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The main directions of improving the efficiency of drilling operations: theoretical and practical aspect

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Abstract. The process of drilling oil and gas wells contains a complex of complex controlled subprocesses. Therefore, the reliable implementation of the well drilling process is primarily associated with the peculiarities of the implementation of these subprocesses on a sustainable basis. And since the essence of these processes is mainly expressed in conditions of complex impact of geological and technical factors, first of all it is necessary to clarify the nature of these factors. In modern conditions, there are many software tools that allow you to assess the impact of various factors on the main technological parameters of the drilling process, taking into account the possibilities of automation, and in some cases attempts are being made to use them. Such opportunities have significantly expanded the possibilities of using appropriate digital technologies. In connection with the above, the article reveals the essence of the relevant theoretical and practical issues to ensure an increase in the efficiency of drilling operations, the relevant theoretical models that are used are considered.
Key words: Well drilling, reliability, Technological parameters, Drilling mode.

1. İNTRODUCTİON

Scientific-technical problems are now solved using a variety of modern research methods, and it is important to elucidate the factors that categorize the multi-level sub-processes related to the drilling process of oil and gas wells in modern conditions and consider their complex impact on the drilling process. The application of these methods can contribute significantly to the formulation of necessary decisions in an operational regime.

In this context, the selection of factors influencing drilling regimes in the drilling process, differentiation of technological process parameters from theoretical values, and enhancement of the reliability of the drilling process are identified as key features to be explored. Analyzing methodological approaches in theoretical and empirical levels for solving these issues is currently considered a significant research direction. Addressing these issues is crucial for the cost-effective execution of drilling complex wells under present conditions, which involve substantial technical and technological complexities requiring substantial investments.

Purpose Relevance of the problem and related research

The reliable implementation of the drilling process for oil and gas wells is primarily ensured by the robust implementation of several relevant sub-processes, depending on the stable characteristics of drilling regimes. These processes are implemented based on clarifying the nature of essential geological and technical factors and understanding their complex impact on the drilling process. Considerable research efforts have been devoted to clarifying these issues from a theoretical and empirical perspective [1-3]. Some of these works are noted below.

A system has been developed to optimize drilling processes by controlling the constant torque of the drilling bit and other parameters that may vary within certain intervals.

Improving the efficiency of drilling operations is primarily associated with optimizing the drilling process, which is one of the most important areas. The complexity of the process, due to numerous

technological variables, data streams, uncertainties in geological conditions, the influence of random factors, among others, determines the specifics of managing the process in automatic mode. This article presents the main types of automation tools used in oil and gas fields to maintain and control drilling parameters according to local conditions to optimize the goal functions of the process. [3] discusses the statistical evaluation methodology of factors affecting the difference between theoretical and actual values of technological parameters.

[4] analyzes issues related to improving the reliability of the drilling process by optimizing controlled drilling regime parameters.Studying the results of relevant research reveals that clarifying the theoretical and empirical impact of various factors on the drilling process is currently an important issue.

Methods Characteristics of factors influencing drilling regimes. The efficiency enhancement of the drilling process primarily depends on the selection of drilling regimes. The selection of drilling regimes depends on several factors, including the type, hardness, and size of the drilled well or formation, the equipment used, and the objectives of drilling operations. Specifically:

- The type, hardness, and dimensions of the drilled well or formation play a crucial role in determining the drilling regime. These characteristics are critical factors that affect drilling parameters such as penetration rate, bit weight, and other critical parameters.
- The type of drilling equipment used is also a significant factor in designing drilling regimes. The weight and power of the drilling rig, the type of bit, and the drilling fluid supply all affect drilling parameters and should be considered in designing drilling regimes.
- The depth of the well, the size of the wellbore, and the drilling objectives also influence the drilling regime. The design of the drilling regime should take into account the objectives of the drilling operation and optimize drilling parameters to achieve these objectives. To determine the most accurate drilling regimes in mineral-geological conditions, it is necessary to know the drilling parameters. This allows for the compilation of tables of drilling parameters and drilling regimes during drilling in neighboring wells. The results of relevant laboratory and wellbore studies are essential for designing new wells. Two methods are used for designing regimes: the analytical and recalculative methods. The analytical method is used to identify potential capabilities for improving equipment performance when there is no statistical field data on the operation of equipment in the field. The basic parameters of drilling regimes include load on the bit, penetration rate, drilling power, bit torque, and supply of drilling fluid. To design regimes, it is necessary to know the density distribution of cuttings on the bit during drilling, the contact duration of the teeth with the cuttings when determining the drilling rate, cutting resistance, as well as the provision of drilling fluid for surface cleaning.

Considering the basic considerations when selecting drilling parameters on the bit, the distribution of cuttings volume, determining the drilling rate by the contact time of the teeth with the cuttings, cutting resistance, and provision of drilling fluid for surface cleaning.

The optimization of drilling regimes is an integral part of the drilling process and can significantly improve efficiency, safety, and costs. The selection of drilling regimes depends on the type of drilled well or formation, the equipment used, and the key parameters of the drilling regime.

Assessment of the difference in theoretical values of technological process parameters.

