Rotary steerable technology driving ambitious well designs, need for ever-higher ROPs

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IN THE MID-1990S, rotary steerable drilling systems emerged and promised to revolutionize directional drilling. Initially it was thought that they would simply improve gross rate of penetration (ROP) in certain wells by changing the directional drilling process. It soon became apparent, however, that these systems could reliably steer wells to inaccessible parts of the reservoir and position those wells with unprecedented accuracy in the most productive zones, thereby increasing recoverable reserves. Today, such is the confidence in the capabilities of these systems: whole field developments around the world are planned around and completely rely on them. It is therefore no exaggeration to state that, over the past 10 years, the value that rotary steerable drilling has delivered runs into the many tens of billions of dollars (SPE/IADC 87168).

PUSHING THE ENVELOPE

As is our industry's norm, boundaries are continually tested to drive improvement. In the case of rotary steerable drilling, boundaries include parameters such as ROP, the lateral reach a well can attain to a distant target, or the limits of geometric complexity a well can be drilled to produce from an otherwise inaccessible pocket of reserve. As a result, well designs became more ambitious while increasing the accuracy of wellbore placement, and the drive for further efficiency gains pushed the need for yet higher ROP. Simultaneously, advanced logging while drilling (LWD) services were introduced, allowing fuller real-time subsurface descriptions, enhancing geosteering capabilities for even more effective wellbore placement.

LESSONS LEARNED

To attain reasonable ROP from a rotary steerable system, it is normally necessary to rotate the drillstring from surface at continuously high rotary speeds. It is common practice when using these systems to maintain surface rotary speed in the range of 120 rpm to 190 rpm. Continuously rotating the drillstring at this rate increases drillstring and casing wear. Experience shows that it is not uncommon during rotary steerable drilling to incur a higher frequency of drillstring washouts than previously seen, and reduced drillpipe life through OD wear has been noted. It is also wise to model and monitor casing wear when rotary steerables are to be used – especially when re-entering old wells where the casing is already worn from prior drilling activity and may be corroded to some extent.

Another challenge posed by the need to rotate at high surface rotary speeds is that it is sometimes not easily achievable. Increased use of less lubricious water-based drilling fluids in extended-reach or complex 3D well trajectories pushes drilling torque higher. At a certain point, the rig top drive has to be set to low gear, limiting maximum surface rotary speed below that desired for optimum ROP. This can limit the reach of a well – defining the drilling reach envelope and ultimately negatively affecting field recovery.

MOTOR-POWERED ROTARY STEERABLE SYSTEMS

The concept of driving the rotary steerable device with a downhole drilling motor is not a new idea to address the above mentioned challenges. Some major service providers have tried this from an early stage of their introduction in the mid- to late 1990s.

Initial results indicated that improvements in many areas could be achieved, but rotary steerable systems at the time were not well-suited to running in this manner. One limiting factor was the total rotary speed specification of the rotary steerable device, which reduced reliability. Most rotary steerable systems are specified up to approximately 250 rpm rotary speed.

When operating below a drilling motor, the total speed seen by the device is the sum of surface rotary speed and the additional rotary speed supplied by the downhole motor. This total rotary speed often proved to be too high for the rotary steerable device – especially when a certain drillstring rotary speed was desirable to maintain effective hole cleaning. A second limitation was lack of communication with the rotary steerable device through the downhole motor, which effectively meant drilling "blind" with respect to steering system behaviour.

