ROTARY STEERABLE

advances push reliability, applications, performance up another level
In February 2008, when Exxon Neftegas Ltd (ENL) completed the world-record extended-reach well on Russia’s Sakhalin Island — drilled with Baker Hughes INTEQ’s AutoTrak G3.0 system — the well’s measured depth of 38,322 ft (11,680 m) stood as a testament to how far rotary steerables had come.

Once an unreliable tool that was exclusively deployed on the highest-end offshore projects, it was loved and hated at the same time — loved for its precise 3D steering capability and potential for improving drilling performance, yet hated for its limited reliability and added costs. Slowly but surely, especially in the past five years, rotary steerable technology has finally grown up.

Nowadays, everywhere there’s drilling, rotary steerables are used to increase ROP, enable complex 3D well or ERD profiles and provide precise TVD control and geosteering capabilities to meet the geological target in production zones.

“Rotary steerables bring so many benefits in terms of efficiency that many operators have run them purely for the time savings,” said Blaine Comeaux, global marketing manager for Halliburton’s Sperry Drilling Services. “We’re running rotary steerables day-in and day-out on wells that don’t require it from a directional perspective, but the tremendous benefits in efficiency far outweigh the additional costs.”

Sperry’s rotary steerable system, the Geo-Pilot, is a point-the-bit system “that takes the point-the-bit concept to the next level” by incorporating an extended-gauge FullDrift bit into the geometry that drills the curve, Mr Comeaux said. Unlike traditional short-gauge bits with a few inches of gauge, FullDrift bits used with the Geo-Pilot have extended gauges that keep the bit centered in the hole, ensuring excellent hole quality and low vibrations.

In a recent case history from the deepwater Gulf of Mexico, a major operator needed to drill a development well to investigate the lateral extent of the reservoir on the Perseus deepwater project. Good hole quality was a must so that accurate LWD and wireline data could be obtained – future drilling plans depended on this data.

Using the Geo-Pilot with a Security DBS extended-gauge PDC bit, the operator kicked off the well from vertical, built to 56º of angle and drilled the 5,734-ft interval in one run. ROP was intentionally limited to acquire high-density LWD data but still averaged 164 ft/hr. Drilling time was reduced by four days on the interval, saving an estimated $960,000. The hole quality was proven in the three back-to-back wireline runs that reached bottom in this high-angle well without any conditioning runs.

Further savings were realized by eliminating the need for pipe-conveyed logging. Once open-hole operations were completed, the casing string was immediately run to bottom successfully, a critically important success due to an approaching storm that required a complete rig evacuation.

SLIMHOLE BEGINNINGS

Weatherford’s Revolution rotary steerable system was initially designed for the slimhole market (4 ¾ in.), said Ivor Sinclair, global product line manager for rotary steerables, “because nobody really had a slimhole RSS at the time and because it’s easier to engineer upwards to bigger sizes than downwards to smaller sizes.” Weatherford now has a complete suite of RSS hole sizes up to 17 ½ in.

Like the Geo-Pilot, the Revolution system is a point-the-bit system. Versus push-the-bit designs, according to Weatherford, point-the-bit configurations can provide smoother, cleaner wellbores by orienting the drill bit axis with the axis of the hole. Cutting action is kept square on...
the face of the bit to eliminate inefficient side-cutting forces, increasing bit life and efficiency and enhancing steering accuracy. The Revolution system’s near-bit stabilizer also orients the drill bit axis with the hole axis to increase bit stability and improve directional control and wellbore quality. Design simplicity in effect means improved reliability, Mr Sinclair said, simply because there are fewer parts to break down.

The system is currently rated to perform in environments up to 165°C and 25,000 psi, and Mr Sinclair noted that the company is looking at upgrading the tool to 180°C. “That would match the system with the rest of our offerings for 180°C, but there are significant challenges. Moreover, the market is just not that big at the moment.” (Weatherford recently completed a project in Abu Dhabi, where the operator was able to drill the ultra-narrow 6-ft target zone using the Revolution RSS combined with a LWD service. For details, please see Page 34.)

POINT VS PUSH

While Sperry and Weatherford have clearly chosen point-the-bit over push-the-bit, PathFinder Energy Services says it sees the benefits of both designs – its PathMaker RSS can be configured either way. It’s more important to match the configuration to the formation type, said Peter Leonard, PathMaker business development manager.

