Advances in new drill bit technology moved at an accelerating pace in the past year, as engineers continued to design bits to drill larger, higher-quality holes with better rates of penetration and more control. Shale is still on operators’ minds, and PDC bits are still the tool of choice.

HENRY TERRELL, News Editor

Pathfinder engineers prepare to pick up a Smith Bits Spear drill bit with Onyx II PDC cutters. Photo courtesy of Schlumberger.

Since every trip to replace a bit adds significantly to time and well cost, the focus of new bit technology has been on increased durability, reduced bit erosion and longer runs, whether drilling the vertical, curve or lateral section. As in previous years, several records fell in the categories of both shortened time and increased distance drilled without pulling to surface.

Developments were made in bit customization—it is becoming more and more common to utilize bits that are tailor-made for the particular well. Cutting structure, geometry and other parameters are customized to fit formations encountered and desired well characteristics, and improvements in design software have enhanced efficiency and turnaround time.

Rotary steerable systems (RSS) have also driven improvements in bit design. Roller-cone bits are still a viable choice for many wells, and better, more abrasion-resistant materials are available for robust cutting and high rates of penetration (ROP). Large diameters and greater power requirements have created the need for increased lubricant volumes and larger grease reservoirs. As with PDC bits, designs are adjusted to match the operating requirements and the needs of steerable systems.

There is a small but growing market for drill bits used in non-petroleum drilling, notably geothermal, with its own particular demands. Extremely hard formations and temperatures greater than 350°F have led to increased research into seal configurations and thermally stable greases that can withstand geothermal environments.

Finally, hybrid drill bits, combining the characteristics of roller-cone and PDC technology, are finding increasing use in large-diameter and directional drilling situations.

SMITH BITS

Smith Bits, a Schlumberger company, has continued development of synthetic diamond technology, seeking to advance hard materials science and processes to expand the application of PDC bits into more challenging applications. In 2008, Smith Bits introduced Onyx PDC cutter technology for more efficient drilling in...
harsh formations.

A team of experts from manufacturing, product engineering and R&D were tasked to improve the durability of the original Onyx cutter. This initiative involved a detailed analysis of dull bit condition to document cutter wear, which provided critical information enabling materials scientists to develop new technology to enhance cutter life. This effort was matched by manufacturing specialists who focused on ways to improve diamond press technology to optimize the sintering process and improve diamond-to-diamond bonding. This approach led to the recent introduction of new Onyx II PDC cutter technology.

Bits equipped with the Onyx II cutter (Fig. 4) were compared against previous generations in a controlled laboratory environment. Using component testing facilities, engineers evaluated the cutter/rock interaction on specialized test equipment. To simulate harsh and abrasive drilling conditions, granite blocks were used to exacerbate wear conditions to clearly determine the cutter’s downhole characteristics. In direct comparison to the original Onyx cutter, the Onyx II bit displayed increased resistance to edge wear with significantly less chipping and spalling, Fig. 5.

With laboratory tests demonstrating the increased stamina of the new cutter, the next step was to validate these improvements in field test trials. Working closely with an operator to identify harsh drilling challenges, the Onyx II cutters were brazed into selected PDC designs for field testing. In an application in Sublette County, Wyoming, a 6-in. PDC bit (five blades, 16-mm cutters) outperformed an offset well drilled with original Onyx cutters. The new cutters enabled the bit to drill 4,775 ft in 78.5 hours at a rate of 60.8 ft/hr, compared to the 3,900 ft drilled in 79.4 hours at an average rate of 49.1 ft/hr with standard Onyx cutters. The Onyx II cutters also improved the bit’s dull condition and have delivered estimated cost savings in the application of $850,000 to $1 million per rig per year.

Geothermal. In geothermal drilling, operators face the daunting challenge of penetrating igneous and metamorphic lithologies, including granite and schist. Adding complexity to the drilling challenge is high downhole temperature in excess of 350°F, which can severely reduce bit life and increase drilling costs. In most cases, these hard and abrasive rocks are drilled with a roller-cone bit, but extreme heat reduces on-bottom drilling hours, leading to multiple bit runs that drive up development costs. Elevated downhole temperatures can also exist in deep oil and gas environments, as well as high-pressure/high-temperature (HPHT) wells. The industry requires new roller-cone technology that can endure the extreme downhole environment to increase on-bottom drilling hours while reducing total bit consumption and tripping for bit change out.

To solve the problem, Smith Bits launched a focused initiative to develop roller-cone technology specifically for geothermal applications. The project started with an engineering and research analysis to fully understand the complexity of downhole temperatures and pressures in geothermal wells. Armed with the knowledge gained, a structured effort was launched to develop seal materials and grease formulas that could withstand the rigors of the challenging downhole environments encountered in geothermal drilling.

The development efforts led to specialized fluorocarbon elastomer seal compounds and proprietary grease reservoir components. Specifically, the seals are made from fabric-reinforced materials that provide excellent thermal stability and wear resistance. Laboratory tests show the mechanical properties of the compounds to be well suited for high-temperature environments. To ensure adequate lubricity in the geothermal applications, an innovative high-temperature grease compound was developed from selected synthetic base oils, lithium and various functional additives to increase load capacity at elevated temperature. Lab test results show that the load capacity of the new grease holds consistent up to 500°F, whereas the standard grease load capacity dropped by 75% at 350°F.

The synergistic performance of the high-temperature sealing system was confirmed using a custom-designed test apparatus in an environment that accurately simulates downhole drilling conditions including rotational speed, temperature, pressure, drilling fluids and misalignment of the cone/leg. The new seals and grease formula were recently evaluated during a field test in a European geothermal application with very successful results. A total of three roller-cone bits, equipped with a single seal configuration, were used in the 8½-in. hole section to drill a hard and abrasive granite with average temperatures of 320°F–350°F, with spikes up to 570°F. The three bits demonstrated superior performance compared to standard roller-cone products and came out of the hole in good dull condition.

The last bit run set new field records of 76.5 hours on bottom and 300,000 total revolutions. Overall, the performance of the new seal and grease configuration had a positive impact on run lengths and produced an increase of up to 37% in the number of on-bottom drilling hours compared with the baseline offset bits. The development of a fit-for-purpose...
seal and grease system for high temperatures should greatly improve drilling efficiency in geothermal applications.

CONCLUSIONS
The greatest achievements in new drill bit technology have not been just in materials. New cutters, better metallurgy and tougher lubricants are just a part of the equation. The real results have come from a greater understanding of what a bit does in the real world and the engineer’s ability to simulate realistic conditions in the computer and in the laboratory. As operators find themselves facing new lithologies and ever-changing requirements, engineers are better able to produce bits optimized to meet the new challenges.