New tools bring higher efficiency and production improvements

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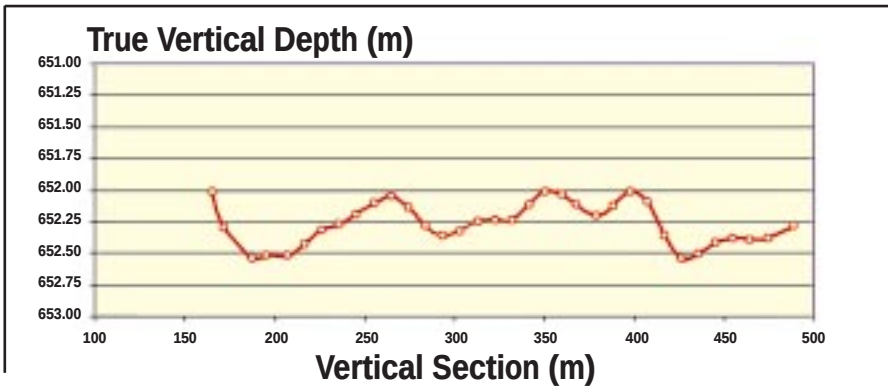
AS THE EFFORT to produce smaller and smaller pockets of oil at remote distances from existing infrastructures intensifies, the challenge for drilling teams has never been tougher. In today's market it is important to land a well in the right place and keep it there for as long as required for maximum production capability, which may involve following the formation trends. New tools are turning what was once only a dream into reality.

GAUGING INCLINATION AT BIT

New-generation at-bit inclination measurements give the driller real-time continuous inclination a few inches behind the bit. Combined with continuous measurement-while-drilling (MWD) surveys, these new measurements take the guesswork out of well placement. Once the well is landed, it is then possible to drill a wellbore within a very tight vertical tolerance with minimum undulations or geosteer when other logging-while-drilling (LWD) tools are added in the drill string. In the example demonstrated in Figure 1, an operator in West Africa required maximum true vertical depth (TVD) fluctuation be kept within ±1 m of a targeted TVD to control water coning. Using the at-bit inclination measurements, the well was kept to a ±0.30-m tolerance through the planned 350-m horizontal trajectory.

In another example from the same region, a client achieved a TVD tolerance of 0.26 m in a very marginal reservoir with water drive and dip close to zero. At-bit inclination measurements were used with other LWD measurements to geologically steer with precision geometric placement. Using these measurements, well azimuth was adjusted while drilling to follow a trajectory through the optimum porosity section of the formation. The porosity of the formation along the drilled wellpath was greater than that in the plan.

Openhole sidetracking in highly competent formations is a difficult operation, and chances of success grow slimmer with increases in formation strength. With new technology, this procedure has become much more predictable. In North America, rig time was saved by using the at-bit inclination system to perform an openhole sidetrack to adjust well trajectory when a client encountered geological uncertainty. Inclination data available less than 1 ft from the bit showed that despite careful procedures, the drillstring had deviated back into the old hole twice in the first 4 ft of the attempted sidetrack. Using early indications of progress from the at-bit system, the sidetrack was completed in 39 ft, and the rig quickly returned to rotary mode for faster drilling. Normally this decision would have been delayed until the MWD string, located 50 ft behind the bit, had confirmed the assembly was in a new hole.



Marginal plays demand increasingly tight downhole tolerances: The decreasing size of typical hydrocarbon plays demands tight drilling tolerances. For the well reflected in Figure 1 above, the operator required that TVD fluctuation be within a 1 m tolerance to control water coning. Using at-bit inclination measurements, the drilling team kept that variance to just 0.3 m throughout the 350-m section.

Other operators have shown that accumulations of water in undulations act as downhole chokes, restricting flow and production. This is especially true in a three-phase (oil, gas and water) reservoir. The use of at-bit inclination technology can minimize these chokes.

