

On the issue of improving the technical and economic indicators of well wiring in difficult mining and geological conditions

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Abstract. In this work, the vulnerability of standard PDC bits was established when conducting wells in difficult mining and geological conditions, in particular, with frequent layering of rocks with different hardness. The use of adaptive TerrAdapt chisels, which automatically change the depth of cutting and the aggressiveness of the chisel, is proposed in Russian deposits with frequently alternating rocks. These bits can be combined with overhead dampers if the dynamic coefficient is in the critical range. This solution will improve the technical and economic performance when drilling wells.

1 Introduction

The chisel in the process of drilling wells is often forced to work in conditions of frequent transition from soft rocks to hard rocks and vice versa. By far the most common type of chisels worldwide are PDC chisels. The cutting elements of these types of chisels are cutters, which are a carbide substrate with a layer of polycrystalline synthetic diamond (PDS) fixed on it [1-4]. Diamond, being the hardest material on Earth, provides unique opportunities for these types of chisels to destroy rocks by cutting.

However, when passing intervals with frequent layering in strength and hardness of rock interlayers, powerful vibrations and shocks are created at the bottom, transmitted to the entire string of drill pipes and leading to a spread in torque, impact wear of the cutters and the body of a standard PDC bit (Figure 1) [5-8]. In addition, premature wear of downhole motors and other elements of the BHA occurs, as well as an abrupt change in pressure in the circulation system of the drilling rig [9].

2 Methods and Materials

As a result, an additional lowering and lifting operation of the drill string is necessary to replace the rock-crushing tool. In addition to the cost of a new bit, the cost of a simple

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drilling crew and a well during technical work is high, which can exceed 2 million rubles per day.

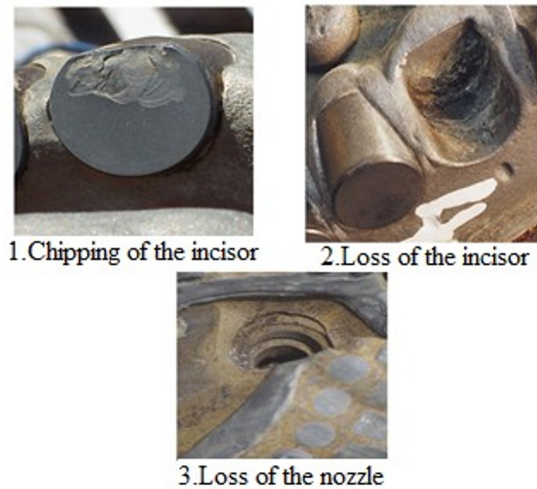


Fig. 1. Impact wear of the PDC chisel.

To solve the tasks set, the basic laws of theoretical mechanics, comparative analysis, analytical and experimental methods were used.

3 Results and Discussion

In order to solve these problems, let's consider the design of a new line of bits from Baker Hughes - TerrAdapt Adaptive Drill Bit System [10-11]. Movable controlled elements in gold with self-adjusting penetration depths into the rock can change the aggressiveness of the chisel depending on the lithology of the rocks. The TerrAdapt system uses a passive hydro-mechanical return mechanism located in cartridges mounted inside the body of the PDC chisel. The ball elements (Figures 2 and 3) located in these cartridges may retract or bulge outwards. They respond to loads and vibrations, protecting the chisel from major damage when passing difficult sections. Thus, vibrations and shocks are significantly reduced, the penetration per bit increases, the drilling speed and its efficiency [12].

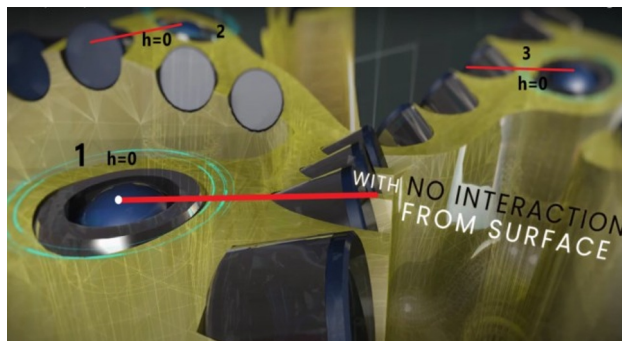


Fig. 2. Maximum cutting depth.

It was found that due to the automatic adjustment of the depth of the incisors during drilling at one of the fields, the TerrAdapt adaptive chisel stabilized the moment on the bit

and its rotation frequency, reduced the amplitude of longitudinal and torsional vibrations of the tool, increased the mechanical and flight drilling speeds (Figure 4) [13].

