PROGRAM facts

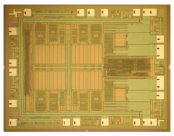
U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Strategic Center for Natural Gas & Oil

3/2006

DEEP TREK PROGRAM–EXTREME TOOLS FOR EXTREME ENVIRONMENTS

High Temperature Electronic Components — Oklahoma State University and Honeywell International each are developing high temperature electronic components that can be used for instrumentation in deep gas drilling and logging systems. Many current electronic components cannot withstand high temperature (HT) environments, and are therefore unable to provide the building blocks needed by downhole tools to drill HT/HP (high pressure) wells and characterize potential deep reservoirs. For their project, Honeywell formed a Joint Industry Partnership (JIP) to help direct the project and ensure that it addresses the most relevant set of system specifications and functionality required by the industry. Of more than 24 components identified by the JIP, only the top four components fit within the project's budget. These components will utilize silicon-on-insulator (SOI) technology and include an industry-first non-volatile HT programmable memory (EEPROM), a volatile field programmable gate array (FPGA), a precision operation amplifier, and an 18-bit sigma-delta analog to digital converter. The precision operation amplifier was distributed to JIP members in June 2005 and has been tested at 300 °C for more than 1,000 hours. Oklahoma State University recently began their project to build a Downhole Microcomputer System (DMS) that will operate at 275 °C. This particular component will utilize silica-on-sapphire (SOS) technology and is built around a 68HC11 microcontroller that will have an external RAM and ROM. For more information on their respective projects, contact Bruce Ohme at Honeywell at 763-954-2189 or by e-mail at bruce.ohme@honeywell.com, or Dr. Chris Hutchens at Oklahoma State University at 405-744-5168 or by e-mail hutchen@okstate.edu.


Op Amp


A-to-D Converter

FPGA

High-Temperature Turbine Generator - Dexter Magnetic Technologies, Inc. is developing a downhole high-temperature turbine generator (HTTG) capable of operating at high pressures (>20,000 psi) and high temperatures (≥250 °C), to power equipment such as rotary steerable tools, MWD and LWD tools, and other components both currently commercial and those under development. Today, the primary electrical power source for LWD, MWD and other downhole electronics is lithium-ion batteries (LIBs). However, current state-of-the-art LIBs are not suitable for hotter environments. Even if batteries were developed for elevated temperatures, they would still be very expensive and not reusable. The only possible solution to power intelligent downhole tools is a new HPHT power source. The advanced HTTG will have a significant impact on the cost of recovering gas from deep, hot wells. The HTTG will provide reduced dollar-per-amp-hour costs, an important benefit for reducing drilling costs and making the deep reservoirs cited in the Deep Trek initiative commercially viable. Without a suitable HTTG, it will be impossible to use other intelligent drilling tools in HPHT wells. Dexter is currently performing a feasibility study of the HTTG and developing a set of specifications. For more information, contact Timothy F. Price at 847-956-1140 x3500 or by e-mail at tprice@dextermag.com.

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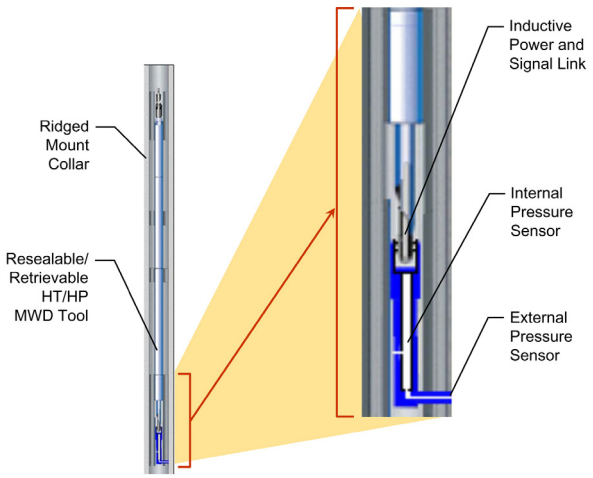
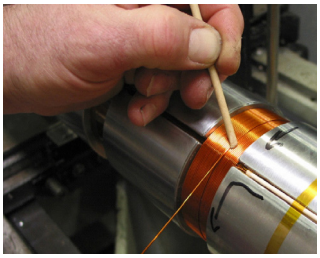


Schematic of Proposed HT/HP MWD

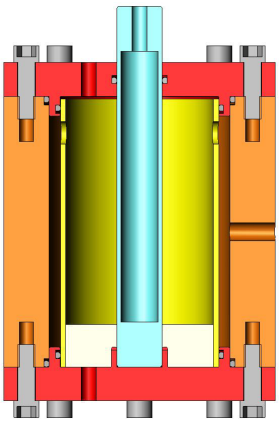
High Temperature/High Pressure Measurement While Drilling — Schlumberger Technology Corporation is developing a retrievable and reseatable HT/HP measurement while drilling (MWD) tool. The MWD tool will be able to provide real-time continuous inclination, vibration detection, annular pressure, and gamma ray detection. These capabilities are critical to increasing rate of penetration and reducing overall well costs in deep natural gas wells. An MWD tool like this will also allow well operators to detect high pressure gas zones earlier, allowing greater optimization of fluid balance, as well as improving safety. Schlumberger is currently analyzing temperature performance of analog/digital electronic components and testing failure pressure of other off-the-shelf electronics, packaging, materials, and pressure housings. Commercial sources for a magnetometer are being pursued as well. This tool will also integrate the HT silicon-on-insulator components being developed under the Honeywell Deep Trek/Joint Industry Partnership project. A prototype of the new tool is under construction and field tests are planned for spring 2006. For more information, contact James Mayes at 281-285-7631 or by e-mail at jmayes@slb.com.