STEERABLE MOTORS

Mud motors are quietly evolving to offer more power under more difficult conditions. A new series of motors that can apply 30% more power to the bit than the previous industry leader was introduced recently in North America. These new motors are designed to improve performance in wells where power to the bit is all important. More available power has become increasingly critical to drive aggressive new PDC bits favored by operators to improve penetration rates.

The real value of these new motors can be seen when comparing 2 opposing laterals deep in the Louisiana chalk. The first well took 31 days from kickoff to total depth (TD). The 3,895 ft of lateral took 3 bottomhole assemblies (BHAs) and 324 total on-bottom drilling hours. Average rate of penetration (ROP) while rotating was 13.4 ft/hr. The opposing lateral was drilled from the same pad a few months later using the new motors. This well was drilled from kickoff to TD in only 12 days. The 3,116 ft of lateral was drilled in 2 BHAs with an average rotating ROP of 51.2 ft/hr. This equated to an improvement of nearly 400%, with on-bottom drilling time of nearly 200 hr for a 3,100-ft lateral.

POWER STEERING

The application of power to effective destruction of rock is also crucial. New generations of drill bits are pushing the envelope by delivering solutions to demanding directional drilling operations. Directional drilling problems have always revolved around issues such as build and turn rates, torque fluctuations and control and BHA design. A new design concept evolved through an in-depth study of bit lengths, cutter components, gauge designs and directional database. The quest to improve directional control by reducing torque has also led to innovative cutter designs that feature chamfered geometry, high back-rake angles and improved impact resistance. The culmination of these efforts to create purposeful and focused change in drilling optimization is the development of new bit technology. The design incorporates antiwhirl technology and features that solve many of the standard bit problems.

In Holland, the 12 ¼-in. version of this new bit drilled 922 ft in 64.7 hr. Apart from delivering superior rates of penetration, it replaced three insert bits and was directionally friendly enough to build angle from 29° to 45° while turning from 326° to 334°. This was in a formation where steering was previously possible only with rock bits. Drilling hours and cost per foot improved by 49% and 37%, respectively.

In a well in Nigeria, using this bit significantly improved MWD signal/noise ratios, making LWD activities possible while drilling the abrasive sands of the Niger Delta. Previous PDC bits used in this reservoir produced significant torque fluctuations that decreased steerability, inhibited directional control and increased motor pulsation noise.

ROTARY STEERABLE SYSTEMS

As existing fields are depleted drillers are challenged to reach farther and farther into the basin structure. Extended-reach drilling is rapidly coming of age. The horizontal displacement world record now stands at 10.1 km for **BP** Wytch Farm Well M-11. This extreme reach allowed drainage of new reservoir sections, but brought significant challenges for steering and control. The well was planned using the latest software and integrating all the experience gained on offset wells. Armed with the latest in technology, new rotary steerable systems have made it possible for the operator to push the limits beyond what was thought possible just a few years ago.

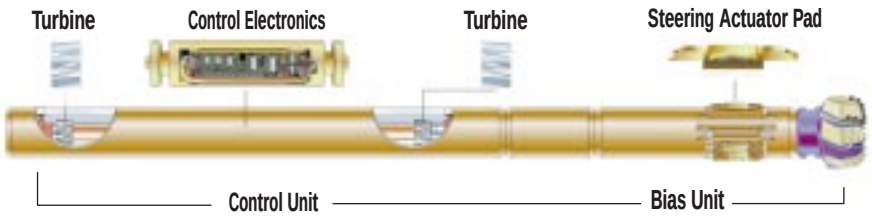


Figure 2: Details of the control module and steering actuation system for a rotary steerable system.

The system used to drill the final reservoir section of Well M-11 is shown in Fig. 2. The continuous rotation and directional control provided by this rotary steerable system allowed the driller to overcome extended-reach drilling problems associated with torque, drag and cuttings transport to reach beyond what would have been possible with a conventional assembly. Efficiency gains were equally impressive. A total of 7,681 ft of horizontal hole was drilled in 44 days, quite an improvement over the plan of 5,548 ft in 49 days. This savings was achieved largely by eliminating BHA sliding that normally would have been required to steer. New wells are expected to break the 10.1-km record.

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