Directional drilling: Improving efficiency and control

IADC/SPE 59194

At-Bit Inclination Measurements Improve Directional Drilling Efficiency and Control

A system has been developed that provides inclination measurements 1 ft behind the bit, utilizing a single-axis inclinometer and electronics mounted inside the driveshaft of a positive displacement motor. Inclination measurements are continuously transmitted to the measurement-while-drilling (MWD) receiver using inductive telemetry during both steering and rotary drilling operations. The MWD system then transmits inclination data to surface using mud pulse telemetry.

Benefits include improved openhole sidetrack performance, increased gross rate of penetration, accurate landing of horizontal wells, reduced stuck pipe risk and fewer problems running casing and completion strings. Well tortuosity is minimized, reducing drillstring torque.

—T Skillingstad, Schlumberger Oilfield Services

IADC/SPE 59195

Directional Drilling of Geothermal Wells in Hard Rock Formation

A new Norwegian law demands that 30% of the energy for Norway's official buildings obtained from alternate sources in the near future. From the drilling technology point of view, ideas were voiced to do a first step in this direction and obtain geothermal energy to heat a new hospital in Oslo. A clear disadvantage was the large depth where the heat can be found—more than 4,000 m—and the hard formation (granite). Another challenge was to obtain a circulation loop and consequently the connection of the 2 wells required (one vertical, the other directionally drilled into the first one). Conventional directional drilling systems could only achieve low ROP and, as a consequence, total project costs were very high.

Hence, a creative type of drilling system was developed which includes a fluid hammer, a downhole motor, a thruster and a steerable Coiled Tubing system. The mining-industry-proven fluid hammer generates high frequency impact forces. The downhole motor creates the required torque and the thruster decouples the high frequency shocks and vibration from the sensitive electronics within the electronic-hydraulic orienting tool of the Coiled Tubing System. The functionality of the entire system was proven and ROP was increased 5 times in comparison with offset data during a field test in Stavanger in November 1998.

—U Hahne and M Reich, Baker Hughes INTEQ GmbH

IADC/SPE 59196

The Directional Difficulty Index: A New Approach to Performance Benchmarking

This paper puts forward a simple methodology—the Directional Difficulty Index, which provides a first-pass evaluation of a wells relative difficulty. While accepting that there are various approaches to tackle the problem, it was found that the employment of a straightforward questionnaire, with sufficient distribution, could be developed to reach consensus on what the key measures were. This Directional Difficulty Indexcan be used to group wells of similar characteristics and complexity.

The key value drivers of quality, service and time can then be examined on a "like for like" basis. Key principles of performance measurement are addressed: a balanced approach, focussed on value drivers, adding value, demonstrating "organisational learning", linking planning and strategy and service company performance.

—A W Oag and M Williams, Schlumberger Oilfield Services

IADC/SPE 59197

Deepwater Subsalt Development: Directional Drilling Challenges and Solutions

The "Gemini" Deepwater Development is located in 3,400 ft of water in Mississippi Canyon Block 292, approximately 90 miles southeast of New Orleans in the Gulf of Mexico. To achieve the desired horizontal displacement for development of the subsalt reservoirs, the 2 development wells required kicking off at as shallow a depth as possible, necessitating:

• Kicking off the well in large diameter hole, riserless;

• Controlling wellbore trajectory by holding then dropping angle through more than 3,000 ft of salt;

• Executing whipstock sidetracks to revised bottom hole targets after initial geological evaluation.

Success was achieved through detailed planning from a directorial drilling aspect taking into consideration the geological, engineering and economic requirements and novel application of technology.

—J Cromb III, Texaco Exploration and Production Inc, *et al*

IADC/SPE 59198

A New Borehole Surveying Technique for Horizontal Drilling Processes Using One Fiber Optic Gyroscope and Three Accelerometers

The fiber optic gyroscope (FOG) currently employed in different navigation applications can be adapted for borehole surveying. Previous feasibility study showed that the FOG has immunity to the severe downhole environment existing downhole. The objective of this article is to develop a new navigation algorithm utilizing the FOG mounted on the horizontal plane of the borehole assembly together with three orthogonal accelerometers. The mechanization equations necessary to process the measurements from the FOG and the three accelerometers and deliver the drill bit attitude (azimuth, pitch and roll) as well as its coordinates (latitude, longitude and depth) are provided. In addition, adaptive Kalman filter techniques are presented to compensate for the measurement errors from both the FOG and the accelerometers and for the computational errors due to some simplifications made to the algorithm.

