Rotary steerable drilling technology matures

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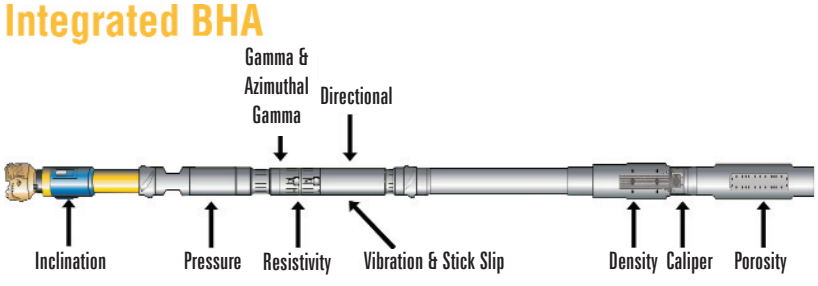
JUST FIVE SHORT years ago, rotary steerable drilling systems were considered an exotic new technology, commanding what some considered exorbitant daily costs, showing poor reliability and unproven value. For these reasons, the systems were used only on selected projects where benefits from application of the technology were very clear. Additionally, there were only very limited numbers of these tools available and their use was almost exclusively reserved for projects in high cost, high activity areas with short supply chains (e.g., North Sea and Gulf of Mexico).



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That was five years ago. Today, the picture is much different. The technology has matured with a wide range of benefits accepted by the industry, value proven and tremendous improvements seen in reliability. Rotary steerable drilling systems are now used the world over with an estimated 7 million feet to be drilled using them this year alone and growing by approximately 50% per year.

TECHNOLOGY OVERVIEW

Conventional directional drilling techniques require the use of bent housing downhole motors to be oriented in the borehole and "slid" along the borehole without rotation of the drillstring to achieve a change in the well's trajectory. Periods of this "slide" drilling are interspersed with periods of rotary drilling to achieve the desired three-dimensional wellbore trajectory.

Rotary steerable drilling is, as its name suggests, technology that enables full three-dimensional directional drilling control to be performed while drilling with continuous drillstring rotation from surface. No "slide" drilling is necessary. This capability requires a special BHA component above the bit to direct the wellpath in the desired direction, maintaining the orientation of the drilling trajectory independent of the rotation of the BHA and drillpipe above it. This component is the rotary steering device.

How the different available rotary steering devices accomplish their task varies from relatively simple gravity-based orientation systems to more sophisticated flexure of internal driveshafts or flexure of the lower portion of the BHA by application of forces from pads against the borehole wall. Some systems also employ automatic drilling modes where the wellbore is automatically steered using closed loop control systems programmed in the downhole tool. These systems (such as the AutoTrak® Rotary Closed Loop System) deliver significant benefits in wellbore placement and overall wellbore quality compared to non-automated systems.

In addition to differences in the mechanisms, which these systems use to physically steer the well, there are also differences in the manner in which systems are communicated with from surface and also the level of integration with the MWD and LWD systems employed in the BHA.

Efficient communication from surface results in significant time savings and a higher level of integration with MWD/LWD systems allows positioning of LWD sensors close to the bit while simultaneously minimizing BHA length and increasing reliability.

Each different system has its own merits with regards to drilling efficiency, predictability of directional control, precision of wellbore placement, physical hole quality and cost effectiveness on a particular application. It is important to recognize that while there is a natural desire to commoditize this technology and not recognize the significance of the differences between the available systems, these differences are fundamentally critical to the cost effectiveness on any particular project.

THE ADVANTAGES

Eliminating the need to drill without drillstring rotation using bent housing motors to achieve directional drilling control has some immediately obvious benefits. These include significant time saving through ROP improvements, continuous effective hole cleaning and drilling of a hole with lower "tortuosity". Other accepted benefits include drilling of much more ambitious well trajectories (either complex 3D and/or ERD) with lower technical risk to achieving objectives. These benefits are considered "tangible" and it is quite easy to calculate a dollar value for them when establishing the cost effectiveness of applying rotary steerable technology. As experience in the use of these systems has grown, the less obvious or intangible benefits have gained acceptance and are arguably of more value than the immediately obvious benefits indicated above. These less obvious benefits include, but are not limited to, the following:

Safety When drilling with rotary steerable systems, fewer trips in and out of hole of the drillstring should be required. These systems commonly utilize fixed cutter bits where previously Tricone® bits may have been used for directional control reasons. The longer life of fixed cutter bits results in more footage per bit and thus fewer trips for bit change. In addition, continuous rotation at high rotary speeds results in very efficient hole cleaning, removing the need for many short trips. Rotary steerable systems are also much more versatile and should be able to drill all of the required section trajectories (build, drop, tangent, turn) using a single BHA design, resulting in fewer trips for "BHA

