Steerable drilling needs minimal well interaction

Mike Williams, Schlumberger Oilfield Services

ROTARY STEERABLE DRILLING systems were commercialized and introduced to the oil and gas industry 6-7 years ago, and work using two different techniques, either push the bit or point the bit. Both work very well and the technology has been accepted by most oil and gas companies to more precisely and efficiently target their geological objectives, especially in long horizontal wells.

With push the bit systems, pads are used to steer the tool. These are typically close to the bit but there still must be some interaction with the wellbore, which occasionally results in some limitations on the tool's capabilities. For example, in openhole sidetracks once the sidetrack is started the pad can only push so far before it loses contact with the wellbore. If drilling in a very soft formation, the pad might not have anything to push against because the hole could be washed out. Most point the bit systems also require well bore interaction to maintain directional control and many of the same limitations apply.

IMPROVED EFFICIENCY

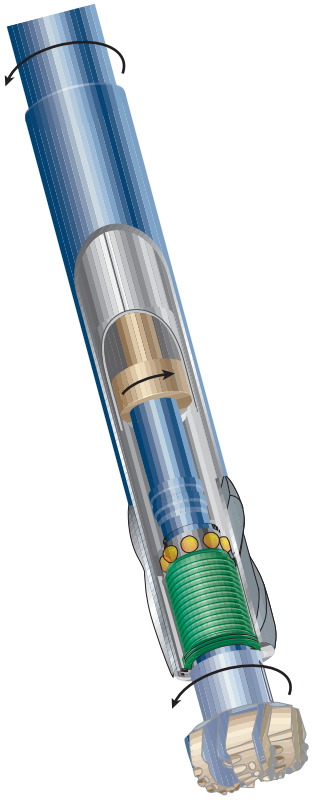
To overcome these obstacles and challenges, Schlumberger developed its PowerDrive suite of fully rotating rotary steerable systems, which keep any interaction with the wellbore to a minimum, and ensure any interaction is at drillstring rpm. The fully rotational capability makes the system very unobtrusive to the drilling process, and provides the capability for the driller to drill, ream and back ream without any increased risk of mechanical or differential sticking.

Fully rotating systems provide additional benefits. The flow of drilled cuttings past the bottomhole assembly is enhanced because annular bottlenecks are not created in the wellbore. Penetration rates are improved since there are no stationary components to create friction. Risk of mechanical and differential sticking are also reduced since no stationary or slow rotating components contact the casing, whipstock or wellbore.

Tool life is enhanced by stationary internal seals that are not exposed to fluids containing abrasive cuttings. The steering system operates equally well in all types of fluid environments.

ORIENTING THE BIT

There still was one challenge that needed to be overcome, and that was drilling in soft formations and consistently performing open hole sidetracks with



The steering section assembly of the PowerDrive Xceed continuously orients the tilted shaft to control the drilling directions and the dogleg severity of the borehole.

rotary steerable systems, which is where the PowerDrive Xceed technology comes into play. With this system, the only interaction with the wellbore is through a normal stabilizer near the bit. No pads are necessary to push against the wellbore or slow rotating sections needed to interact with the wellbore for steering control when drilling in soft formations, openhole sidetracks or rough drilling conditions.

Communication is based around the company's PowerPulse MWD telemetry system and includes a full set of survey electronics that rotates with the system. When combined with PowerPulse, Xceed provides real-time toolface, inclination and azimuth data for reliable, long runs. Based upon this information, commands can be transmitted to the system to maintain or change the bit's trajectory. The electronic survey package constantly references itself to the high side of the hole internally without the need for wellbore interaction.

Steering the bit itself is accomplished in a unique but simple manner. The bit is mounted on a short shaft that spins to the right at drill string rpm. The back end of the shaft is attached to a disc with an eccentric connection between the bit shaft and an electric motor that rotates to the left at the same rpm as the bit. The disc is also attached to a controller that matches the varying rpm of the bit as it increases or decreases rotation as it drills ahead.

To steer the bit, for example, changing the trajectory of the bit to point upward, a command is transmitted from the surface to the electronics. The disc will then turn itself around so that the offset in the disc is at the bottom relative to the wellbore, meaning the back end of the shaft is also at the bottom and the bit is pointing upward.

If the system is used in a straight hole in what is referred to as neutral mode, the disc spins at a slightly different rpm enabling the bit to wobble slightly, drilling a straight but slightly over gauge hole. The system always has a bend of 0.6 so if a straight tangent is drilled it will result in 1/8-in. gauge hole, much smaller than a traditional positive displacement motor.

