The influx of tailored tools has helped operators improve well construction efficiency, reduce drilling costs, and maximize production. To continue this trend, the industry has renewed its focus on improving horizontal drilling performance through shale formations. Analysis of several shale plays has revealed that PDC bit profile plays a major role in increasing performance. While the industry has successfully increased on-bottom ROP, thereby reducing drilling time and costs, it also must reduce flat time between successive bit runs.

**Application challenge**

The unique extended-reach horizontal shale drilling application has created a new set of specific challenges. Smith Bits, a Schlumberger company, has extensive experience drilling long horizontal sections through sand and limestone, and the logical tendency was to continue the established trend of using matrix body PDC bits for shale applications. However, early in the campaign it became clear that matrix body PDC bits did not perform to operator expectations in the new environment. After field and laboratory analysis, engineers identified several key issues, including bit balling, directional behavior, and tool face control responsible for premature bit failure that prevented operators from optimizing horizontal production zones.

**New shale PDC bits**

From the drill bit perspective, the problem was solved with a fundamental steel-body approach to PDC drill bit design and optimization. Historically, steel-body bits have been aimed at low-cost/low-profile applications with little difference between models and practically no ability to upgrade the technology for a specific application. This has changed with the introduction of Smith Bits’ new Shale PDC Bits.

With well-defined goals and a thorough understanding of the application, design engineers and material specialists re-examined steel-body PDC bits. It was apparent that the steel body would allow designers to successfully address application challenges and provide a cost-effective shale PDC bit solution.

Manufacturing bits from steel gives greater flexibility in the design criteria and allows increased blade heights to optimize the overall blade/body configuration for shale drilling. Due to the generation of large amounts of cuttings, it was critical that the body geometry be configured for their rapid evacuation. This poses additional challenges on the steel body as drilling mud entrained with cuttings can cause steel erosion. The problem was solved using advanced computational fluid...
dynamics that simulated the at-bit flow regime to ensure precise nozzle placement and orientation along with blade contour angles to optimize fluid flow at, along, and above the bit.

Further improvements were made to the specialized hardfacing materials that help protect the steel from the erosive drilling fluid. This focused engineering effort has improved bit life in the horizontal section, allowing operators to drill an entire section with one bit run.

The new extended-reach shale application created an additional challenge for the drill bit: successfully maneuver the drilling assembly horizontally through the shale formation. The use of the positive displacement motor became essential in drilling these wells. Effective tool face control is critical so drillers can effectively “steer” the bit within the shale formation. Previous bits had steerability issues that led to loss of directional control, resulting in poor borehole quality.

**Predicting performance**
The solution to optimize directional bit behavior was accomplished using Smith Bit’s 4-D simulation and modeling tool IDEAS to accurately predict drill bit and bottomhole assembly performance. Using advanced computer workstations running detailed finite element analysis, the modeling tool analyzed the entire drill-string from bit to rig floor. This allowed the design engineer to fine-tune the cutting structure by optimizing blade geometry, cutter positions, and overall length of the bit, delivering maximum ROP potential while ensuring the smooth directional response required to successfully complete the well.

**Performance results**
Combining and updating technology has led to a step change in shale drilling performance. The new bits are setting new performance benchmarks in the Haynesville, Marcellus, and Eagle Ford plays.

In the Marcellus application, the target ROP goal for drilling the horizontal leg with an 8¾-in. bit was 50 ft/hr (15 m/hr). Using the advanced modeling/simulation package, the bit was designed for the application and run successfully, achieving ROPs in excess of 65 ft/hr (20 m/hr), a 30% improvement over the operator-set target. In the Haynesville, a new 6¾-in. steel-body PDC bit has been drilling horizontal sections in a single run at ROPs that are 10% to 20% faster than the best offset performance.

The new generation of steel-body PDC bits is allowing operators to reduce costs and increase overall drilling efficiency in a variety of North American shale applications.