Range of hole sizes, internal steering features of Schlumberger RSS

ROTARY STEERABLE SYSTEMS first appeared in the mid-1990s, and, for **Schlumberger**, matured in the North Sea, **Mike Williams**, global sales manager for **Schlumberger**, said in a recent conversation with DRILLING CONTRACTOR. This step-change application was prompted by the limitations of motor drilling in directional and ERD wells.

RSS are a critical enabling drilling technology. Thanks to RSS, operators enjoy greatly improved penetration rates, compared with conventional mud motors.

RSS DRIVERS

The major driver for using RSS is increased penetration rates. However, the technology also boasts other advantages, Mr Williams said. First, hole quality is greatly enhanced, compared with motors. This is because motors, when rotating, produce an over-gauge hole because the bit wobbles off center. Difficult wells might require a bigger bend, and hole quality deteriorates as bend size increases. Rotary steerable systems, lacking fixed bends, have none of these problems and drill gauge holes whether steering or not, in general.

In addition, when drilling with motors, the BHA remains stationary. Hence, the risk of getting differentially stuck is much greater when sliding than when rotating. Because the RSS is continuously rotating at all points along the drill string, at least in Schlumberger models, the chances of becoming stuck are far less, he said.

Finally, because the RSS is continuously rotating, cuttings are well stirred, resulting in improved hole cleaning.

MOTORS VS RSS

A motor contains a mechanism within a bent housing that turns the bit. While motors drill very quickly in rotating mode, sliding can be problematic. First, frictional effects cripple ROP, dropping penetration rate to as little as one-third of rotational rates. Second, orienting the motor for correct directional drilling is tedious and time-consuming; the deeper the well, the greater the preparation time. Proper orientation is complicated at depth by reactive torques swinging the bit to the left.

The "everything touching the wellbore rotates" concept is a critical advantage of Schlumberger's rotary steerable systems.

Rotary steerable systems obviate these issues by providing the benefit of simultaneously rotating and steering in a discrete direction, according to Mr Williams. To make that a reality, the industry challenge was to find a means of providing the tool a reference in space relative to the hole even as the drill string and tool rotates. While adjustable stabilizers and similar tools can be vertically oriented using gravity as a benchmark, supplying a means to provide direction left and right was challenging. The answer was to provide a geo-stationary platform within the tool, he said.

There are two basic means to accomplish this goal. One is to use a non-rotating sleeve outside the tool. The other, which Schlumberger adopted, is installing a non-rotating device within the tool.

Schlumberger took the latter route, which provides decisive advantages. The critical implication is that all parts of the drillstring touching the wellbore rotate. As a result, none of the drillstring drags on the wellbore, as a stationary sleeve does, impeding ROP. This is a critical advantage of Schlumberger rotary steerable systems that is not found in other major industry systems.

Schlumberger tools use one of two approaches to provide a geo-stationary platform, Mr Williams pointed out. The first approach is use of a stationary electronics cartridge within the drill string. The cartridge remains stationary, despite rotation of the collar. The second means is via software in a survey package. This second approach represents a virtual stationary package.

Either approach means that everything touching the wellbore rotates. This means that no part of the drillstring is dragging on the wellbore, impeding ROP. Because all parts rotate, the system can ream, backream and drill out shoes. The "everything touching the wellbore rotates" concept is a critical advantage of Schlumberger's rotary steerable systems.

RELIABILITY

Reliability has long been the Achilles Heel of rotary steerable systems. Unlike a mud motor, a RSS relies on complex electronics to steer the device, electronics once vulnerable to shock and vibration damage. The problem was once so acute that some operators preferred using a mud motor over a RSS. The time lost in tedious motor orientation could, at times, undercut the nonproductive time in making extra trips to pull a failed RSS.

As a consequence, the industry has focused immense effort on improving RSS reliability, Mr Williams said, and with good result. Building on experience with MWD systems, special attention has gone toward simplifying the tool and making it more rugged. Key enhancements include bolstering pad attachment and extending life of the electronics. Today Schlumberger's systems average 30,000 drilled feet between failures, a significant improvement over early entries. This is akin to MWD reliability.

EXPANDING RSS RANGE

The earliest tools were confined to 8 ½-in. holes. Schlumberger's latest efforts have gone into expanding the range of its rotary steerable systems. Currently, alone in the industry, it offers tools in hole sizes from 26 in. to 3 ⅞ in.

The advantage of PowerDrive is that the electronics are identical for all sizes from 5 ⅞ in. to 26 in, he pointed out.

As a result, a single tool can be used for a wide range of hole sizes. Only the mechanical bias unit need change out.