The tool OD is 6 ¾-in. and is capable of drilling from 8 ½-in. to 9 7/8-in. hole size. The tool can drill in temperatures up to 300° F.

LOWER COST WELLBORES

Since the tool does not push against the wellbore in order to build angle, or interact with it to reference itself, the Xceed system is very effective for steering in soft formations and where over gauge or

washed out hole is present. This independence from the wellbore enables doglegs and sidetracks to be drilled at high build rates reliably. In soft formations the system can develop dogleg severity as high as 8°/100 ft, significantly higher than systems that depend on wellbore contact to steer. This independence from the wellbore to steer reduces the tendency for the hole to spiral due to variations in trajectory.

Steering that is independent of the wellbore also allows for the use of bicenter bits to increase hole gauge. This capability is advantageous in extended reach and deepwater applications where directional drilling techniques are often required.

The totally enclosed internal steering mechanism limits tool exposure to extreme wellbore conditions. Additionally, the field proven electronics provides significant wear and reliability advantages in hot and high-shock applications, resulting in a system that is less susceptible to wear when drilling through sandstone or other highly abrasive conditions. The result is lower drilling costs and longer tool life for reduced risk and improved economics. The system provides accurate and responsive steering regardless of the formation or hole gauge, resulting in more reliable and predictable drilling of doglegs and sidetracks.

CASE HISTORIES

Several case histories show that utilizing the Xceed system can result in faster drilling and savings of potentially millions of dollars per run.

North Sea. In one application the fully rotational system saved Norsk Hydro more than $200,000 by drilling a sidetrack in one run. The tool was used to drill an 862 m openhole sidetrack in a single run of 145 pumping hours in the geologically complex Njord field in the Norwegian North Sea. Directional drillers initiated the sidetrack at 91° inclination at 4,246 m measured depth and geosteered the bit to a total depth using VISION formation evaluation and imaging while drilling real-time density images and near-bit data from the Xceed system.

The quick communication resulting from formation evaluation and imaging data increased geosteering efficiency. Narrow flow thresholds for downlinking allowed 90% of the directional control settings to be made on bottom while drilling ahead, further increasing the efficiency and economics of the system.As a result of successfully performing the sidetrack, the well contributed high net present value from the additional reserves.

Angola. The system was selected for a well in the thin-bed Girassol formation of Angola based upon the need to increase drilling performance, optimize drainage and enhance of hole quality for running screens and logs. Using conventional rotary steerable systems for the required doglegs in the unconsolidated formations had been unsuccessful as conventional drilling systems do not

allow azimuthal density neutron logging while sliding. The Xceed system consistently delivered doglegs of more than 4.5°/30 m. Using the system provided consistent dogleg capabilities derived from a deflection principle based upon bottomhole assembly curvature.

Use of the system accomplished both the required dogleg severity and drain placement while maintaining hole quality. The unique fully rotating technology was used to respond quickly to changes in formation dip using continuous inclination 4 m from the bit.

Indonesia. The system was successfully used to drill doglegs that were previously impossible in an 8 ½-in. section of extremely difficult drilling conditions. Doglegs of 1.8°-2.4°/10 m were achieved while building angle from 51.91° inclination to 85° to hit the pay sand. Total well depth was 4,346 m. The highly interbedded formation has highly compressed shale-limestone-sand-coal sequences. To avoid stuck pipe, the coal layers were drilled in 50 cm steps. The driller often had to backream at 150 rpm when passing through those layers.

Middle East. Footage drilled increased dramatically in a heavily faulted sandstone reservoir. Resulting primarily from a 91% increase in drilling efficiency per bit run with the Xceed system, $1.5 million reduction (52%) in total well costs resulted. This experience convinced the operator to replace conventional motor technology throughout its ongoing field program.

During the second phase of the multiwell program, the operator needed increased capability to overcome obstacles in the laterally variable sandstone reservoir.

Nearly 90% of the wells require openhole sidetracks for geological realignment. Rotation of the entire drillstring and less wellbore tortuosity resulted in a 68% reduction in trip time, which in turn was a result of improved hole quality.

Using the rotary steerable system resulted in the longest well drilled in the field; the first time the sandstone section was drilled (13,689 ft) in one run; two successful openhole sidetracks eliminating two round trips; run length exceeding 191 circulating hours; and maximum dogleg of 12°. ■