New Drill Bit Designs
Maximize Performance In Horizontal Shale Wells

By Danny Boyd
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Drill bit designers and engineers are equipping operators with new bit capabilities that are eliminating trips, cutting costs and allowing oil and gas companies to stretch dollars in the hunt for new reserves, driving a resurgence in drilling activity and arresting a decades-long decline in U.S. oil output.

With oil topping $100 a barrel, the focus on exploiting oil and liquids-rich natural gas acreage continues to drive domestic drilling activity. In fact, the number of oil wells drilled last year in the United States outnumbered gas wells for the first time since 1996. The rig count is up 27 percent over the past 12 months and 57 percent over the past two years, signaling a healthy recovery from the 2008-09 downturn. Moreover, industry data show that the total estimated footage drilled in January was up 63 percent year-to-year, reaching the highest levels since late 2008.

But while all the activity trend lines are up, new drill bit technology and innovations to existing bit systems are enabling operators to maximize efficiencies and hold the line on drilling costs. With operators focused on drilling long-lateral horizontal shale and tight sands wells, many of the advances in bit design are engineered specifically for these demanding applications, including bits capable of drilling steep curves and extending laterals all the way to total depth without requiring a trip.
Shale-Optimized Bit

Responding to the challenge of designing a bit capable of providing optimum steerability through complex trajectories while also achieving high penetration rates in long, low-hydraulic laterals, Smith Bits unveiled its Spear™ shale-optimized steel-body PDC drill bit in February. The bit is designed to reduce drilling costs by meeting demands in the Bakken, Barnett, Marcellus, Haynesville and Eagle Ford shale formations, according to Robert Ford, senior director of engineering.

“We have tried to understand what operators are seeking to achieve in developing a bit capable of performing well in both curve and lateral sections,” he states. “In the past, operators took a two-bit mentality, with one bottom-hole assembly for the curve and another for the lateral. Ultimately, that increased costs because of the associated trip time.”

Bits targeting the curve typically have strong build tendencies and predictable tool face control, but low rates of penetration in the lateral. On the other hand, bits for the lateral section are built for aggressive, fast penetration rates, but usually increase the risk of improper build rates in the curve, Ford points out. The industry clearly needed a bit that was equally capable in both scenarios.

Long lateral drilling in shale plays also presents additional challenges from ribbon-like cuttings accumulating at the bottom of the well. As a result, the cuttings impede bit access to fresh rock, resulting in low penetration rates, packed blades, nozzle plugging and stick/slip. “But the Spear shale-optimized bit, in addition to reducing trips, lowers nonproductive time by minimizing vibration and preventing packed blades, plugged nozzles and cutter damage,” says Ford.

The Spear drill bit permits high penetration rates through a combination of tall and thin blades, which provide a large area for cuttings flow, he elaborates. The bit’s hydraulic design directs flow toward the cutter faces, keeping them sharp while sweeping cuttings away from the bottom of the hole and around the bullet-shaped body into the annulus. This immediately exposes fresh rock that then can be drilled and is a key element of the bit’s performance, Ford says.

“Small cutters on the bit provide lower torque response and improve directional control. Lo-Vibe™ depth of cut control inserts behind the shoulder and gauge cutters lower and redistribute cutter loading and minimize vibration caused by rock strength,” he notes.

Smith Bits opted to use steel instead of carbide for the bit material to overcome limitations of blade geometry that contributed to bit balling and nozzle plugging in shales, he says. “Steel has been used for many years, but it tended to lose favor in the past because of issues regarding resistivity and wear. However, those are not problems in shale applications, and by using steel we are able to really extend the blade height, thereby creating much more area for cuttings clearance,” Ford points out. “So a steel bodied bit overcomes hydraulic challenges while maximizing hole cleaning, improving directional response, reducing bore hole tortuosity and enhancing stability.”

Dynamic Simulation

Spear bits are certified through Smith Bits’ Integrated Drillbit Design Platform (IDEAS™), which allows engineers to create a computer-generated virtual picture of the bottom-hole pattern, as well as analyze bit vibration and cutter forces to adjust the design, according to Ford. “We are able to make subtle changes in terms of cutter geometry and blade orientation within a simulation, and from that understand the dynamic behavior of the bit even before it gets to the field,” he comments. “That is a key difference for how Smith Bits designs and optimizes bits.”

The Spear can be easily fitted with Smith Bits’ premium ONYX™ PDC Cutters for hard rock drilling applications. “In the curve, we are drilling through a more challenging rock, which can include interbedded mixtures of sandstone, limestone and shale,” Ford explains. “In that case, we see a more abrasive component to the formation. In response, operators are choosing the ONYX because of the extra durability it gives the cutter. If you drill the curve in a challenging rock environment and then have to drill a long lateral, you need a cutter that can handle that formation change and provide the longevity at peak performance to get the well drilled.”

The Spear shale-optimized steel-body PDC drill bit has been used successfully in shale plays with more than 1,500 runs performed in North America, he reveals. In the Marcellus, the target penetration rate for drilling the horizontal leg was 50 feet an hour for one operator, but the Spear bit achieved in excess of 65 feet/hour, a 30 percent improvement, Ford reveals. In the Haynesville Shale, the bit drilled the horizontal section in one run 10-20 percent faster than the best offset performance, he adds.

The Spear bit was developed for a Haynesville operator who wanted to reduce the number of days and trips required to drill the 6½-inch production interval, by drilling both the curve and lateral sections in one run, Ford states. Cooperation between the operator and Smith Bits’ team of field and design engineers and hydraulic specialists led to the Spear 6½-inch SD611 new PDC bit, which Ford says provides a good balance between superior directional control and fast penetration rates.

The steel-bodied bit, together with a 2.0-degree, fixed-bend steerable motor, drilled the 6,063-foot curve and horizontal intervals in one run, setting a Haynesville horizontal drilling record of 49.7 feet/hour, according to Ford. “Although faster lateral runs have been posted, no other bit had drilled the entire curve and lateral sections at that combined rate,” he claims.
Based on comparisons with two direct offset wells, the total drilling time was reduced by 124 hours. The improved performance saved the Haynesville operator an estimated $365,000 in rig time and bit costs, and shortened time to production, allowing more wells to be drilled in a given period, Ford concludes.