As known, deviations from given parameters are possible during the excavation of wells in technological processes. In such cases, statistical methods are used to improve accuracy. This is particularly important during drilling in deep and complex conditions. In this regard, the deviation probability is based on a statistical method relying on the normal distribution law, where the obtained results are confirmed through mathematical processing of multiple mathematical observations.

In this direction, one of the possible approaches is the automated testing of the deviation of the probability distribution according to the Shapiro-Wilk criterion (W-criterion) from the normal law. This test is carried out in two ways. First, the W-criterion is calculated, and then this value is compared with the critical value of $W(\alpha)$ (where α is the level of reliability). If $W < W(\alpha)$, then the null hypothesis of normal distribution is rejected. In this case, the use of special tables is necessary to determine the statistics of W and $W(\alpha)$, which simplifies the operation of the respective software by providing automatic access to them. Overcoming this complexity is ensured by using the simplified W1 form of the Shapiro-Wilk criterion. According to this approach, special tables are replaced with the respective approximations of dependencies. For example, let's consider the following selection of data:

$$X=-1;\ 0;\ 1;\ 2;\ 3;\ 5;\ 6;\ 7;\ 10;\ 15.$$

Let's consider testing the hypothesis of normal distribution for the random variable X using the W1 Shapiro-Wilk approximation measure by taking α = 0.05. In this case, the following rule is used:

$$W_1 = \left(1 - \frac{0{,}6695}{n^{0{,}6518}}\right)\frac{s^2}{B}$$

Here, n represents the number of elements in the selected plurality; s and B are parameters of the measure, and accordingly, they are calculated with the following expressions:

$$s^2 = \sum_{i=1}^{n}(X_i - X_{orta})^2;$$

$$B = [\sum_{k=1}^{m} a_k(X_{n-i+1} - X_i)]^2,$$

The calculation of the empirical numbers a_k is based on the following formula for a sample with elements arranged in ascending order X_i , i=1,2,...,n; X_{avr} represents the sample's calculated median value. In our example, n=10.

$$a_k = a_0\left[z_k + \frac{1483}{(3 - z_k)^{10{,}345}} + \frac{71{,}61 \cdot 10^{-10}}{(1{,}1 - z_k)^{3{,}26}}\right]$$
$$a_0 = \frac{0{,}899}{(n-2{,}4)^{0{,}4162}} - 0{,}02; \;\; z_k = \frac{n-2k+1}{n-0{,}5}.$$

Based on the calculation results, if W_1<1, then the null hypothesis of the normal distribution of variable X is rejected. It should be noted that this assessment, based on a simplified heuristic criterion, can be easily programmed and implemented in the Matlab system.

Issues of Increasing Reliability in Excavation Processes

A modern excavation system consists of various interconnected mechanisms, devices, and tools. The malfunction of at least one critical element in a complex system can lead to the failure of the entire system. Reduced reliability of excavation equipment typically results in increased operational costs and downtime. Moreover, inadequate reliability can lead to sudden failures of components and parts due to the breakdown of installed technology, resulting in significant expenses for rectification. However, enhancing reliability is associated with the complexity and cost increase of equipment. Therefore, designing, manufacturing, and operating equipment should be

S.I.Yusifov, Y.Alishov, E.Agasiyev, Ecoenergetics, №1, pp.19-22, 2024

In this regard, improving the reliability of excavations is directly achievable by considering the complex interplay of various multidimensional factors in this process. For example, if the probability of an axe operating without issues is assumed as the researched reliability parameter, then this probability can be determined using the Laplace function as follows:

$$P(t) = \Phi_0\left(\frac{T_{orta}-t}{\sigma}\right),$$

In this formula, σ represents the root mean square slope; T_{avr} is the average processing time until fatigue. This principle is used in the analytical research of optimizing controlled drilling regime parameters to increase the reliability of the drilling process. Such analytical models, as well as the latest information technologies, especially machine learning technologies, can assist in evaluating possible disruptions during drilling according to the reliability model of equipment, which is in line with similar problems focused on forecasting disruptions during the extraction of wells. The resolution of these issues often involves the application of decision-making principles considering the uncertainty of information [5].

Increasing the volume of drilling operations requires an increase in the relevant drilling indicators. This poses significant challenges in the effective application of drilling technologies commonly used in many cases. Therefore, optimization of drilling regime parameters is considered a necessary solution to such problems. Geological-technological research enables direct solutions to the processing of information issues, thus enhancing the efficiency of the drilling process. Therefore, the implementation of an algorithm for determining optimal regime parameters is required due to the abundance of geological-technological information involved in the drilling process.

In complex structured deposits, as well as in deposits with complex stress-deformation conditions, ensuring the reliable implementation of the drilling process requires, first of all, the correct prediction of pressures and lithological-attitude parameters of formations. Another related issue is the improvement of the reliability of drilling processes in anomalies with high formation pressures. Taking into account this factor involves issues such as selecting the drilling mud, as well as determining the optimal drilling speed, which requires the formulation and resolution of respective optimization problems. In many cases, neglecting these factors can lead to complications during drilling,

3.CONCLUSİON

The main characteristics of selecting factors influencing the drilling regimes in the process of well drilling, differentiation of technological process

parameters from theoretical values, and increasing the reliability of the well drilling process have been analyzed from a theoretical-experimental aspect in the article. Based on some factual examples, possibilities for solving these issues have been discussed.

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