

BACK TO BASICS

Measurement while drilling tells what happens downhole

Editor's note: *With this article, Drilling Contractor launches Back to Basics, a series of features designed to provide fundamental information on key drilling technologies and practices. We look forward to continuing this series in future issues.*

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UNTIL THE 1970S, the industry had no measurements from the bottom of the hole while drilling. All data were obtained by stopping the drilling process for wire line logging, etc. The first MWD tools were developed in the early 1970's, measuring and transmitting to surface using the mud stream inside the drill pipe during the drilling process.

The most common data transmission system uses mud pulses. Other means are electromagnetic transmission used for air drilling, for example, and also by means of wire or wired drill pipes currently under development. The wire transmission allows for speed and flows thousands of baud.

DIRECTIONAL DRILLING

The system delivers three basic data: inclination and azimuth for trajectory computation (drilling with no rotation but with PDM for trajectory corrections, or build, drop, turn phase); and tool face orientation for directional drilling in sliding mode. The directional driller builds the trajectory from station to the next station.

Knowing the coordinates of the last station, the new station is computed with the measured depth between the two stations, the azimuth and inclination of the new station making geometrical construction with the assumption that the trajectory is an arc of circle with minimum radius of curvature (other assumptions exist).

To this effect, two families of sensors are in the MWD "sensor cartridge". First, three accelerometers (replacing the pendulum used in single or multi shot) compare the orientation of the MWD with the gravity. This measure allows the computation of the inclination.

Second, three magnetometers replace the compass. They compare the orientation of the MWD body with magnetic North, allowing the determination of the azimuth. The acquisition of both allows the computation of the tool face.

OTHER MEASURES

Most MWD are equipped with a gamma ray sensor to detect natural radio activity and characterize shale presence. When equipped with resistivity or compensated dual resistivity for oil-base mud (LWD), it characterizes the level of saturation in hydrocarbons.

They are used in horizontal drilling for narrow pay zones. Other sensors exist on new LWD, which are equivalent to those in wire line logging (Neutron, Density).

The other sensors are gauges to measure annular pressure, which are very useful in slim hole drilling to monitor ECD, strain gauges to measure weight on bit and torque at bit. The latter sensors are seldom used and would be located below the MWD tool.

The MWD system uses the mud stream inside the drill pipe as a communication link via pulse. The analogical data from sensors are converted to binary language in sequence of words. The pulses can be positive or negative. Positive pulses are created hydraulically by activation of a poppet that chokes the mud flow. Such pulses correspond to a slow rate of transmission.

The power can be generated by a small turbine. Modern types have a battery and venting valve to allow faster pulse generation. Negative pulses are generated by a valve opening or closing the outside body of the MWD tool, creating an instant depression.

Signals are read at surface by a pressure gauge on stand pipe. Sensors are of piezoelectric type, with a crystal transducer. Typical sensitivity is 5 volts/70 bars (1,015 PSI) with a maximum constant pressure of 10,000 psi. Raw data are decrypted and the computer transforms them into measures necessary for the driller, directional driller and geologist to conduct the operation.

MWD exists for all bore-hole diameter 4 3/4-in. to 17 1/2-in. OD. The tools range from 3 1/2-in. to 9 1/2-in. The MWD tool is placed above the PDM, and results in measurements taken at a distance of 10m or more of the drill bit. As a consequence, trajectory corrections must be anticipated.

The mud pumps must deliver a constant pressure. It is essential that the pump dampeners are well maintained, as non-tabilized pressure could create interferences detrimental to signal reading.

The above reflects the basic technology of mud

pulse MWD. Continuous wave transmission where pulses are replaced by phase difference has not been described, however, the basic principles are similar. Today, the technology has dramatically improved with the rotary steerable system where information communicates both ways due to an actuate stabilizer. ■