“In consolidated formations, the point-the-bit configuration works very well, and we use it to get smooth wellbores. In areas with high potential for washouts, such as the Gulf of Mexico or water-based type environments, we use push-the-bit for better steerability.”

The PathMaker incorporates a rotating drive shaft through the center of the tool and a non-rotating housing with three blades that maintain constant contact with the wellbore. To achieve directional steering, the blades are positioned to offset the tool center from the center line of the hole. The blades also provide near-bit caliper measurements as well as stability to the lower part of the BHA, Mr Leonard said. The “point” system uses a near-bit stabilizer to provide a fulcrum point to tilt the bit in the desired direction. The “push” system uses the steering unit to push the bit directly sideways.

INTEQ’s AutoTrak G3.0 RCLS (rotary closed-loop system) also isn’t meant to be classified as either point-the-bit or push-the-bit. The system’s Geo-Pilot rotary steerable system design incorporates an extended-gauge bit into the geometry that drills the curve, effectively keeping the bit centered in the hole.

The integration of a downhole mud motor into a rotary steerable system, such as with the INTEQ AutoTrak X-treme, can increase ROP, reduce drillpipe/casing wear and extend a rig’s capability in ERD applications.
push-the-bit, said Carsten Freyer, product line manager. Rather, he explained, it operates in and between both of the classifications depending on the wellbore’s immediate requirements. When initiating a change to wellbore trajectory (i.e., end of a tangent, commencing a 3D turn), the bit is immediately pushed to the side by applying precisely controlled continuous forces against the borehole wall. This is operating predominantly in the push-the-bit mode. Once a few feet of the new curvature is drilled, the steering mechanism is used to bend the bottomhole assembly into the new curvature and effectively point the bit in the direction to be steered, thus operating in a predominantly point-the-bit principle.

“Therefore, the AutoTrak operating principle is defined as a ‘hybrid’ steering principle. AutoTrak systems are more agile than pure ‘point’ systems, deliver higher borehole quality than ‘push’ systems and steer more consistently in a wider range of formation types,” Mr Freyer said.

As an automated closed-loop system, the AutoTrak automatically controls the programmed inclination and deviations, updating every 5 seconds and adjusting power parameters to bring the bit back on track.

“The key to achieving the kind of extended-reach well we drilled on Sakhalin is using advanced closed-loop drilling modes such as the inclination hold mode to deliver a laser-straight and smooth hole, which is the only way to keep the unwanted torque and drag under control; otherwise you can’t provide any sufficient weight on bit in these long wellbores,” Mr Freyer said. The closed loop aspect provides a precise and straight wellbore — less friction in smooth wellbores allows you to drill further out.

“The integration of advanced MWD/LWD sensors into the AutoTrak G3.0 system enables us to deliver the industry’s closest LWD-to-bit sensor offset, which is key to providing the most precise geosteering and reservoir navigation service — to and through your reservoirs,” he added.

A new drilling tool called the Modular Motor was developed based on INTEQ’s X-treme motor technology. It is a straight motor with a continuous hardwired communication and power line running along its entire length. It can provide high-speed communication to the steering unit “so we’re not losing any accuracy or steerability,” Mr Freyer said. This allows the Modular Motor to be positioned within the AutoTrak BHA to deliver high drilling power to the drill bit.

Integration of these two technologies is called AutoTrak X-treme, which was commercially introduced in March 2006.

Other benefits of a motor-powered system include:

- Increasing ROP by adding more power at the bit.
- Drilling in and through harsh, interbedded formations, drillpipe RPM can be reduced once a motor is added to mitigate vibration or stick-slip problems.
- Reducing drillpipe RPM also reduces wear of drillpipe and casing. “This is a huge added value for a customer when rotating the drillpipe in complex top hole sections where the casing is already cemented in,” Mr Freyer explained.

• A motor-powered RSS can help overcome insufficient power from the rig top drive. “We saw this in the North Sea, where we started to drill a long horizontal well with our standard AutoTrak G3.0 set-up, but, at a certain point, the power from the rig wasn’t enough to drill further. The motor-driven AutoTrak X-treme provided the power to extend the well,” he said.

