High-Power Turbodrill and Drill Bit for Drilling with Coiled Tubing

DE-FC26-05NT15486

Goal

The project entails developing and testing an effective downhole drive mechanism and a novel drill bit for drilling small-diameter vertical and horizontal wellbores with coiled tubing.

Performers

Technology International, Inc. (TII)
Houston, TX

Smith International, Inc. (SII)
Houston, TX

Gas Technology Institute (GTI)
Catoosa, OK

Terra Tek
Salt Lake City, UT

Results

Baseline testing of an existing 2?-inch diameter Turbodrill with polycrystalline diamond compact (PDC) and impregnated diamond drill bits was performed successfully at GTI's Catoosa, OK, field test site. The hydraulic efficiency of the baseline MK2 turbine blades has been increased so far by 13 percent. Basic research performed at NASA Ames Research Center, Mountain View, CA, in evolutionary algorithms, response surface methodology, and geometry modeling and the associated codes are being utilized to further improve the hydraulic efficiency of the Turbodrill.
The advanced PDC drill bit will employ unique microwave-brazed, thermally stable diamond (TSP) cutters. Use of the cutters allows the bit to be rotated at higher speeds than conventional rotary speeds without the excessive wear that would occur if commercially available PDC cutters were used. Thermal modeling of the TSP cutters revealed an unexpected result: TSP cutters are able to be rotated at speeds of at least 2,000 rpm without excessive wear. Because of their thermal properties, the TSP cutters will operate at a lower temperature when compared with the commercial PDC cutter.

Improvements in the Turbodrill and the advanced high rotary speed drill bit will be incorporated in drilling systems to be tested at the Terra Tek Drilling Laboratory and the Catoosa field test site.

The PDC and impregnated diamond drill bit being developed in this project.

Benefits

Benefits to the industry from successful development of a microhole coiled tubing Turbodrill and high-speed drill bit include:

- Delivery of more power to the bit than with positive displacement motors.
- Lower reactive torque for improved directional control.
- Longer drill bit life.
- Less vibration.
- Steady dynamics at the bit.
- Smaller cuttings that are easier to clean from the hole.
- Drilling at a higher rate of penetration (ROP) with less weight on bit (higher rotary speeds to 2,200 rpm provide higher ROP and lower cost per foot drilled).
- Operation at high downhole temperatures.
- Operation in two-phase muds at higher rotary speeds and for underbalanced drilling applications.
- Improved hole quality.
- High reliability.

Background

Dr. Steve Holditch, 2002 president of the Society of Petroleum Engineers, said, "To economically recover gas, we need to learn how to drill smaller boreholes more rapidly and less expensively." But drilling today does not necessarily mean using a conventional drilling rig. Coiled tubing units increasingly are being used to drill for oil and natural gas deposits at lower costs and with a much smaller environmental footprint. Coiled tubing drilling is a cost-effective alternative for drilling highly deviated wells or drilling new hole sections in existing wells. The use of a relatively high-speed Turbodrill and high-temperature drill bit will reduce the cost per foot drilled.

Summary

The prototype coiled tubing turbine motor and drill bit being developed in this project are designed to:

- Drill a vertical hole to a depth of 5,000 feet.
- Drill laterals to 1,000 feet.
- Demonstrate the economic advantages of the coiled tubing drilling operation when compared with conventional drill pipe-conveyed downhole assemblies.

The performance of the Turbodrill and bit system will lead to an advance in the design of components that ultimately will lead to a higher-power turbine section.

The next step in the project is to incorporate the design improvements into a new downhole drilling assembly for a microhole drilling system. Tools will be made available to microhole project partners for independent field applications in re-entry wells and workover operations using commercial coiled tubing rigs.

A thermal model is being developed by TII to predict cutter temperatures while drilling hard and abrasive rock at high rpm. Being able to estimate cutter tip temperatures will aid in the development of a more durable drill bit employing high-temperature cutters.

A special high-speed laboratory drilling test is being added to the project. Testing will be performed at the Terra Tek Drilling Laboratory in Salt Lake City, UT. The project will provide the Turbodrill and drill bit, and Terra Tek will provide use of the facility and test rocks.

Optimization and geometry modeling algorithms developed by NASA Ames are used being used to increase the hydraulic efficiency of the existing 2⅞-inch diameter Turbodrill.

Current Status (January 2007)

Initial tests of prototype hardware were conducted at drilling research centers to expedite the testing process and to ensure maintenance of carefully controlled operating conditions. Baseline Turbodrill and drill bit testing was completed in March 2005. A turbine blade hydraulic design model was used to redesign the turbine blades, and successful dynamometer testing was completed in June 2005. Further turbodrill hydraulic modeling is currently underway.

Finite-element thermal modeling of TSP cutters has recently been completed, and the results have been incorporated into a new version of an existing drag-bit design code. The new software, called DRAGBIT, is a Windows-based program that calculates cutter forces, cutter temperatures, cutter wear rates, weight-on-bit, drilling torque, and bit imbalance forces for a given bit design, based on downhole operating parameters such as rock type, fluid temperature, fluid cooling rate, rotary speed, and penetration rate. Based on cutter wear rates, the cutter geometries are modified throughout the simulated drilling process to calculate the effects of cutter wear on bit performance. The software allows both TSP and PDC cutters to be specified on the same bit, thereby allowing the user to optimize the placement of TSP cutters in the higher-temperature positions across the bit face. DRAGBIT has been run for a 4⅛-inch diameter fixed-cutter bit design employing both PDC and TSP cutters. Cutter temperatures and wear rates as well as overall bit performance parameters were estimated for rotary speeds up to 2200 RPM in order to simulate drilling with the improved 2⅞-inch diameter Turbodrill.

Testing of an existing 2⅞-inch diameter Turbodrill with PDC and impregnated diamond drill bits at the Catoosa, OK, drilling test facility.

Funding

This project was selected in response to DOE's Oil Exploration and Production solicitation DE-PS26-04NT15480, Microhole Technology Initiative, August 2, 2004.

Publications

Project results have been presented by the project performer at PTTC Microhole Integration Meetings held at the Houston Research Center on August 17, 2005, November 16, 2005, and March 22, 2006.

Project Start: February 7, 2005
Project End: June 30, 2007

Anticipated DOE Contribution: $759,668
Performer Contribution: $200,000 (26 percent of total)

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