Downhole screw motor with integrated telemetry system

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Abstract. The experience of using downhole screw motors with an integrated telemetry system manufactured by Research and Production Company VNIIGIS-ZTK LLC, which allows solving urgent problems of horizontal well construction — precise determination of the opening time of a productive formation and operational control of the wellbore trajectory with the aim of conducting it along the most productive collector.

1. Introduction

Today, the issue of improving the accuracy of drilling directional and horizontal wells in Russia, and in most oil-producing countries, is particularly acute. A large degree of depletion of reserves, difficult conditions of occurrence of the reservoir, low-power formations - all this forces manufacturers, contractors and subsoil users to look for new technological solutions in the field of drilling techniques and tools, which can improve development efficiency. This is especially true for drilling multilateral and horizontal wells, including long ones. Field development using horizontal technology requires a large investment. The accuracy of the wiring in this case plays a key role, since it allows you to position the wellbore in the reservoir in an optimal way, which directly affects the production capabilities [1].

Modern telemetry complexes in the basic configuration are equipped with an inclinometer module and a gamma-ray logging tool located at a distance of 15–20 m from the bit (depending on the type of tele-system and BHA elements). Thus, geophysical information arrives at a point of the current position of the face with a large delay in time. This situation is critical in the case of drilling horizontal wells in the conditions of low-power formations or the uncertainty of the position of the productive part of the formation. Such difficult geological conditions are typical, for example, for the fields of the Volga-Ural oil and gas province, which are characterized by a high degree of depletion of reserves [2].

If a discrepancy between actual geology and design is found during drilling, it is necessary to drill about 50 meters or more in the formation with the worst reservoir properties to return to the productive formation. As a result, a significant part of the horizontal section appears to be drawn along low-permeability zones. Measurement systems located in the immediate vicinity of the bit help to avoid such situations.

2. Over-bit module OBM

The first measuring system located in the immediate vicinity of the bit in Russia was the over-bit
module (OBM) (Figure 1) produced by Research and Production Company VNIIGIS-ZTK LLC (Oktyabrsky, Republic of Bashkortostan). The technology is unique and today has no analogues. The main advantage of OBM is the ability to transmit geophysical and technological information from the bottom of the well to the surface in real time. In total, 6 measured downhole parameters are transmitted via the communication channel: shaft rotation frequency, annular pressure, axial load on the bit, gamma-ray logging, apparent resistivity logging, zenith angle. The principle of data transmission is based on the use of a short high-speed electromagnetic communication channel between the supra-bit module and the base telemetry system. The over-bit module is essentially an autonomous small-sized telesystem, as it has its own power supply and is not connected by direct contact with the main units of the telemetric complex [3, 4].

**Figure 1.** The appearance of the over-bit module

The use of an over-bit module in the layout of the bottom of the drill string (BHA) reduces the non-metering zone to 0.5 meters. Also in OBM a two-channel gamma-ray logging system is implemented: GK up, GK-down. Azimuthally oriented measurements of gamma activity allow us to solve the problem of controlling the position of the clay cover of the reservoir, when, due to the existing geological uncertainty, it is not clear where the device is located relative to the clay - above or below. The data of the zenith angle sensor located in the OBM allow operational monitoring of the well path control when changing geological conditions [5, 6].

Using the over-bit module, more than 500 wells were drilled in various mining and geological conditions at the fields of Perm region, Bashkortostan, Samara Region, etc. The main part of the study was performed at the facilities of PJSC TATNEFT of the Republic of Tatarstan in cooperation with LLC UK TATBURREF and LLC TNG -Groups [7].

The operation of the over-bit module has a number of limitations:
- data transmission from OBM is possible only when the receiving splitter is in the open trunk;
- the rotation of the drill string is possible with a skew angle of the downhole motor of not more than 1.5 degrees;
- the inclusion of OBM in the BHA slightly reduces the intensity of the curvature due to the increase in the length of the lower arm of the layout;
- zenith angle measurement is possible only in static
- the inability to turn on the calibrator in the BHA at the same time as the OBM.

