbore curvature angle change on the length of the turbodrill-bit assembly (L_T) for various *t* values. From figure 3, it is evident that reducing the length of the turbodrill-bit assembly leads to a significant increase in the possible curvature angle change ($\Delta\alpha_{10}$). Moreover, the growth of $\Delta\alpha_{10}$ with decreasing L_T becomes more pronounced as the *t* value increases.

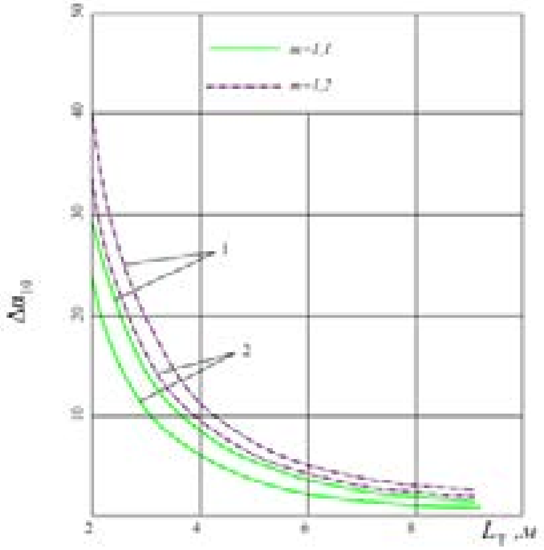

Fig. 3. Variation of potential deviation angle change based on turbodrill bit length: 1 - bit #10, Turbodrill TPO-8”; 2 - bit #8, Turbodrill TPO-6⅝”.

It is important to note that when a deflector is employed, the curvature angle of the wellbore will not remain at its maximum throughout the entirety of the drilling process. The maximum curvature angle change can only be achieved over a certain interval when the full milling capacity of the bottom-hole assembly with the deflector is utilised. Expressions (9) and (10), which take into account the actual wellbore diameter, provide further elucidation regarding the underlying causes of the observed variation in curvature angle during a run with the deflector. A review of borehole caliper logs for inclined wells reveals a considerable degree of variation in diameter within soft and medium-hard formations. This variation in the wellbore diameter gives rise to a corresponding alteration in the value of h_1=Dc-dт, which in turn affects the values of R and $\Delta_{\alpha 10}$.

Thus, during a single run with the deflector, the change in the wellbore curvature angle will vary due to several factors:

-The changing influence of the normal component of the weight of the bit-turbodrill system (Buglov, et al., 2022; Nazarov, 2021; Neskoromnykh, 2015; Nikulshin, et al., 2010).

-Variations in the elastic deflecting force due to changes in the wellbore diameter and Δα10 (Gadzhiev, et al., 2014; Khnychkin, et al., 2012).

-The reduction in the bit’s milling capacity caused by the wear of the roller cones due to bit diameter loss and the increase in axial play of the roller cones.

-Finally, changes in $h_1=D_c-d_{\text{т}}$, which directly affect the curvature radius and angle.

Discussion

The study demonstrated that the calibration of drilling models to account for the actual wellbore diameter can markedly enhance the precision of curvature parameter determination. To illustrate, the utilisation of enhanced models indicated that the actual minimal radii of curvature for wells A and B are 15% and 43% larger, respectively, than those projected by conventional models. This improvement serves to enhance the control of the drilling process, reduce the risk of accidents, and increase the efficiency of production.

Additionally, it was found that the change in the curvature angle for well A is 13% smaller than predicted by model (1), which serves to emphasise the importance of adapting technological parameters to specific conditions. Moreover, an increase in the borehole diameter enlargement coefficient from 1.0 to 1.2 resulted in a 236% and 225% increase in the potential curvature angle change for various drilling equipment configurations.

These quantitative results highlight the necessity of integrating the developed models into drilling practices. It is anticipated that further research and the development of more accurate models based on real operational data will result in the creation of adaptive systems that automatically adjust drilling parameters in real time, thereby maximising efficiency and safety during the drilling process.

Conclusion

1. The analysis demonstrated that the application of refined mathematical models facilitates a more accurate determination of the minimum radius of wellbore curvature. To illustrate, the actual minimum radius of curvature for well A was 302.4 metres, which is 15% larger than the value predicted by the standard model. This signifies enhanced reliability and precision in drilling operations.

2. The incorporation of actual well parameters revealed a change in curvature angle for Well A of 1.9°, a value that is 13% smaller than the predicted 2.19°. This highlights the necessity of precise data for optimising curvature angles and reducing the likelihood of errors.

3. The study demonstrated that an increase in the borehole diameter enlargement coefficient from 1.0 to 1.2 resulted in a 2.36-fold increase in the potential curvature angle change for a well drilled with bit No. 9 and turbodrill TPO-7½”. This permits a more flexible approach to well design and enhances the structural characteristics.

4. The research findings corroborate the assertion that the selection of bit size and turbodrill type exert a pronounced influence on well curvature parameters. To illustrate, the utilisation of bit No. 8 with turbodrill TPO-6⅝” demonstrated that an augmentation in the borehole enlargement coefficient resulted in a 25% diminution in the potential angle alteration, thereby facilitating a more efficacious organisation of drilling operations.

5. The validated research results provide a foundation for the development of

automated systems capable of adapting drilling parameters in real time based on current data on wellbore diameter and other critical parameters. Such systems will assist in the reduction of risks and the enhancement of the overall efficiency of the drilling process.

