

ANNOTATION

Thesis submitted for the degree of Doctor of Philosophy (PhD) in the specialty
6D070800-Oil and Gas Business
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"Identification of the model of drillability and prediction of drilling parameters of rock (for example, the Uzen field)"

General characteristics of the dissertation research

This paper is devoted to the development of a drillability model and the prediction of drilling performance by rock-cutting tools operating in cutting mode in order to optimize the entire drilling process. The performed experimental studies and analysis of the obtained data allowed us to develop a method for determining the identification constants of the drillability model with PDC bits, which take into account the technological, technical and design parameters of drilling.

The relevance of the study lies in the fact that despite the sharp increase in technical and economic indicators of drilling operations using PDC bits and screw downhole motors for their rotation, there is no drillability model that takes into account the mining and geological conditions of the field and the parameters of the drilling mode. In turn, without a drillability model, it is impossible to predict drilling performance (the rate of dredging at any point in time using the tool and the durability of the latter). The relevance of research in this direction is not in doubt, since they are aimed at developing a model of drillability with PDC bits, which will optimize the drilling process, predict its performance, reduce the cost of drilling and the overall cost of well construction.

The main idea of the work is that:

- 1) when developing a drillability model, the degree of reduction in the resource of each PDC bit, which was registered earlier during the drilling of the previous well intervals, was taken into account.
- 2) Due to the high durability of PDC bits, when developing a drillability model, it should be taken into account that one bit can be used in several wells until it is completely worn out.

The aim of the thesis is to develop a mathematical model of drillability of PDC bits based on the example of its application at the Uzen field, and based on the developed model, to issue recommendations for predicting performance and optimizing the drilling process.

In the framework of this study, the following tasks were set and solved:

1. Analysis of the design, technology and application of PDC bits.
2. Analysis of existing drillability models and justification of the choice of the method of developing a model for PDC bits.
3. Time observations of drilling performance and reduction in the life of PDC bits while the well is being dredged under the production string (the largest number of drilling bits) at the Uzen field.

4. Grouping of data on the performance of PDC bits based on the time of their use in drilling. Processing the data obtained by mathematical statistics with the definition of the correlation between the speed and time of use of the bit.
5. Determination of the degree of reduction in the life of the PDC bits after drilling each interval under the production string by measuring the drilling rate at the end and beginning of the penetration interval.
6. Construction of a mathematical model of drillability of PDC-bits for drilling conditions at the Uzen field. For this purpose, the initial drilling rate, its rate of decrease, and the drilling rate at which the drilling time is raised are determined theoretically and experimentally.
7. Development of methods for predicting the performance of the drilling process and its optimization using PDC-bits.
8. Improving the technological properties of drilling fluids using PDC bits.

The object of study is the mining and geological conditions of drilling oil and gas wells in the Uzen field.

Methods for solving problems

To solve the set tasks, a comprehensive research method was adopted, containing a synthesis and analysis of literature, field and time observations, processing of the collected data on the use of PDC bits by mathematical statistics methods, methods of mathematical modeling and optimization, technical and economic analysis, and experimental studies of technological data. properties of drilling fluids used in drilling with PDC bits.

The scientific novelty of the results of the work is as follows.

1. A theoretical formula has been obtained for determining the drilling speed with PDC bits, which functionally links the PDC cutter geometry and tool dimensions, axial load and rotational speed, as well as the hardness of the drilled rock. The derived formula was confirmed in practice.
2. The sharp decrease in the speed of drilling with PDC bits at the final stage of its reduction in the life of the bit is explained by the fact that the contact area of the armament increases dramatically and consists of the cross-sectional areas of the diamond layer, carbide base and the carbide tool section itself, which also begins to wear out.
3. For Uzen field, according to one methodology, mathematical drillability models were developed for PDC bits and roller cones previously used on the Uzen field. Comparison of these rock-cutting tools in terms of the main indicators showed that PDC bits in performance are 1.8–2 times greater than roller cone bits, and 7 times in tool life.

The scientific and practical value of the work is to develop a methodology for the model.

to determine the degree of reduction of the bit life and predict their performance depending on the time of operation at the bottom of the well, as well as to improve the formulation of drilling fluids used for flushing wells at the Uzen field.

The implementation of the work. The recommendations are implemented for practical application in the technology of construction of oil wells in the Uzen field.

The theoretical significance of the research lies in the fact that this method of determining the drillability model is relatively easy to calculate and has an accuracy of at least 90% compared to practice, contains only 3 identification constants functionally related to the drilling parameters and the PDC bit design. On the basis of this technique, it is possible in the future, with the appearance of new types of rock-cutting tools, it is easy to make up a mathematical dependence of the well deepening over time and evaluate the effectiveness of their work. The peculiarity of the work is the optimization of the drilling process as a whole using the developed drillability model, which shows the importance of correct use of the bit resource, which gives not a small economic effect.

The main provisions for the defense:

1. A technique has been developed for determining the drillability model identification constants for PDC bits.
2. Minimizing the cost of 1 m of a well for PDC bits is achieved by searching for the optimum using a mathematical model of drillability for the mentioned bits by the criterion of specific operating costs for drilling.
3. The degree of wear of the PDC - bits in a uniform section is determined by the ratio of drilling rates at the end of the well dredging time interval to the drilling rate at the beginning of this interval.

The personal contribution of the author consists in the practical implementation of work on the review of literature on the topic of the thesis, setting tasks, developing a research strategy, analytical research to identify theoretical and engineering computing solutions of the proposed model, conducting experimental research, processing and analyzing the results, numerical studies on optimization of the drilling process and calculation of the corresponding economic effect.

Testing The main provisions of the work were reported and discussed at international conferences: in Tashkent (“Innovation 2017”) in Krasnodar (“Bulat Readings”, 2017), Almaty (“Satpayev Readings”, 2017).

Publications. On the topic of the dissertation, 9 scientific papers were published, including 4 in scientific journals recommended by the Committee for Control in Education and Science, 2 in scientific journals included in the information base of Scopus, 3 in materials of international conferences.

The scope and structure of the thesis. The thesis work is presented on 122 pages of computer text, consists of an introduction, 4 chapters, conclusion, bibliography of 85 titles, contains 57 figures, 17 tables and applications in the form of additional mathematical formulas, tables and figures.

In the first chapter of the thesis, a literary review and analysis of research works aimed at studying PDC bits, their design, principle of operation and their field of application were carried out. According to the literature review and analysis of the research works of authors from different countries of the world, it can be concluded that at the moment there is a problem of creating a model of drillability of PDC bits, which have been used very widely instead of roller shears.

In the second chapter, the existing drillability models and their rational choice for the specific conditions of the Uzen field are considered.

In the third chapter, a model of drillability with PDC bits in the construction of oil and gas wells at the Uzen fields has been developed. For this, the corresponding identification constants are defined.

The fourth substantiates the economic effect of the proposed most advantageous replacement of a worn bit by a new one. A comparative economic assessment of roller bits and PDC bits at a cost of 1 m of drilling is given.