3. Screw downhole motor with integrated measuring module

The next generation of measuring systems located in the immediate vicinity of the bit was the integration of measuring sensors directly into the body of a downhole screw motor (Figure 2, Table 1). The downhole screw motor with an integrated measuring module (Figure 3) is designed for drilling directional and horizontal wells with bits with a diameter of 142.9–244.5 mm, measuring and transmitting geophysical and technological parameters during drilling: zenith angle, gamma activity, shaft rotation speed, logging apparent resistance [8].
Figure 2. The layout of the main components in the downhole screw motor with an integrated measuring module

Figure 3. Appearance of a downhole motor with integrated OBM

The main advantage of this technology in comparison with OBM is the ability to measure zenith angle in dynamics and four-channel azimuthal gamma-ray logging in real time. Each measuring channel is associated with the corresponding sector of the downhole motor diverter (Figure 4). The available possibility of registering space-oriented gamma-ray logging allows using specialized software systems (Figure 5) to build a scan (GK image) (Figure 6) [9].

Table 1. Technical data downhole screw motor with integrated measuring module

| Parameter                                    | Measuring range |
|----------------------------------------------|-----------------|
| Zenith angle, gr.                            | 0-180           |
| Natural rock radioactivity                   |                 |
| (4-channel GK), μR / h                       | 2-100           |
| Apparent resistance (KS indicator), Ohm · m | 0-100           |
| Motor shaft rotation frequency, rpm          | 0-300           |
| Pressure in the borehole space, MPa          | 0-60            |
| Maximum working temperature, °C              | 120             |
| Sizes, mm                                    | 106; 120; 172   |
A downhole screw motor with an integrated measuring system is a joint development of Research and Production Company VNIIGIS-ZTK LLC (Oktyabrsky), LLC Tatburnneft Management Company (Almetyevsk) and VNIIBT-Drilling Instrument LLC (Perm), which also has no Russian counterparts. The first tests of a downhole screw motor with a built-in telemetry system DR3-106TS in a dimension of 106 mm were carried out in 2015 in the Republic of Tatarstan. Subsequently, engines with housing diameters of 120 mm and 172 mm were designed and tested. The industrial introduction of technology
began in 2018 at the facilities of PJSC TATNEFT. Downhole screw motor with an integrated measuring module allows you to drill wells of various complexity categories: sidetracks, directional and horizontal wells. Pilot tests have confirmed the reliability of the equipment when working on any type of drilling fluid (MudMax, Unidrill, BPSR, etc.) in combination with cone bits and PDC. The technical capabilities of the engine allow you to quickly maneuver during the installation of a horizontal wellbore with a selected angle of bias, depending on the changing readings of the main assembly (Figure 7). The calculated wellbore curvature rate is achieved much faster than in a conventional OBM [10,11].

Figure 7. Pavlovskoye field, Republic of Tatarstan. Results of recording inclinometry and GK from DR3-120TS

In August 2018, using the DR3-120TS, a horizontal well was drilled for the first time in Vatereft deposits with a horizontal section length of 800 meters at PJSC TATNEFT.

4. Conclusion
Advantages of using downhole screw motors with an integrated measuring module compared to over-bit modules:
- the ability to measure the zenith angle in dynamics (continuously);
- construction of four-channel azimuthal gamma-ray logging in real time;
- fewer threaded connections;
- the ability to work with the calibrator.

The innovativeness of the approach lies in the fact that for the first time the measuring system was placed in the spindle part of the hydraulic downhole motor and this allowed to reduce the non-measuring interval to the recording point of the GK sensors and zenith angle to 0.8 m. At the same time, the technical characteristics of the hydraulic downhole motors remained unchanged. When working with DR3-TS, a calibrator could be used. Fewer threaded connections and an all-metal casing increase the wear resistance and structural strength of the OBM integrated into the motor casing. To
date, more than 50 wells have been drilled with engines with integrated OBM in various regions of Russia.

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