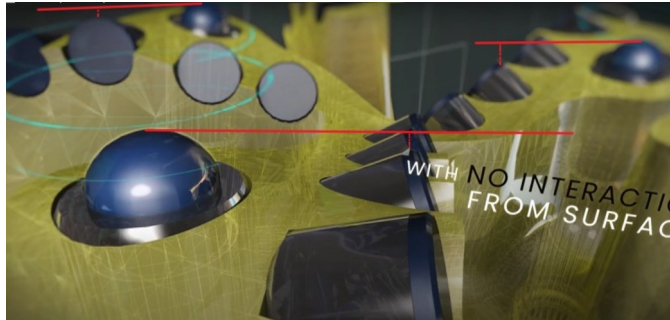


Fig. 3. The cutting depth is minimal.

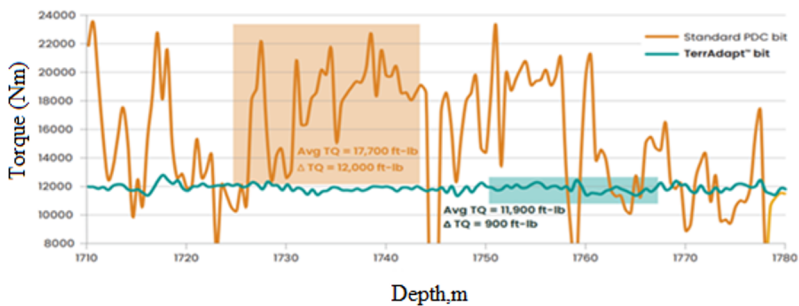


Fig. 4. A graph of torque changes during drilling using a standard bit and an adaptive TerrAdapt bit.

The graphs (Figure 5) show the dependence of well depth values on time when using standard PDC bits and the TerrAdapt adaptive bit. The graph shows that the TerrAdapt chisel completed a 2,743-meter section in one pass, increasing the penetration rate by an average of 27% compared to drilling speeds with standard PDC chisels in similar drilling conditions [14].

The horizontal lines (A-B) show that when using standard PDC bits, there were cases of breakage of the bits and, accordingly, forced SPO to replace the bits.

Frequent layering of terrigenous and carbonate rocks occurs, in particular, at the Usinsk deposit [15]. When drilling wells with standard PDC bits, the drilling contractor incurs significant economic losses associated with complications due to vibrations, the source of which is the processes at the bottom. Drilling large numbers of wells in this field requires increased efficiency through the use of specially designed bit modifications.

To analyze the characteristics of rocks along the trunk of one of the wells at the Usinsk field, drilled under conditions of frequent layering of layers of different hardness, geophysical materials were studied. Figure 6 shows the results of GIS measurements of the studied intervals.

This figure shows a lithological section (Lithology Log) in the range 3500-3600. The analysis shows that with intensive alternation of different rocks (3560-3600), their strength (UCS) changes in an abrupt manner [16]. During the drilling of wells in this field, significant vibrations of the BHA were noted in the considered interval, as well as the uncontrollability of the layouts with VZD and PDC bits. As a result, during the passage of this interval, strong vibrations of the column appear, which lead to wear of the cutters and PDC bit housings, longitudinal, transverse and torsional vibrations of the layout.

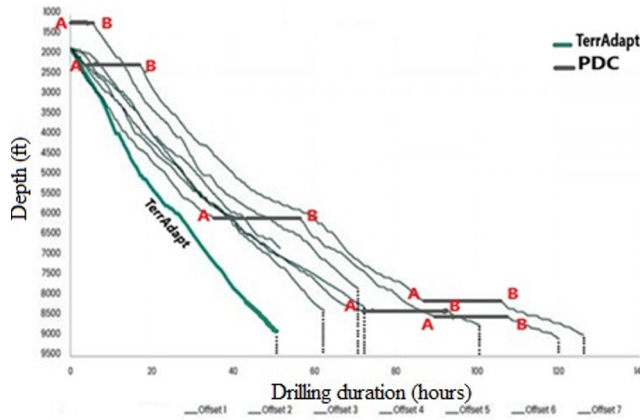


Fig. 5. Technical indicators for the use of an adaptive bit in drilling in conditions of frequent stratification of rocks of different hardness.

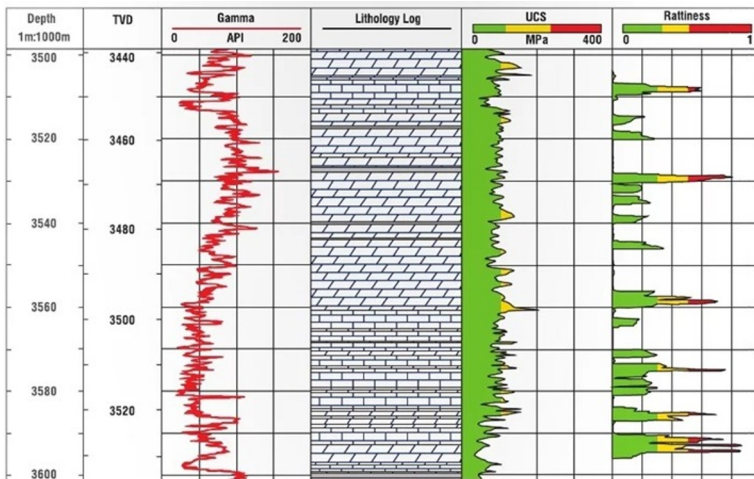


Fig. 6. Lithological section of one well at the Usinsk field.

