Rotary steerable system design enables directional performance in washed-out holes

By Mitch Hale, PathFinder

A WISE MAN once said that the shortest distance between two points is a straight line. But out in the oilfield, the shortest distance between two points is the client's bottom line — where profitability and timeliness are the most crucial components to a well's success. The PathFinder 3D rotary steerable system — the PathMaker RSS — plays a key role in steering clients to their bottom line in a timely and profitable manner.

Many RSS tools are available on the market, and on the surface, it can be confusing how each RSS manufacturer differentiates itself. Each RSS possesses specific design advantages based primarily on the way each system's steering mechanism operates. One specific differentiator — and a vital issue for all RSS — is how the design enables the operator to directionally perform in washed-out holes.

Some rotary steerable tools rely on borehole contact to produce steering force, or contact to maintain and hold the steering section stationary while the drill string is rotating. The PathMaker RSS possesses distinct advantages in this respect. Most notably, the system's steering pads can extend up to 1 in. each, allowing the system to maintain wall contact in borehole sizes up to 13 in. with the 12 ¼-in. hole size tool. This allows the system to maintain directional control in washed-out holes up to 13 in. It is this design that enables successful performance in all environments, from extremely soft to very hard rock, from water-based to oil-based muds, and from in-gauge to over-gauge holes.

To ensure that the RSS consistently provides this level of performance, it has been designed to operate in both point-the-bit and push-the-bit configurations.

POINTING THE BIT

Since its commercial release in August 2004, the 12 ¼-in. point-the-bit RSS has proven itself in a string of drilling jobs from vertical to near-horizontal applications, drilling more than 290,000 ft of hole in areas such as Gulf of Mexico, US land, North Sea and Middle East.

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The 12 ¼-in. system recently saved a client in Egypt seven days of rig time by eliminating a hole-opener run. Client savings neared a half-million dollars.

Officially the first 12 ¼-in. RSS-by-17 ½-in. underreamer section drilled onshore Egypt, the well was successfully completed in record time. The directional drilling objectives were to drill out the shoe, activate the underreamer, build at 2º/30 m to 39º inclination and maintain the tangent section to casing point, all while simultaneously enlarging the 12 ¼-in. pilot hole to 17 ½ in.

While drilling the curve, the system's Non-Intrusive RPM Downlink design enabled the directional driller to make minor steering adjustments while on bottom drilling ahead. The tangent section was drilled in automated hold mode, which means that no downlink commands were necessary, thus reducing human interaction with the directional drilling operation. Excellent LWD log quality was obtained over the interval.

In all, the RSS drilled 1,218 m of hole in 126 drilling hours, achieving all directional objectives. Consistent 2º/30 m build rates were obtained, with 30% deflection at the steering unit. 620 m of tangent section was drilled in automated hold mode. A unique Real-Time Vibration and Stick Slip Detection (RSVD) system was used throughout the run to monitor for unwanted downhole vibrations. The system's only Real-Time Pad Contact Caliper (RPCC) measurement enabled the directional driller to monitor the gauge of the pilot hole for consistent and smooth dogleg results throughout the section.

STICK-SLIP, VIBRATION DETECTION

In extended-reach and horizontal well drilling environments, stick-slip becomes increasingly problematic. Surface detection of bottomhole assembly stick-slip and vibration becomes ever more difficult. The RSVD was incorporated into the RSS to increase drilling efficiency in deep wells and to protect the RSS and the MWD/LWD tools from harmful vibrations.

This near-bit vibration sensor is integrated into the RSS to detect three principal modes of the drillstring vibration — torsional, lateral and axial. The sensor is located 6.3 ft above the bit in the push-the-bit configuration and 9.3 ft above the bit in the point-the-bit configuration, and utilizes the RSS's existing rotation and vibration sensors to quantify the severity of downhole torsional (stick-slip), as well as lateral and axial, vibrations. The system transmits the detected stick-slip severity to the surface in real time, allowing operators to change drilling parameters if harmful downhole conditions are detected.

The real-time stick-slip and vibration data, along with pad contact measurements, are always available in real time to directional drillers and MWD engineers while drilling complex 3D wells.

In 2006, the RSVD system was extensively tested and proved effective for detecting various downhole dynamic conditions. The system was run on 8°/100 ft build sections in Fayette Shale wells with motor and no-motor assist assemblies, build sections in the San Juan Basin and vertical wells in South Texas and Gulf of Mexico. Since its inception, the RSVD system has improved penetration rate and prolonged the optimum performance of the drill bit, BHA, MWD/LWD and rotary steerable tools. The ability to detect BHA instability due to vibrations (with RSVD) and/or borehole washout conditions (with RPCC) allows the RSS operator to take timely remedial actions before the occurrence of downhole RSS failures. As a result, the performance and survivability of the RSS has been improved.

PUSHING THE BIT

The push-the-bit PathMaker is based on the same basic design as point-the-bit system with a few modifications to enhance operation in specific applications. For example, the full-gauge near-bit stabilizer of the point-the-bit system is replaced with a HOG (Hole-on-Gauge) sub on the push-the-bit system, and an undergauge stabilizer is placed below the push-the-bit system's flex collar. This allows the steering pads of the push-the-bit system to be closer to the bit for maximum effect while pushing the bit sideways. The HOG sub is used as a ledge trimmer to "wipe" the hole as it is drilled, thus producing the cleanest cut, highest quality well bore possible from a push-the-bit system.

In April 2006 a series of controlled directional tests were carried out at the Catoosa Test Facility near Tulsa, Okla., with various PDC and rock bits to determine the steerability, predictability and DLS capability of the system through various rock types. The 12 ¼-in. push-the-bit system exhibited excellent directional control while attaining a maximum 6°/100 ft build rate. Tests were run through the upper sandstone and shale sections, then into the harder Mississippi Lime formation. Build, drop and compound turn/build and turn/drop maneuvers proved predictable. No borehole problems were experienced, and torque and drag values were comparable with the point-the-bit system.

PathFinder then searched for a challenging well and found one in Terrebonne Parish, La., in August 2006. The well represented a shallow water-based job in an area renowned for excessive borehole washout. The well called for kick-off at 5,000 ft, build at 2°/100 ft to 20° inclination, maintain for 2,000 ft and drop back to vertical at 1.5°/100 ft. Utilizing the 12 ¼-in. push-the-bit system exclusively, the directional drilling team successfully drilled the well to plan, in borehole sizes ranging from 12 ¼ in. to over 13 in.

Next, the 12¼-in. push-the-bit system was deployed on a water-based job in High Island, Gulf of Mexico. The well plan called for 2° DLS to turn the well from 351° to 314° azimuth, with a gentle build from 39° to 48° inclination. The system achieved the turn, producing the DLS on a 34% offset setting.

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