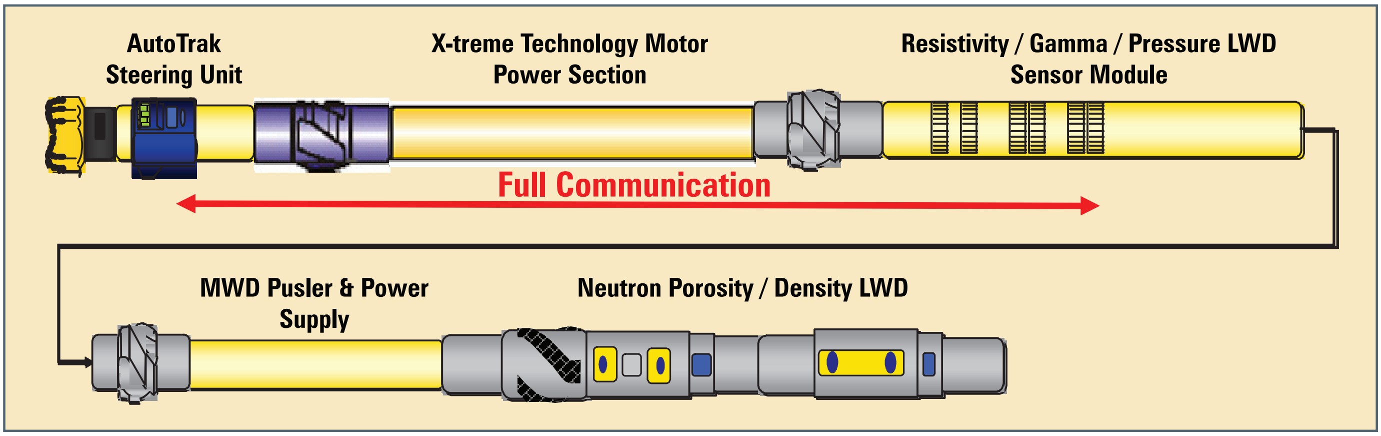

FIGURE 1: Full communication with the steering system is achieved by hard-wiring the high-powered drilling motor integrated into the rotary steerable system BHA.

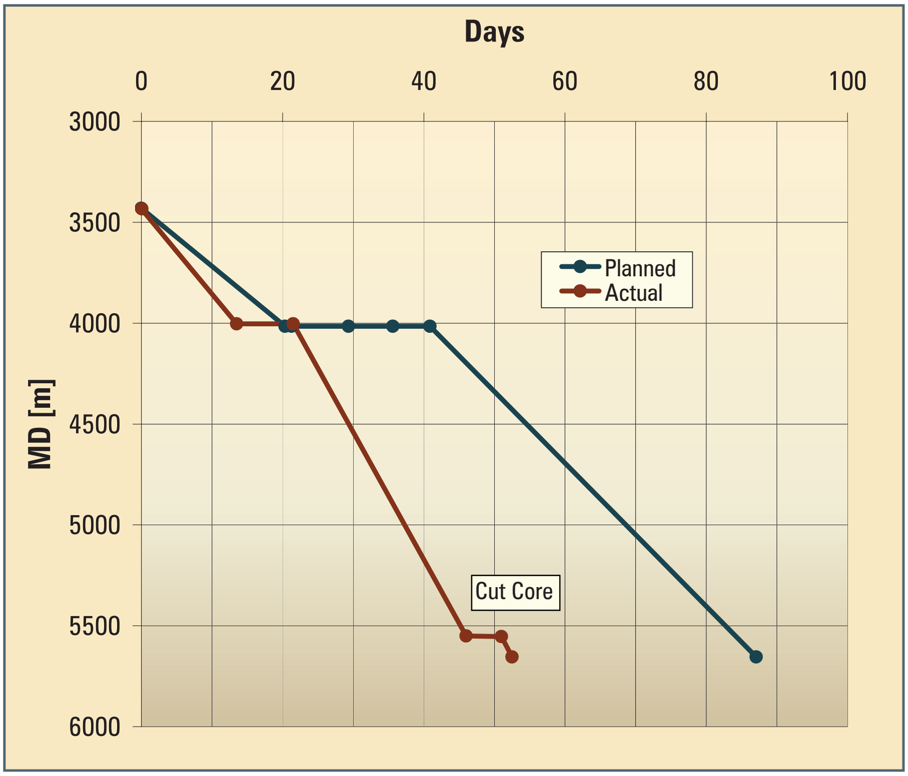

Figure 2: Using AutoTrak X-treme systems in 8½-in. and 6-in. hole sections, over 28 drilling days were saved on a horizontal well through hard rock onshore Italy.

This significantly deteriorates wellbore positioning control far below what was required for the well's optimum production performance.

A NEW SYSTEM

INTEQ's AutoTrak G3.0 Rotary Closed Loop Systems were designed with a modular architecture to allow BHA versatility and to have a significantly higher rotary speed specification (up to 400 rpm vs industry standard specification of about 250 rpm). These basic design criteria were specifically defined to allow future development of a motor-driven version of the system.