4 Conclusion

In order to increase the efficiency of drilling a well in this or similar fields, elements of the BHA are required to control its dynamism. The designs of the TerrAdapt adaptive bit will be able to stabilize the torque, reduce the amount of vibrations, and also protect the bit from brittle destruction of diamond cutters, which, ultimately, will increase the efficiency of well construction by increasing the penetration per bit, increasing the reliability of the entire BHA and eliminating the unproductive time spent on additional SPO.

If the dynamic coefficient of the layout reaches very high values, then this type of chisel can be combined with a damper or shock absorber of various designs installed above the chisel:

- The low efficiency and vulnerability of standard PDC bits have been established when drilling strong and intermittent rocks.

- The design of the TerrAdapt adaptive bit is analyzed as a method for controlling the dynamism of the layout in difficult mining and geological conditions, and in particular at the Usinsk deposit.
- It has been established that the use of the TerrAdapt bit can significantly increase the drilling efficiency when passing through difficult sections of rocks.
- This adaptive chisel will improve the technical and economic performance of well construction and is recommended for use in other fields of the Russian Federation with frequent interlayers of rocks.

References

1. V.S. Shagapov, Y.A. Tazetdinova, A.A. Gizzatullina, On theory of thermal recovery of high-viscosity oil, *Journal of Applied Mechanics and Technical Physics*, **60**, 5 (2019)
2. V.S. Shagapov, Y.A. Tazetdinova, A.A. Gizzatullina, On the theory of extraction of high-viscosity oil from the stratum under thermal action, *Journal of Engineering Physics and Thermophysics*, **92**, 6 (2019)
3. Bakerhughes, <https://www.bakerhughes.com/drilling/drill-bits/adaptive-drill-bits/terradapt-adaptive-drill-bit>
4. Bakerhughes, <https://www.bakerhughes.com/sites/baker-hughes/files/2020-10/TerrAdapt-bit-increased-drilling-efficiency-45-percent-Delaware-Basin-cs.pdf>
5. Bakerhughes, <https://www.bakerhughes.com/sites/baker-hughes/files/2020-10/TerrAdapt-bit-saves-50hrs-165k-permian-cs-op.pdf>
6. F.I. Ermolenko, T.N. Minnivaleev, Simulation of formation fluid withdrawal hydrodynamics using a downhole jet pump when studying the productive formation while well drilling, *Journal of Physics: Conference Series*, **1333**, 032014 (2019)
7. L. Kuleshova, I. Fattakhov, A. Semanov, Efficiency of maintaining reservoir pressure in oil wells during the development of carbonate reservoirs, *International Conference on Ensuring Sustainable Development: Ecology, Energy, Earth Science and Agriculture (AEES2023)*, **494**, 02009 (2024)
8. I. Fattakhov, L. Kuleshova, L. Samigullina, Features of bottomhole zone treatment and formation stimulation by large volumes of hydrochloric solutions, *II International Scientific and Practical Conference "Energy, Ecology and Technology in Agriculture" (EEA2023)*, **480**, 01013 (2024)
9. I.G. Fattakhov, A.S. Semanov, A.I. Semanova, L.S. Kuleshova, V.A. Iktissanov, Analysis of waterflooding performance in mature fields, *Neftyanoe Khozyaystvo – Oil Industry*, 8 (2023)
10. A.A. Gizzatullina, T.N. Minnivaleev, D.R. Zaynutdinova, I.Z. Khatmullina, Approximate analytical solution by sequential changing steady states of problem concerning high-viscosity oil filtration, *30th Russian Conference on Mathematical Modelling in Natural Sciences*, **5**, 0135002 (2023)
11. E.V. Alieva, E.G. Bochkova, S.S. Vasilev, Automation of the process of transportation of petroleum products, *Novainfo.ru*, **2** (50), 22-28 (2016)
12. Yu. Kurokawa, N. Inoue, Identification of size and position of flaw by the TOFD method using multiple probes, *J. Jap. Soc. Nondestructive Inspection*, **62**, 2, 104-111 (2013)
13. E. M. Almukhametova, Recommendations on thermal non-stationary waterflooding when modeling oil field development, *IOP Conference Series: Earth and Environmental Science*, **6**, 0620022018 (2018)

14. T.T. Palisch, M.C. Vincent, P.J. Handren, SPE Annual Technical Conference and Exhibition, 1-20 (2008)
15. G.R. Izmailova, Research on the high-frequency electromagnetic acoustic heating of an oil reservoir with further pumping of a solvent, *High Temperature*, **56(6)** (2018)
16. L.F. Yusupova, K.M. Khalikova, R.R. Khusnutdinova, Technological feature of water shutoff operations, *IOP Conf. Series: Earth and Environmental Science*, **868**, 012086 (2021)