Enhanced RSS Technology Pushes Drilling Envelope

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Increasing technical demands are pushing the envelope of rotary steerable system (RSS) drilling technology. The growing challenges of directional drilling in hard formations, borehole stability issues, difficult hole trajectories, and harsh downhole environments all are placing increasing demands on drilling and adding costs and risks to operations.

RSS advancements have played a key role in pushing drilling into new frontiers such as deepwater and unconventional basins. As wells have become more complex and difficult, the industry seeks continuing advancements to enable the economic development of previously inaccessible resources in a variety of environments.

The Schlumberger PowerDrive Orbit enhanced RSS (Fig. 1) expands the ability to complete multiple functions in one run, tolerating higher revolutions per minute while maintaining good trajectory control, minimizing tortuosity, and accommodating challenging hydraulic designs and muds formulated for more aggressive drilling.

Addressing Challenges
The technology was engineered to address the most challenging drilling conditions and provide the reliability and efficiency needed to plan one run per section from shoe to total depth. The tool reduces the number of trips in and out of the hole, decreases the risk of differential and mechanical sticking, and improves hole cleaning and conditioning capabilities.

The enhanced RSS system includes a newly designed pad actuator, thus increasing reliability and enhancing trajectory control by use of self-steering automation on any type of rig worldwide. The system also offers an optional, or on-demand, stronger pad design to provide greater durability in highly abrasive formations.

In wells that typically would require two or three runs to drill one section, the new design enables operators to drill a section in a single run with improved performance. It also expands the revolution rate limits, tolerating up to 350 RPM, from the current limit of 220 RPM, while maintaining directional control and consistent steerability.

Enhancing Existing Technology
The new RSS system was designed to boost the effectiveness of existing technology. With an improved pad force, push-the-bit system for consistent dogleg severity at higher revolutions per minute, the new technology pushes the operating envelope of PowerDrive push-the-bit systems. When combined with the PowerDrive vorteX powered RSS, it offers a wider tolerance for higher revolutions per minute and torque downhole.

Fig. 1—The PowerDrive Orbit enhanced rotary steerable system increases drilling efficiency by using a newly developed actuation pad system and boosts trajectory control through self-steering automation that can be used on any type of rig worldwide. Image courtesy of Schlumberger.

The new technology allows additional flexibility in pressure requirements at the bit for extended runs and mud type. The metal-to-metal sealing system tolerates muds designed for more aggressive drilling characterized by a high content of low-gravity solids and/or heavy mud weights.

The design has several new features, including a high-resolution gamma ray sensor. This serves as a well placement alternative for shale gas and oil wells with insufficient conductivity contrast to allow the use of logging-while-drilling tools. The comprehensive, 6-axis inclination and azimuth measurements provide better accuracy to enable automatic adjustments in a closed-loop mode, targeting specific inclination and azimuth within a safe tolerance. This results in better trajectory control and reduced tortuosity, which enable the drilling of more deviated wells, such as those with S-type, J-type, or horizontal profiles.

The design provides more precision kickoff from the vertical section, a precise directional control at low inclination (in a defined direction), and a high level of total vertical depth definition, thereby enabling smoother boreholes to be drilled.

In tangent sections, measurements provided by the 6-axis roll sensor enable the system to make automatic adjustments, keeping a specific inclination and azimuth, and resulting in smoother tangents with less tortuosity. This capability saves time and results in better hole quality, which is beneficial when running casing and making trips for bit changes.

The accuracy of the hold inclination and azimuth algorithm helps to reduce the number of confirmations required with static surveys, resulting in saved time and less disturbance to the drilling operation. The new dual-downlink feature gives drillers the unique option of activating downlinks by either the traditional flow change command or by changing the collar rotation rate, depending on the situation.

With the flow variation option, which is typically used, the command is less affected by high stick and slip and high torque. With the collar rate variation, the command is less affected by a slow reaction from the mud pumps when drilling, such as with small mechanical rigs. This application in particular enables an RSS to be run on any type of rig, including mechanical rigs without a silicon-controlled rectifier, which cannot activate flow change commands and require fast-reacting manipulation of surface pumps to different levels.

Case Studies

Following 2 years of field testing, the new system has achieved successful runs in numerous regions globally, including the Middle East, the United States (onshore), Mexico, Colombia, Venezuela, China, and the North Sea.

The enhanced RSS drilled a record 12,690 ft in a single run for a major operator in the Middle East. The operator needed an RSS that could maintain directional control while drilling deep laterals in a challenging onshore crude oil well. Despite severe shock levels and high stick and slip values reaching 350 RPM, the system overcame severe torque to extend the lateral length by 33% and complete the operation 21 days ahead of schedule.

In Mexico, the new system saved 26 hours of rig time, drilling 5,062 ft in a single run with a rate of penetration (ROP) exceeding offset wells by 50%. The pad actuation design delivered full steerability in an environment with high mud weight and limited hydraulic capacities. The system drilled a 12¼-in. hole section from 8,415 ft to 13,478 ft without any of the flat time exhibited by offset wells in the same field.

The new pad actuation feature (Fig. 2) also provided the necessary steering efficiency to drill a high-angle 8½-in. well section in a sandstone reservoir in Venezuela that featured cross-interbedded layers of hard and soft formations. In this case, the operator needed an RSS that could overcome temperatures exceeding 250°F with severe stick and slip, and counteract the formation tendency to turn the drilling system to the right. The system achieved the desired inclination of 45° in the first 200 ft of drilling, saving 8.8 days of rig time and achieving an ROP of 16 ft/hr, a 100% increase over the estimated level.

Fig. 2—The pad actuation system of the enhanced rotary steerable system tolerates the most difficult drilling conditions, such as muds designed for aggressive drilling and severe downhole shock and vibration. Photo courtesy of Schlumberger.