In 2003, design work began on the modular motor. The concept was to integrate a high-performance motor into the AutoTrak G3.0 BHA. This new system would be called AutoTrak X-treme. From the outset, it was determined that full communication with the steering unit was critical to maintain continuous real-time near bit inclination and steering unit diagnostics data. To achieve this, the modular motor features a unique hard-wired communication along its length. By allowing complete real-time information from the system's steering unit, the precise wellbore positioning capabilities of the rotary steerable system are maintained. Without this, wells cannot be positioned with the required accuracy, which reduces production, well life and overall field recovery. Figure 1 shows a schematic of the new system.

Following extensive testing, the first deployment of the AutoTrak X-treme system was made in February 2004 to an ERD horizontal well offshore Denmark. The results were outstanding in terms of increasing the reach of the well far past the existing envelope and increasing ROP. From that beginning, the system was further refined and formally launched in April 2006.

PROVEN RESULTS

As experience with the new system grew, the advantages of drilling in this manner gained rapid acceptance. Similar to the introduction of the early rotary steerable systems, the initial, most visible and easily quantifiable improvement was seen as pure ROP gains. However, in the same way that the real value of rotary steerable drilling is dominated by what it enables in terms of new well designs and positioning wells more precisely in the reservoir, so too the real value of the new motor-powered systems is dominated by pushing the boundaries further still. These systems have now been used extensively in a wide range of applications around the world. Examples include:

- Reducing casing wear in complex multilateral wells offshore India while simultaneously positioning wells precisely in the reservoir to reduce coning and improve field recovery factor (SPE/IADC 104623);

- Increasing the reach of horizontal wells offshore Denmark past prior limits to increase production and optimize field development (SPE/IADC 91810);

- Allowing economic access to trapped reserves in mature UK Central North Sea fields, extending their productive life (SPE/IADC 98471);

- Cutting the operational risks associated with slimhole rotary steerable drilling in Saudi Arabia (SPE/IADC 97422);

- Dramatically improving ROP in hard rock horizontal wells drilled onshore Southern Italy (see Figure 2); and

- Reducing the risk of drillpipe fatigue in highly complex multilateral wells through a thin reservoir offshore Norway (see Figure 3).

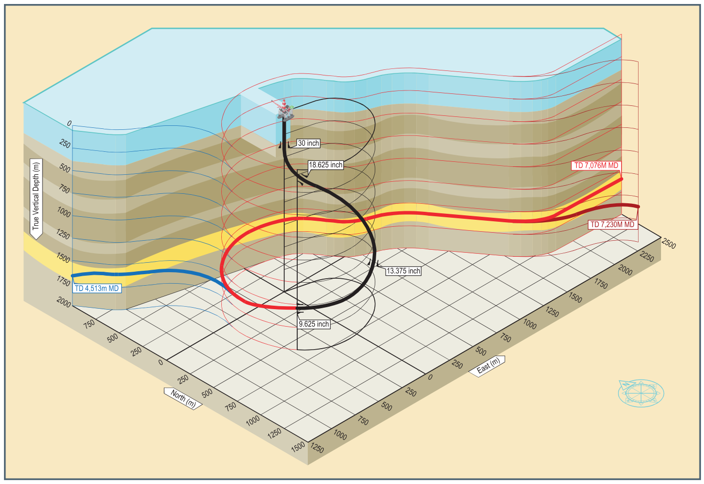

Figure 3: Motor-powered rotary steerable drilling reduces operational risks associated with drilling complex well trajectories and simultaneously improves drilling performance.

LOOKING AHEAD

By December 2006, over 1 million ft (350,000 m) of hole had been drilled with the system.

An example of a well drilled using the new system is shown in Figure 3. This complex North Sea well utilized the system to improve ROP through calcite cemented sands. Simultaneously the risks of drillstring fatigue resulting from rotary steerable drilling the complex, extended-reach, multilateral profile was reduced and, as a direct result of full communication with the steering unit, the well was positioned precisely in the optimum zone, just 0.5 m above the oil-water contact.

Irrespective of the business cycle, the need for reserves replacement will gain ever-higher priority. As understanding of reservoir behaviour grows, it is anticipated that an increasing number of fields will be developed using more demanding well trajectories. Simultaneously, the drive to improve drilling performance will continue on all operations. As a result, it is anticipated that demand for integrated, motor-driven rotary steerable systems will increase — testing the new boundaries and moving them to new levels of performance.