Bit measuring systems

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Abstract. The article describes the overhead module produced by VNIIGIS-ZTK LLC which solves a number of relevant tasks of horizontal wells construction – accurate determination of the moment of well drilling and operational control of the wellbore trajectory along the most productive reservoir.

1. Introduction

Downhole telemetry systems solve three main tasks:

1) operational monitoring of the drilling parameters;
2) monitoring of the wellbore trajectory during the directional drilling process;
3) lithologic dismemberment of the geological section of the well, study of formation parameters which were not distorted by the washing fluid filtrate penetrating into the formation, selection of formations, prediction of areas of abnormal formation pressure.

By obtaining online data on the bit rotation frequency and axial bit load, it is possible to maintain an optimal drilling mode which ensures the maximum mechanical penetration rate with a minimum bit wear.

With ever-increasing volumes of cluster, directional and horizontal drilling, monitoring and control of the wellbore trajectory are crucial tasks [1-3].

Using the geophysical data, it is possible to improve the accuracy of the wellbore location by locating horizontal sections in productive formations. This problem is particularly relevant for thin formations with a thickness of about several meters, below which water is located.

To obtain real-time technological and geophysical parameters near the bit, bit measurement systems are used. One of them is the overhead module (OM) produced by VNIIGIS-ZTK LLC (Figure 1).

2. Overhead module AM

The overhead module OM is a unique product produced by VNIIGIS-ZTK LLC. It is an autonomous small-sized system which wirelessly transmits information to the parent system. Then parameters measured by the telesystem and data obtained from the OM are transmitted to the surface [4].
The overhead module measures the following parameters:
- zenith angle;
- natural radioactivity of rocks (azimuth gamma logging);
- apparent resistance;
- axial bit load;
- engine shaft rotation frequency;
- well space pressure.
Technical characteristics of the overhead module are presented in Table 1.

| Parameter                                      | Measurement range   |
|------------------------------------------------|---------------------|
| Zenith angle, degrees                          | 0-180               |
| Natural radioactivity of rocks (2 channel GR), μR/h | 0-100               |
| Apparent resistance (AR indicator), Ohm · m      | 0.1-100             |
| Bit load, kN                                    | 0-100 (MD), 0-400 (BD) |
| Motor shaft rotation frequency, rpm.            | 0-300               |
| Pressure in well space, MPa                     | 0-40                |
| Time of continuous work, h                      | 250                 |
| Dimension:                                      |                     |
| outer diameter, mm                              | 102, 118, 150       |
| length, mm                                      | 600                 |
| Time of continuous data recording into the device memory, h | 1440               |

The overhead module as a part of the telesystem makes it possible to obtain information from the well bottom in order to promptly react to a change in the geological situation at the bottomhole and control the well bore trajectory during the drilling process [5, 6].

3. Application of the overhead module
In drilling horizontal wells, actual absolute elevations of the roof of productive layers can be shifted relative to the well project. Since the distance from the bit to the inclinometric and geophysical sensors...
is about 16 meters (when using a conventional telesystem with electromagnetic or hydraulic communication channels), the productive formation can exit from the thickness which requires additional time and material costs [7].

Accordingly, the main task is to prevent complications of the well design in order to avoid additional costs of installation of the cement bridge and the cutting. The problem can be solved by using an overhead module in the bottom-hole assembly layouts (BHAL). The measurement point of the zenith angle and gamma-ray data in the OM is 0.4 m from the bit which significantly reduces the non-measurement interval, allows for quick response to changing geological conditions, and significantly saves time for opening and developing a horizontal wellbore section (Figure 2).

**Figure 2.** The layout of the bottom of the drill string with and without an OM: 1 - bit; 2 - overhead module; 3 - downhole motor; 4 - OM receiver; 5 - telemetry system and drilling tools.

Drilling of the reservoir using the overhead module.

The clay cap is set by two azimuthally located gamma-ray channels in the OM (gamma-top GRt and gamma-bottom GRb) (Figure 3) and the entrance to the productive reservoir is fixed. After determining the boundary of the reservoir, the drilling process stops, the drilling tool is lifted and the casing is lowered. Using this method for drilling the formation roof, there is no need to carry out reference logging [8].

The spatially oriented GR in the OM promptly responds to changes in the geological situation at the bottomhole. The close distance from the boundary of the roof or the bottom of the reservoir is recorded by one of the sensors (GRt or GRb) (Figure 4).
Figure 3. Spatially oriented GRs in the ABM.

Figure 4. Drilling of the formation using OM-150: 1 – drilling of the roof of the Kynov horizon; 2 - weakly expressed layer D0; 3 – drilling of the roof of the productive Pashi horizon.

After the boundary of the reservoir was drilled according to gamma-ray logging indicators from the overhead module, the drilling processes was stopped, the tool was lifted and the casing was lowered. Using this technology, the wellbore is more accurately brought to t1 and the influence of unstable mudstones is eliminated [9].

Operational control of the borehole trajectory according to the gamma logging data obtained from the overhead module (Figure 4).
Figure 5. Adjustment of the wellbore trajectory according to the GR data obtained from the OM: 3005Pr is the design profile; 3005F is the actual profile.

The monitoring of the wellbore trajectory was carried out in accordance with GR indicators obtained from the OM. When approaching the clay, the OM showed elevated values for the GR and adjusted the wellbore trajectory.

4. Conclusion

More than 400 wells were drilled using the overhead module OM produced by VNIIGIS-ZTK LLC. Currently, the OM is used along with ZTK-42EMtelesystems with an electromagnetic communication channel and ZTK-42KKtelesystems with a combined communication channel (VNIIGIS-ZTK LLC), as well as with APS Sure Shot telesystems (APS Technology Inc.) with a hydraulic communication channel [10].

The use of the OM as a part of the telesystem reduces financial costs and increases drilling productivity:
- reduction of the non-measurement area for geophysical parameters to 0.4 m allows for obtaining actual data from the well bottom;
- navigation in thin layers;
- obtaining gamma-ray logging data allows for efficient control of the wellbore trajectory aimed at developing the most productive part of the formation and increasing the flow rate of the well;
- technological parameters of the OM allow for selection of the most optimal modes of operation which increases the life of drilling equipment;
- well development without additional binding logs which reduces well construction costs.

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