Running the drillpipe in compression when drilling horizontal will eventually buckle it once the compressive loads exceed buckling limits. This will curtail lateral reach as torque increases and no weight gets to the bit. As torque rises and reaches rig rotary limits in low gear, the extra friction also can cause high stick-slip, Mr Freyer added. This adds to the problem by making the rotation of the bit highly dysfunctional and giving an ineffective cutting action.

“Use of AutoTrak X-treme puts the rotation down at the bit, and we can also run lower WOB so we delay the onset of the pipe buckling. This allows the reach of wells to be extended beyond prior limits,” he explained.

The fact that 15 of the world’s 20 longest ERD wells were drilled with the AutoTrak G3.0, Mr Freyer said, means that the potential already exists to step-out even further with the AutoTrak X-treme setup. “We haven’t reached the limits with this technology yet. This could be the next step for the future, maybe talking about 40,000-ft step-outs and longer.”

Sperry is currently commercially field-testing its motor-powered system, the Geo-Pilot GXT, which will use an even-walled motor to increase horsepower at the bit and reliability. The helical profile inside the motor has historically been formed with elastomer of varying thicknesses at different points down the power section. When heated downhole, the thicker parts swell more and get stressed more. “So you tend to see failures at those thickest points where the heat was causing the greatest expansion,” Mr Comeaux explained.

With an even-walled motor, the helical profile is machined directly into the steel stator tube, so the elastomer thickness can be uniform and expands evenly at all points. “There are no points of weakness anywhere, and it’s a much tighter fit and more efficient motor. That means not only do we get more horsepower out of the motors, we can actually make the motors significantly shorter — that
In the future, most rotary steerables will be used with mud motors to enhance performance, and the use of at-bit measurements will increase, said Ivor Sinclair, Weatherford global product line manager for rotary steerables.

allows us to move LWD sensors closer to the bit.” The GXT is expected to be out by summer 2008.

Mud motors can also be added to the PathMaker and Revolution systems, according to PathFinder and Weatherford.

RELIABILITY

Comparing the reliability of rotary steerables five years ago with that of today, Mr. Sinclair said, it’s “like night and day. Most systems have shown a dramatic increase in reliability.”

One important contributing factor to that has been operators’ increasing willingness to employ drilling optimization services with rotary steerables, Mr. Comeaux said. “They’ve come to realize that these tools are complex and can deliver tremendous gains if operated properly. They recognize that they need to be more attentive to these sensors and to monitoring downhole drilling dynamics in real time, and they’ve become more willing to pay for these services so they can get the most out of high-performing rotary steerable systems.”

To take reliability to the next level, Mr. Freyer suggests the industry take a more systems approach to rotary steerables.

“One of the most important things when working to improve reliability is to not focus just on the tool itself,” he said. “To get maximum reliability out of the system, you have to make sure the bit suits the steering unit and the BHA suits the application. To increase reliability even further, you must know what’s going on downhole so you don’t drill in the dark.”

For example, INTEQ’s CoPilot drilling optimization service simultaneously samples 14 sensor measurements for real-time assessment of downhole drilling parameters. On the surface, a rig floor display lets the driller view downhole data and make corrective decisions. “With this drilling optimization service, the customer will get increased value out of the rotary steerable and improved net ROP. We hope this service becomes more and more standard for every BHA in the future.”

Mr. Freyer estimates that INTEQ has at least doubled its RSS system reliability by monitoring real-time dynamics data delivered from the CoPilot service. It enables the company to adjust surface drilling parameters to mitigate unwanted drilling dysfunctions. However, Mr. Freyer noted, “Torsional vibration is frequently unavoidable in complex or ERD wells as well as simpler profiles drilled with lower specification rigs. As a result, it is critical that the drilling system’s reference steering vector direction physically to the borehole wall to ensure that precise steering is maintained even when stick-slip torsional vibration is present.”

Mr. Leonard noted that another thing to remember when talking about reliability is that, compared with other downhole parts such as mud motors, rotary steerables are a much less mature product line. There’s a learning curve to drilling with RSS.

And the learning curve has been long especially for rotary steerables. “Every one of these rotary steerable designs is a brand-new invention. No one rotary steerables really look much alike,” Mr. Comeaux said. “The lessons learned from one system can’t really be translated to other systems. Each company has to gain insight and understanding into the nuances of their particular design.”