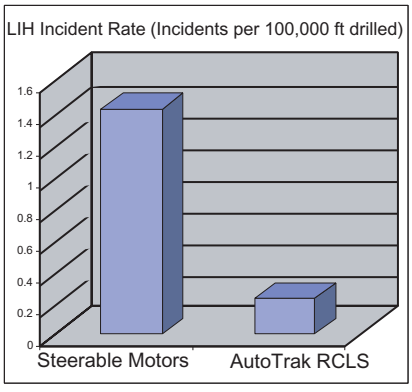
change". This benefit results in less drillfloor activity, less handling of tubulars, and, ultimately, increased safety. Reduced tripping activity can be measured by comparing the footage drilled vs. the total amount of pipe tripped over the course of a project. A study in Norway showed approximately a 50% reduction in tripping activity following the introduction of rotary steerable systems on a development.

Environmental Drilling with rotary steerable assemblies results in a more in-gauge hole than drilling with steerable motor systems. This fundamental benefit results in lower volumes of drilled cuttings waste and lower drilling fluid losses. Additionally, because the cuttings are fresher as a result of continuous hole cleaning, the cuttings are easier to clean and less drilling fluid is lost. For example in a 12¼-in. section, should the hole be drilled over gauge to an average diameter of 14-in., this represents approximately a 30% increase in cuttings waste and correspondingly 30% lower annular velocity compared to drilling the section "in gauge". Environmental impact and waste disposal costs are both reduced where in-gauge hole is drilled. Where "skip & ship" or cuttings re-injection systems are in operation, the constant stream of cuttings coupled with minimized waste volumes from use of rotary steerable systems is a recognized benefit.

Stuck Pipe Continuous pipe rotation, smoother and less "tortuous" trajectory and overall improved hole gauge quality reduce stuck pipe and lost in hole (LIH) incidents. A study comparing LIH incidents of a rotary steerable system and conventional BHA's showed the rotary steerable system LIH rate was only 15% of the conventional systems.

Production Benefits The ability to more precisely land and position wellbores within the reservoir gives an immediate production benefit. The more sophisticated rotary steerable systems, which have automated closed loop control of the steering response, are able to consistently position wells more precisely than even the very best directional driller could achieve using conventional technology. This ability to land and navigate wells precisely within the best production zones has an immediate benefit for improving the production performance of the well. A recent project in China showed how the precise deviation control attainable from INTEQ's AutoTrak System allowed multilateral wells to be drilled in exceptionally tight tolerances, increasing production by whole magnitudes.

Studies have also shown that later in a well's life, when single-phase fluid production changes to multi-phase flow, the more precisely a lateral production hole is drilled, the lower the pressure drawdown. As an example of the level of deviation control achievable, in a North Sea well, the lateral section was nearly 5,000 ft long and only deviated +/-8 inches from the desired TVD along its entire length. This would be impossible to achieve using any other drilling system.



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Reservoir Access & Drainage In areas where three-dimensional directional drilling control is troublesome, rotary steerable systems can provide a much wider range of well trajectory design options at low operational risk.

This has proved beneficial in several fields where the lack of directional drilling control had limited well designs to simple two-dimensional wells which limited reservoir access and field drainage patterns. With the introduction of rotary steerable drilling techniques to these fields, producible reserves are increased through improved reservoir access and drainage pattern.

Bit Selection It's an integral part of the D&E system. No discussion on rotary steerables can exclude the bits. It has taken time and considerable effort to establish what bit design features are required to obtain the best performance (drilling performance, steerability, dynamic stability and physical hole quality) out of each different rotary steerable system. As use of these systems started to grow, there was a belief that rotary steerable systems required very short and aggressive gauge bits to steer effectively.

These bits undoubtedly do steer very well and are useful where top end steering capability is required, but there can be, unfortunately, a price to pay. These bits can create unnecessary vibration in the BHA and can also drill a slightly imperfect hole, which may degrade some logging data sets. Research into bit design has made significant progress in this area.

It is established that there is no such thing as a generic "rotary steerable bit" design. The operating principles of different rotary steerable devices vary, and therefore, require different bit design attributes.

THE FUTURE

The considerable benefits of using rotary steerable technology have been embraced by the industry and reflected in the continuation of exponentially growing demand, irrespective of business cycle. The initially obvious benefits of using these systems has now grown to include a whole host of "less tangible" benefits, which are probably of greater real value than the tangible ones. Bit technology has grown to keep pace with the need to obtain the best performance out of each of the very different available systems. It is becoming increasingly common to tailor-design bits to push performance limits.

So, what's in store for the future? The technologically leading systems dominate the market with closed loop control and systems integration being keys to superior performance. While enhancements in functionality will continue to be introduced, the focus for the time being is on delivering ever increasing total system reliability.

Further in the future, more closed loop control will be introduced to the BHA. An example of this may be automated drilling dynamics and downhole pressure control systems to deliver the next step change in drilling performance. ■