Development of Radar Navigation and Radio Data Transmission for Microhole Coiled Tubing Bottomhole Assemblies

DE-PS26-03NT15477

Goal

The overall goals of this project are to design, manufacture, and test two advanced technologies for the oil and gas industry: 1) real-time measurement-while-drilling (MWD) for guidance and navigation of coiled tubing drilling in hydrocarbon reservoirs and 2) two-way inductive radio data transmission on coiled tubing or via an insulated slickline fed inside the coiled tubing.

Performer

Stolar Research
Raton, NM

Results

A data transmission system has been developed that uses only the outer surface of the drill pipe to propagate communications signals. The system, which is small enough to fit inside a 1.661-inch diameter housing, was successfully tested over 500 feet of pipe inside an uncased, water-filled test hole in the Deer Creek coal mine in Utah. The signal-to-noise ratio at the receiver for the one-way communications test was better than 30 dB. During above-ground tests that simulated borehole conditions, the system was successfully tested over 1,700 feet of pipe.

A prototype digital signal processing (DSP)-based radar system capable of coherent detection of radio waves has been designed and fabricated that provides MWD guidance and navigation of coiled tubing. To track the boundaries in an oil reservoir, a radar system has been devised that operates below 1 MHz with multiple transmitter and receiver antennas to provide directionality and spatial diversity.

Benefits

The technologies developed in this project allow real-time navigation and imaging during exploration with minimum land disturbance and fewer drillholes. The proposed technologies are expected to improve the recovery efficiency of shallow production wells. Through real-time navigation, the operator can eliminate the expensive practice of sidetracking in horizontal drilling.

Background

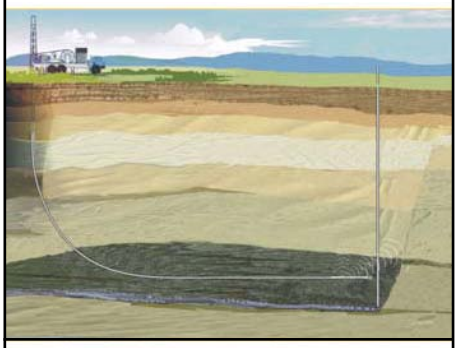
The information from MWD sensors in a bottomhole assembly must quickly be transmitted to the drill operator for real-time navigation of the drillbit. Two methods are currently employed. One common method of transmitting downhole sensor data to the surface is by sending extremely low-frequency (e.g., 40 Hz) signals though the layers of the earth to reach a surface receiver antenna. This method provides a slow communications channel due to its low frequency. The other method uses wire lines (or fiber optics) embedded in the drill pipe to provide high-speed communications with the topside receiver. This is generally an expensive and irreversible process. Stolar's data communications system is a cost-effective alternative to these methods of MWD communication.

Currently, the location of the drillbit in the hydrocarbon reservoir is determined from the gamma ray, neutron, and resistivity sensors. There is no tool available to let the horizontal drilling operator know the distance between the drillbit and the bounding walls of the reservoir. The radar navigation tool eliminates this deficiency.

Summary

Among the project highlights:

- A proof-of-concept prototype data communications system suitable for propagating communications signals along the outer skin of a metal drill rod has been designed, fabricated, and successfully tested in a borehole.
- A prototype DSP-based radar system has been designed and fabricated that can detect and map the reservoir boundary.
- A test of a prototype, 800-kHz system, which employed a transmitter/receiver pair of loop antennas in a deviated borehole, showed that the resonant frequency and the transmission loss can be used in tracking an air-soil boundary in conductive soil.



Radar measurements while drilling for horizontal directional drilling, navigating, and structure detection.

The data transmission system uses frequency-shift keying modulation of 91.5-kHz signals. Radio waves are inductively coupled to and from the skin of the drill pipe using loop antennas. The system takes advantage of the natural waveguide properties of the hydrocarbon seam; the entire drill rod and the immediate surrounding layers of rock become the data transmission channel. The system transmits data collected by the DSP radar at a rate of 2,400 bits/second. The system also is equipped with a downhole navigation package (3-axis magnetometer and accelerometer) that provides bottomhole assembly orientation data that complements the data from the radar.

Current Status (January 2006)

With the communications concept proved with the success of the first prototype in the Deer Creek mine, the focus has been on the design and fabrication of a second, more robust pre-production prototype suitable for MWD applications. This second prototype refines the communication concept and focuses on the practical and operational design aspects required during actual drilling conditions.

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