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Development of A Near Bit MWD System

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TECHNICAL PROGRESS REPORT

PROBLEM STATEMENT

The success of horizontal drilling in increasing oil and gas production rates in tight formations and mitigating problems, such as water coning and sand production, has led to its industry wide acceptance as a viable recovery technique.

Correspondingly, as horizontal drilling and completion technology has improved through evolution, the length of the horizontal sections have grown longer and the need for more accurate directional placement become more critical. The reliance on examining wellbore conditions and borehole directional data some 50 to 80 feet above the bit (see Figure 1) becomes less acceptable as turning radius decreases and target sands become thinner. This is because the impact of standoff distance, namely, looking at what has occurred instead of what is now transpiring, can result in missing thin targets, falling outside productive seams identified from gamma ray logs or dipping into the water or gas cap. Corrections may entail adding one to two hundred feet more drilling or in more critical instances, plugging back and redrilling the lower portion of the hole. Figure 2 illustrates some typical borehole guidance problems caused by monitoring hole conditions from locations spatially separated from the drill bit.

The above problems can be circumvented by placing the data gathering measurements-while-drilling system directly behind the drill bit. This requires design of a special bit sub which houses and protects the borehole environment measuring sensors and communications electronics from damage that can be caused by the torsional, axial and bending loads developed at the drill bit-rock interface.

Figure 1. Conventional MWD Drill-String Location

Figure 2. Borehole Guidance Problems

OBJECTIVE

The project objective is to develop a measurements-while-drilling module that can reliably provide real-time reports of drilling conditions at the bit. The module is to support multiple types of sensors and to sample and encode their outputs in digital form under microprocessor control. The assembled message will then be electromagnetically transmitted along the drill string back to a standard mud-pulse or EM MWD tool for data integration and relay to the surface.

The development effort will consist of reconfiguring the AccuNav EM MWD Directional System manufactured and marketed by Guided Boring Systems, Inc. of Houston, Texas for near-bit use followed by the inclusion of additional sensor types in Phase II.

To maintain focus and provide the desired level of project control, work is divided into two phases. The current Phase 1 goal is to define system specifications followed by design, fabrication and testing of a functioning prototype. This minimizes risk to METC and allows demonstration that the required form, fit and functionality have been achieved prior to embarking on a field test program. To minimize costs, the Phase I prototype will be configured with accelerometers, temperature and pressure. The accelerometers will provide us with inclination angle which, in conjunction with natural gamma ray logs, are two of the most sought after near-bit data elements.

Phase II will consist of incorporating a selected data suite (adding other sensors such as gamma ray) and performing a series of field experiments. Before proceeding to the field test stage, a series of vibration cycle and shock tests will be performed to identify areas to strengthen through redesign and packaging modifications. Pending success of the field tests, final design modifications would be implemented and the system commercialized.

SUMMARY OF TECHNICAL PROGRESS

Define System Specifications

The performance and environmental specifications for the near-bit MWD sensor module were established. The specifications consist of mechanical ratings, sensory response, communications protocols and field service requirements such as the ability to pass lost circulation materials. Table 1 presents the specifications for the 6¾-inch diameter near-bit MWD system. The mechanical specifications are based on the torque, maximum overpull and compressive loads for typical drill pipe and mud motor combinations. The near-bit load housings have been sized to meet or exceed these values.

TABLE 1.
6¾-Inch O.D. Near-Bit MWD System

1. MECHANICAL

Sub Diameter: 6.750 inches
Sub Length: 38 Inches, OAL, 34 Inches Assembled
Flow Area: 7.85 Sq. Inches
Over Pull Capacity: >200,000 lb_f
Pressure Rating: 15,000 psi
Material of Construction: 4140 CHT
Tool Joints: 4½ API Reg. Pin x 4½ API Reg. Box (Down)

2. SENSORY

Type of Sensor Data:
- Triaxial Acceleration
 Range: +/- 1g
 Inclination Accuracy: ±.1 degrees
- Temperature

3. COMMUNICATIONS

Telemetry: EM Frequency Shift Keying
Transmit Frequencies: Selectable
Baud Rate: Selectable

4. OTHER

Power Source: Lithium and Ni-Cad Supported
Lost Circulation Materials: Pass
Retrieval: Overshot

System Electronic and Mechanical Design

The near-bit MWD electronic circuitry has been designed. The electronics are divided into three functional elements: (1) signal conditioning and driver circuitry for the downhole sensors, 2) micro-controller and transmitter card for system control and communications, and 3) switched power supply for providing regulated power at the required voltage levels. A block diagram describing the functional relationships is given in Figure 3.

Figure 3. Electronics Block Diagram

The near-bit mechanical housings have been designed to afford maximum protection against vibration and shock damage to the electronics and environmental sensors. The mechanical design consists of a concentric inner barrel containing the electronic circuitry and an outer housing which forms the primary load bearing member. An examination of the expected vibration amplitudes and frequencies was performed and used to select special damping mountings to reduce the potential of mechanical failure of components. The effectiveness of the mounts in a near-bit application have as yet been determined although the technique has been quite successful in our standard MWD probes.

Efforts in the next quarter will consist of the fabrication and assembly of the near-bit MWD probe followed by verification tests.

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