Winding MR magnet coil on damper

Torsional bearing with ball bearings in place

Drilling Vibration and Monitoring Control System — APS Technology, Inc. is developing a unique system to monitor and control drilling vibration. This system has two primary elements: 1) an active vibration damper (AVD) to minimize harmful vibrations, whose hardness is continuously adjusted, and 2) a real-time system to monitor 3-axis drillstring vibration and related parameters, including temperature, and weight- and torque-on-bit. This monitor will determine the local vibration environment and adjust the vibration damper component accordingly via advanced spring and magnetorheological fluid technologies. The system offers the first approach that will monitor downhole vibration and act to reduce it in an autonomous closed-loop system without intervention from the surface, thereby reducing the time needed to drill a well and improving the economics of deep well drilling. By keeping the bit in constant contact with the well bottom, and maintaining the actual weight applied to the bit at an optimum level, the instantaneous rate-of-penetration is increased. Additionally, by reducing the levels of vibration throughout the bottomhole assembly, the operating life of all downhole components (bits, motors, MWD systems, etc.) is increased. These advantages will apply in all wells, but their value increases significantly in deep drilling. APS has tested a retrofitted laboratory prototype in a drilling laboratory with successful results. In comparison to the baseline drills, there was a visible reduction in vibration of the drill rig and WOB was maintained with the AVD in line. APS is currently manufacturing pre-commercial prototype systems to be tested in shallow wells. Additional pre-commercial prototypes will be built and undergo extensive field testing in deeper, high temperature wells in early 2007. For more information, contact Martin E. Cobern at 860-613-4450 or by e-mail at mcobern@aps-tech.com.



Annular Seal Model Testing Apparatus

Development of HT/HP Cement — CSI Technologies, LLC is developing cement capable of sealing the annuli of deep, hot wells. Conducted over three phases, CSI is systematically testing, analyzing, and modeling Portland and non-Portland cement systems, as well as non-cement binding materials (Phase I) for field testing (Phase II and III) and eventual commercialization. Phase I identified 10 Portland and non-Portland system formulas for further investigation. The supercement will possess superior pipe and formation-bonding capabilities to ensure a tight annular seal at depths exceeding 16,000 feet. It will have the tensile strength, permeability, compressive strength, and expansive properties required for long-term durability. The supercement will improve well economics by minimizing the potential for costly mechanical failures and remedial work at temperatures exceeding 350 °F and pressures exceeding 15,000 psi. CSI personnel are currently building a novel high temperature test apparatus to evaluate tensile strength, expansion, as well as the annular sealing capacity of the formulas utilized in Phase II. For more information, contact Fred Sabins at 281-784-7902 or by e-mail at fsabins@csi-tech.net.

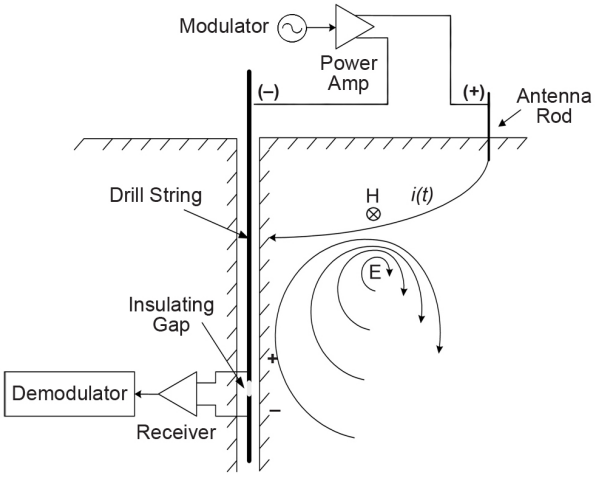
Deep Drilling Performance Optimization and Benchmark Testing of Advanced Diamond Product Bits and HP/HT Fluids —Working with recognized leaders in the engineering, design and operation of deep drilling projects, TerraTek, Inc. is leading a project in proof-of-concept testing of new drilling components to increase the rate-of-penetration while drilling deep wells at high borehole pressures and temperatures. This project will cover three phases. Phase I work was recently completed and involved benchmarking diamond product drill bits, fluids, and concepts for deep drilling performance at TerraTek's Drilling and Completions Laboratory. Borehole pressures for these tests were 10,000 psi, an industry first for a borehole simulator. Phase I data will be utilized in Phase II, providing a basis for design improvements for bits and fluids, which will be tested in a similar test matrix scenario as used in Phase I. Phase III activities involve actual field testing followed by commercialization of these new smart deep drilling bit-fluid concepts. Utilization of this improved technology by the industry has the potential to increase the rate-of-penetration, which can significantly reduce drilling costs and improve the economics of drilling for deep gas reserves. For more information, contact Arnis Judzis at 801-584-2483 or by e-mail at judzis@terratek.com.