LATEST SYSTEMS

Determining how to deflect the bit from the surface on a rotating drillstring was a parallel challenge. A constant force has to be applied to the bit, whether the RSS is pushing or pointing the bit. Schlumberger's answer, as encapsulated in its PowerDrive Rotary Steerable System, was to employ pads contacting the hole to direct the bit.

Using the reference point provided by the geo-locating system, the pads open and close in a set command sequence, exerting consistent and constant side forces opposite to the desired direction. PowerDrive was commercially introduced in 1999. The latest model is the PowerDrive X5.

The latest-generation tool, PowerDrive Xceed, features a fully enclosed internal steering mechanism, rather than relying on pads, Mr Williams said. Because Xceed does not touch the wellbore, it is especially suitable for niche applications, such as sidetracking open hole, drilling in soft formations and punching through hard layers. Further, its independence from borehole contact means PowerDrive Xceed is compatible with bicenter bits, used to increase hole gauge. This ability to open the hole is advantageous in extended-reach and deepwater applications, where directional drilling techniques are often necessary.

PowerDrive Xceed was launched in 2003 with 8 ½-in. hole size. Most recently, Xceed 900 was introduced. Capable of 12 ¼-in. and 14 ¾-in. hole, Xceed 900 is currently being field tested.

CASE HISTORY 1: QATAR

In drilling thin sands in the Nahr Umr reservoir in Qatar for **Maersk Oil Qatar AS**, the PowerDrive Xceed provided excellent geosteering control. The bit stayed within the sand section through 99% of the 6,581-ft, 8 ½-in. hole. More than 90% of the drain section was drilled within the optimum zone. During operations, the system achieved a 90° change in well trajectory at an extended step-out.

A deepwater GOM operator planned and successfully executed two kick-offs in 26-in. hole using the PowerDrive Rotary Steerable System. This was the world's first application of RSS technology for directional work in this hole size.

The industry has focused immense effort on improving RSS reliability. Building on experience with MWD systems, Schlumberger has paid special attention to simplifying the tool and making it more rugged.

The kick-offs were executed 300 ft below the mud line while drilling riserless in over 6,000 ft of water. PowerDrive was able to provide directional control to build to the required 240° inclination.

CASE HISTORY 2

Previous directional attempts in 26-in. hole in this formation using conventional mud-motors presented several challenges, including reduced ROP while sliding. Longer time to drill increased wellbore exposure to the water-based drilling fluid. These factors contributed to significantly over-gauged hole. This made the following cement job nearly impossible and held serious implications for isolation and support of the surface casing string

PowerDrive was used previously in vertical 26-in. sections, but the ability to build inclination in this hole size, given the soft formation, was unproven.

PLANNING FOR SUCCESS

A pre-job analysis was conducted to determine the compressive strengths of the shallow sediment. Based on the results of this analysis, it was determined that the formation was sufficiently competent to allow the 26-in. bias unit to adequately push off of the borehole wall.

The well trajectory was planned to kick off 100 ft below the mudline and required a conservative build rate of 1.00/100 ft. The BHA design incorporated a flex joint to improve dogleg capability. The PowerPulse MWD was run below the ARC to provide directional measurements closer to the bit. This would provide the directional team with an earlier evaluation of the BHA performance and so enable them to quickly respond to any undesired tendencies, thus keeping the well on track.

WELL #1

The trajectory called for kicking off 50 ft below the 36-in. conductor and building at 1.0°/100 ft to an inclination of 25.8° at section TD. The ROP for the first few stands drilled ranged from 360 to 540 ft/hr. The early surveys showed the PD tool to be building angle at 0.3° to 0.6° on each survey with a total dogleg output of 0.4° to 0.7°/100 ft.

With approximately 3° of angle in the hole, a switch to a gravity toolface was made, and the well lined up the desired azimuth. This setting produced 1.6° of build and 6° of turn per 100 ft. Multiple settings were then used to keep the well on the desired trajectory on the way to TD. The final survey showed 22.5° inclination with an azimuth of 215°. The well was successfully cased and cemented.

WELL #2

The trajectory called for kicking off 100 ft below the 36-in. conductor and building at 1.0°/100 ft to an inclination of 25.8° at section TD. The lessons learned from the previous run were incorporated into this run, with BHA design kick-off procedures adjusted slightly.

As seen in the first run, the ROP slowed after the first few stands as more competent formation was encountered. About 900 ft into the run, the BHA began to drop angle as it drilled through a sand interval. A 288/100% set was used but still could not address the drop tendency. Once out of this formation, PowerDrive was able to quickly recover the lost inclination (~3.2°) and continue to build at an average dog-leg of 1.5°/100 ft to TD.

Overall ROP on this section was ~ 170 ft/hr compared with ~120 ft/hr on the previous run attributed to improved practices to reduce the impact of bit balling. The final survey showed 24.5° inclination with an azimuth of 60°. The well was successfully cased and cemented.

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