The biggest challenge to 100% reliability is mitigating downhole dynamics—temperature, pressure, vibration, Mr. Sinclair said. “You’re putting the tool through very harsh environments. Until we have technology to mitigate that, it will be a bottleneck.” And, like any tool in this industry, rotary steerables may never become 100% reliable, he said, “but the goal is to get it up there.”

COST CONCERNS

Aside from reliability, one of operators’ most-cited concerns with rotary steerables continues to be cost. Costs have not come down on rotary steerables, the service companies say, mainly because of price increases on raw materials like alloy steels and electronic boards and on specialty machinery shops. The cost of fuel itself has caused vendors to step up their prices as well.

Especially for lower spread-cost environments like land or shallow-water, rotary steerable costs have been tough to swallow, however beneficial and efficient the tools are. One way that service companies are addressing this is through more cost-effective rotary steerable systems. INTEQ is preparing to commercially launch this summer its new AutoTrak eXpress system, a base-level rotary steerable tailored for these markets.

“One of the main goals for these clients is to increase rig efficiency to drill more wells per rig per
Rather than choose either point-the-bit or push-the-bit, PathFinder says it sees the benefits of both designs and has made its PathMaker RSS configurable either way. The company says it selects which configuration to use based on the formation type.

However, he said that service companies understand operators’ cost concerns and are continually looking for lower-cost materials and ways to improve maintenance cycles.

WIRED PIPE
On the flip side of low-cost operations, offshore exploration drilling, especially complex development drilling or deepwater applications, are requiring high-speed data transmission rates way beyond what mud pulse telemetry can offer. Along came Grant Prideco’s IntelliServ Network. With this high-speed, real-time drill string telemetry system, data can be transmitted from downhole to surface and back in milliseconds, allowing instantaneous and clearer understanding of downhole conditions and formations.

About 90% of all wells drilled so far utilizing the IntelliServ Network have been with AutoTrak, Mr Freyer said, though both Halliburton and Weatherford said they have interfaces available for their systems to work with the wired pipe system. Halliburton noted that it has successfully used the interface with their rotary steerable system in Mexico.

The wired pipe approach is “a quantum leap” higher than traditional mud pulse telemetry, Mr Freyer said. But he points out that industry is still developing the right applications, “otherwise the customer cannot see the value.” One application, for example, is managed pressure drilling, where online pressure readings are necessary so surface pressures can be adjusted in real time. Other applications will come, he said, as the industry moves toward real-time seismic while drilling or imaging services, where significant amounts of information must be sent from downhole to surface in real time. Imaging services provide high-resolution images from the borehole wall and from resistivity/density logs to better understand rock mechanics and formation geology. With better information about the formation geology, drillers can make earlier geosteering corrections to stay in or reach the highest production zone.

So if wired pipe is the broadband of drilling, then is mud pulse telemetry on its way out?

“Definitely not,” Mr Freyer replied. Mud pulse telemetry is improving, and high-speed mud-pulse telemetries now go up in the range of 20 bits/sec or more, compared with about 3-6 bits/sec with traditional systems. “Existing general mud pulse telemetries are sufficient for most applications, and there continue to be further developments in high-speed mud pulse telemetry. That is the way forward as we see more critical well profiles where a lot of LWD sensors will be required. In 3-4 years, high-speed mud-pulse telemetry will become more standard.”

THE FUTURE
PathFinder’s Mr Leonard notes that most drilling markets, especially those outside North America, have already learned the intangible benefits of rotary steerable systems — smoother wellbore, better hole cleaning, casing programs going down easier, etc. Even if the RSS doesn’t increase ROP, their intangible benefits make them worth running.

In North America, that recognition is increasing but still not happening as much outside of complex offshore operations, he said. “Its use, especially on land, is increasing as more people try to reduce their drilling costs, but it’s not 100% there yet. There needs to be more acceptance of the technology as well as better reliability. As the RSS market goes forward, it will become more reliable and accepted.”

In the future, Mr Sinclair believes that most rotary steerable systems will be used with mud motors to enhance performance. The use of at-bit measurements will increase to enhance geosteering capabilities. And cost eventually will come down, he said, as the tool goes through its life cycle.

“We will continue to look at new designs and ways to improve, because we realize we have to continue innovating.”