TerraTek Rig Tower

Example Bottomhole Pattern

Diamond Product Bits

Electromagnetic Telemetry Tool for Deep Well Drilling Applications — E-Spectrum Technologies, Inc. is developing a wireless, ultra-low frequency electromagnetic (ULF-EM) based telemetry system to improve deep well drilling. This telemetry system will facilitate measurement-while-drilling operations within a high temperature, deep drilling environment. Design activities include developing and testing a new high efficiency power amplifier and advanced signal processing algorithms. The tool will communicate real-time information gathered near the bit, enabling an enhanced rate-of-penetration, and reducing overall well costs in deep natural gas wells. Testing in the Barnett Shale demonstrated a successful uplink/recovery with less than 1.7 W transmission powers using the data fusion receiver at the surface. The data fusion receiver successfully recovered over 90percent of these low-power uplinks in the presence of strong interference. This test was conducted over ten days at a well depth of > 9,000 ft MD (~ 7,000 ft TVD). For more information, contact Jeffery Gablemann at 210-696-8848 or by e-mail at jgablemann@espectech.com.



Schematic of a EM Telemetry Tool

Gamma Detector for Harsh-Environment — General Electric (GE) Global Research Center is developing a revolutionary solid-state gamma-ray detector suitable for use in harsh drilling environments. Gamma detection is used to identify possible petroleum bearing formations in downhole gas and oil exploration. Currently, the industry is using scintillation crystal technology, which produces optical photons when excited by a gamma ray, and a photomultiplier tube (PMT). The PMT technology can support useful detector lifetimes in the area of 1,000 hours at 150 °C, but only 100 to 200 hours at 175 °C. The new detector will have a system temperature operating capability of 225 °C and a reliability of 1,000 hours at 200 °C. The GE team is fabricating and characterizing the essential elements of an advanced scintillation detector system using Avalanche Photodiodes (APD) fabricated from silicon carbide. The new detector will offer two main

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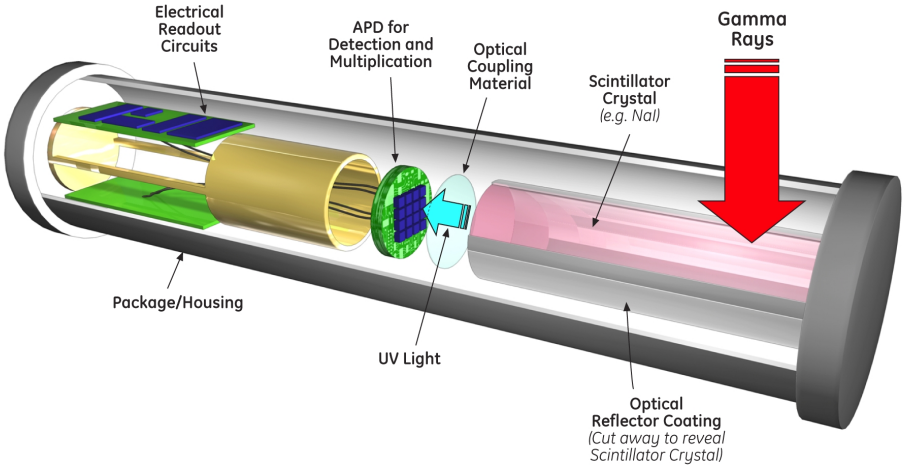
From the sidebar at left, select "Technologies," and then "Oil & Natural Gas Supplies." Under "Key Links," select "Deep Trek."

advantages over current detectors. First, it will be able to operate at higher temperatures, which will allow for deeper drilling and exploration. Second, because the solid-state photodetector has a higher immunity to shock and vibration, it will have a longer life downhole. Both of these advantages will help to reduce the risk and costs for deep drilling. For more information, contact Peter Sandvik at 518-387-4166 or by e-mail at sandvik@research.ge.com.



Ultra Deep Drilling Lab — NETL researchers are developing a laboratory dedicated to the study of effective and efficient drilling and production of hydrocarbons at great depths (>20,000 feet), high pressure (>20 ksi), and high temperature (>250 °C). The initial project is the construction of an Ultra-deep Drilling Simulator (UDS) by TerraTek that will enable study of the interactions of fluids, cutters, and rock at HP/HT via physical simulation. Concurrently with the physical simulation efforts, numerical modeling will be done to back analyze physical data and help develop better predictive models and a more complete understanding of fundamental rock mechanic phenomena present in HP/HT drilling environments. Long term objectives are to establish a HP/HT drilling lab where the interactions between drilling mud, rock and drilling devices can be investigated, develop robust and accurate drilling models (computer simulations) utilizing physical data, and develop expertise that will facilitate deep HP/HT rock mechanics modeling applicable to drilling in deep HP/HT environments. For more information, contact Dave Lyons at 304-285-4379 or kdavid.lyons@netl.doe.gov.