References

Barajas, P. E., et al. (2023). The role of auto driller, rig control systems, and driller procedures in the reduction of BHA failures. SPE Annual Technical Conference and Exhibition, San Antonio, October 16–18, 2023. https://doi.org/10.2118/214997-MS

Buglov, N. A., Pushmin, P. S. (2022). Justification of the optimal parameters of stabilizing column assemblies when drilling wells under conditions of natural curvature. Bulletin of Tomsk Polytechnic University. Geo-Resource Engineering, 333(7), 20-29. https://doi.org/10.18799/24131830/2022/7/3549

Carpenter, C. (2023). Autodrillers, rig-control systems, driller procedures reduce BHA failures. Journal of Petroleum Technology, 75(12), 80-82. https://doi.org/10.2118/214997-MS

Gadzhiev, G. K., Aliyev, E. M., & Bagirov, Sh. A. (2014). The influence of the profile of deviated wells on the water cut of their production. Oilfield Business, (9), 51-54.

Grechin, E., Kuznetsov, V., Bastrikov, S. (2018). Studying performance of downhole diverting assembly with a motor-diverter. Oil Industry Journal, (12), 103-105. https://doi.org/10.24887/0028-2448-2018-12-103-105

Gulizade, M., Mamedbekov, O. (1982). Calculation of the rate of spatial curvature of inclined wells during drilling with non-oriented BHA. Theory and Practice of Drilling Deviated Wells, (1), pp. 63.

Hegde, C., Millwater, H., Gray, K. (2019). Classification of drilling stick slip severity using machine learning. Journal of Petroleum Science and Engineering, 179, 1023-1036. https://doi.org/10.1016/j.petrol.2019.05.021

Ivanov, R., Lushpey, V. (2017). Development of a mathematical model of controlled movement of the drilling tool. Natural and Technical Sciences, (11), 105-111.

Inyang, I. J., Whidborne, J. F., Bayliss, M. T. (2017). Directional drilling attitude control with input disturbances and feedback delay. IFAC-PapersOnLine, 50(1), 1409-1414. https://doi.org/10.1016/j.ifacol.2017.08.246

Khnychkin, E. V., Pulya, Yu. A., Lukyanov, V. T. (2012). Stabilization of the zenith angle of deviated wells during drilling with curved sub-assemblies. Drilling and Oil and Gas Wells Construction on Land and at Sea, (5), 18-22.

Ma, T., Chen, P., Zhao, J. (2016). Overview on vertical and directional drilling technologies for the exploration and exploitation of deep petroleum resources. Geomechanics and Geophysics for Geo-Energy and Geo-Resources, 2, 365-395. https://doi.org/10.1007/s40948-016-0038-y

Marland, C., Gonzalez, D., Koy, J. (2022). Challenging standard practices: How a review of standard practices resulted in an improvement in BHA reliability. Proceedings of the SPE Annual Technical Conference and Exhibition, Houston, October 3–5, 2022, p. D031S045R007. https://doi.org/10.2118/210340-MS

Nazarov, A. (2021). Methodology for predicting the parameters of natural curvature of inclined well intervals. New Ideas in Earth Sciences, pp. 227-231.

Neskoromnykh, V. (2015). Directional Drilling and Coremetry Basics. 2nd ed. Moscow: INFRA-M; Krasnoyarsk: Siberian Federal University. 336 p. www.dx.doi.org/10.12737/5067

Nikulshin, K., Esaulenko, V., Grigulevsky, V. (2010). Construction of a mathematical model of the process of wellbore curvature during drilling. Automation, Telemechanization, and Communication in the Oil Industry, (11), 15-16.

Prasetyo, D., Sitaresmi, R., Prakoso, S. (2019). Optimization of Drillstring Design to Produce More Stable Dynamic Drilling on Horizontal Drilling by Applying Different Stiffness Combinations.

Journal of Earth Energy Science, Engineering, and Technology, 2(2). https://doi.org/10.25105/jeeset.v2i2.4679

Voevidko, I. V. (2013). Non-oriented assemblies of increased activity based on screw motors for combating wellbore curvature. Drilling and Oil and Gas Wells Construction on Land and at Sea, (3), 4-6.

Wang, X., Ni, H., Wang, R., Liu, T., Xu, J. (2017). Modeling and analyzing the movement of drill string while being rocked on the ground. Journal of Natural Gas Science and Engineering, 39, 28-43. https://doi.org/10.1016/j.jngse.2017.01.011

Wang, X., Ni, H., Wang, R., Wang, P., Zhang, L. (2018). Theoretical study of tool-face disorientation mechanisms during slide drilling and correction by surface-rotation pulses. Proceedings of the SPE Drilling & Completion Conference. Houston, September 10–12, 2018, pp. 351-362. https://doi.org/10.2118/191374-PA

Willerth, M., Dodson, B., McCue, K., Farrag, M. (2022). When slick is not smooth: Bottomhole assembly selection and its impact on wellbore quality. Proceedings of the SPE Drilling & Completion Conference. Houston, April 25–27, 2022, pp. 126-140. https://doi.org/10.2118/204129-PA.

Zholbassarova A.T.,Bayamirova R.Y.,Ratov B.T.,Khomenko V.L.,Togasheva., et al. (2024). Development of technology for intensification of oil production using emulsion based on natural gasoline and solutions of nitrite compounds. SOCAR Proceedings, (2), 48-55. http://dx.doi.org/10.5510/OGP20240200965

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