—A M Noureldin
University of Calgary, et al

IADC/SPE 59199

Square Motor Used to Reduce Drag While Maximizing Penetration Rates

Extended power section motors have been used, together with low-viscosity muds, to dramatically increase instantaneous penetration rates in tectonically stressed areas of Western Canada. However, these penetration rate increases have been accompanied by doglegs induced by steep formation dips and faulting. Steering, required to remain on course, induces further doglegs. The result of such a tortuous wellpath has been high drag. To reduce this drag, motor drilled holes have been reamed on time consuming, dedicated trips made with square drill collars.

A square motor has been developed to combine the penetration rate benefits of extended power section mud motors with the stiffness characteristics of a square drill collar. The square motor has been used in the drilling of wells in a number of tectonically stressed fields, and has demonstrated: instantaneous penetration rates equal to those obtainable with conventional (round) motors, reliable directional characteristics, significant reduction in drag when tangent sections are drilled with square motors rather than steered with directional motors and elimination of reaming time through square motor drilled interval.

—R S Moore, R T Barnett and T R Smith, Shell Canada Ltd

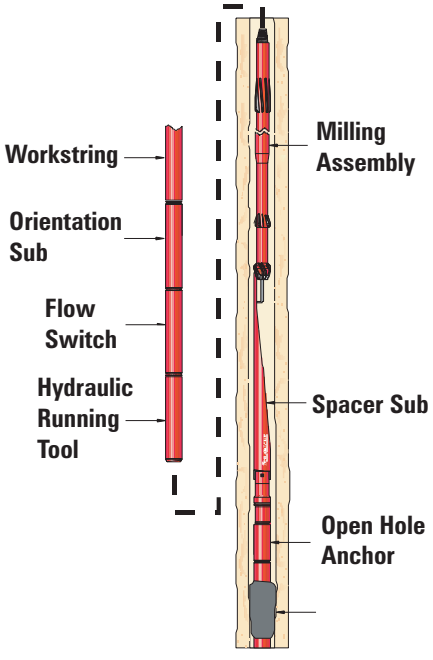
IADC/SPE 59200 (ALTERNATE)

Gravity Azimuth: A New Technique to Determine your Well Path

This paper describes the use of a new and novel technique that uses the earth's gravitational field to determine the direction of a well. Direction from gravity may normally not be considered technically possible. However, measuring the difference in the spatial position between 2 sets of accelerometers 30 m apart provides the change in azimuth over this interval. These changes accumulate to show the well path trajectory.

The use of this gravity azimuth technique may help solve the problems associated with magnetic interference on magnetic survey instruments. The wider application of this technology into areas with localized magnetic interference, like drilling out of casing windows, multiwell avoidance and multilaterals becomes evident.

—G A McElhinney,
Pathfinder Energy Services, *et al*



IADC/SPE 59201: Design of this open hole retrievable sidetracking system centered on anchoring and retrieving in the open hole, while maintaining integrity through the drilling process.

IADC/SPE 59201 (ALTERNATE)

Development of an Open Hole Retrievable Sidetracking System

Sidetracking in an open hole environment has been used for many years with great success, using time drilling techniques, cement plugs, and permanent whipstocks. However, problems have been identified in certain applications that warrant alternative sidetracking methods or techniques. For example, when time drilling, harder formations can prevent the lateral hole from being initiated, and softer formations allow ghost holes to develop. Each condition is time consuming and costly.

To address these problems, an open hole retrievable sidetracking system was developed and tested. Design considerations revolved around anchoring and retrieving in the open hole, while maintaining integrity through the drilling process.

—R A .Seale, Smith Drilling & Completions
–C O Stokeley, Tam International