TIM BEATON, SHEAR BITS, USA, REVEALS NEW HYBRID DRILL BIT DESIGNS THAT HAVE BEEN DEVELOPED TO PROVIDE ENHANCED DRILLING PERFORMANCE.

GETTING AHEAD WITH HYBRIDS

Figure 1. *Gouging/shearing cutting actions.*

If there is one common theme that pervades the drilling industry, it is one of continuous performance improvement. Every year wells are drilled faster and more efficiently than the year before, and that is a situation that has not changed in decades. A well that required dozens of bits to drill 40 years ago can be completed with 2 - 3 bits today. Some wells that took over a month to complete even a few years ago can now be completed in a week. There are obviously many contributing technologies and developments that have created the environment of efficiency that exists today, in areas from surface equipment to mud systems, but there is no doubt that drill bit technology has also played a key role. This progression of performance has allowed some new applications to become economically viable, and, in the current environment of reduced oil prices, has improved economics in what are now marginal applications.

The most significant development in the world of drill bits that has contributed to the dramatic improvement in drilling performance is the changeover from rollercone bits to PDC bits in most applications. However, it would appear that conventional PDC bits have approached, or possibly even reached their technical limit for market penetration. It is now estimated that approximately 80% of the footage drilled in the world for oil and gas is completed with PDC drill bits. The remaining applications are ones where rollercone bits are either used due to pricing issues (rollercone bits are much less expensive than PDC bits), due to formation issues (many types of rock are not PDC drillable) or due to drilling behaviour issues (in many challenging applications, rollercone bits are still used due to the challenges associated with managing torque fluctuations with conventional PDC bits). Unfortunately, rollercone bits in these applications still carry the same disadvantages that caused them to be replaced by PDC bits in all other applications – slow rate of penetration (ROP) and relatively short life (due to the mechanical limit of bearings and seals).

Figure 2. *8 ¾ in. Pexus hybrid directional bit.*

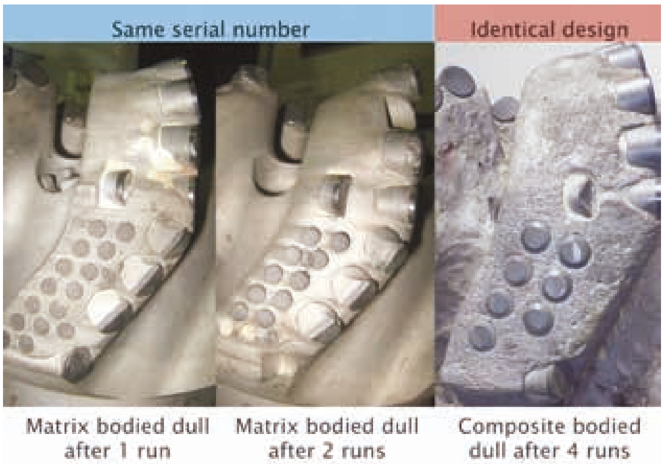

Figure 3. *Comparison of dull photos from bit runs in the Canadian oilsands.*

Figure 4. *10 ⅝ in. Pexus hybrid directional bit.*

Figure 5. *6 ¼ in. Pexus hybrid directional bit.*

Thus, an opportunity exists to positively effect the industry through technology that results in performance enhancement in the applications that still utilise rollercone bits; however, addressing the shortcomings of both PDC and rollercone technologies requires a completely new and innovative approach. SHEAR BITS' Pexus™ hybrid drill bit technology introduces a step change in drilling performance through a unique combination of rock failure mechanisms: gouging and shearing (Figure 1). The rotating and gouging (RNG) inserts remove formation far more efficiently than the crushing mechanism of rollercone bits, and durability is not compromised by the threat of bearing or seal failures. Moreover, the RNG inserts provide greater impact resistance, smoother torque response, larger cuttings and better hole condition compared to shearing cutters alone. The result of Pexus hybrid technology is ultimately an increase in durability and steerability over conventional PDC bits, while still maintaining exceptional ROP capabilities.[1]

New technology

Pexus hybrid bits have been developed to offer the best attributes of various leading industry technologies. In addition to providing enhanced drilling performance characteristics compared to both rollercone and PDC cutting structures, these bits are formed with SHEAR BITS' composite body construction, which offers improved performance compared to conventional fixed bladed body technologies. All conventional fixed bladed drill bits (e.g. PDC drill bits) are constructed either from a steel body or a matrix body. Steel-bodied bits have many drilling performance advantages over matrix-bodied bits, but typically lack the erosion resistance required to maintain consistent durability in challenging applications. The potential performance benefits of steel bodies are therefore unrealised in many situations.

Steel bodies have superior toughness and ductility to matrix bodies, thus making them more flexible to be designed with geometry that maximises junk slot area and optimises hydraulics. This results in bits with taller, thinner blades, which produces higher ROP in many situations, and more interchangeable nozzles (no fixed TFA) to create efficient hydraulic layouts in the field. Another significant benefit to steel body construction is that machined cutter pocket positions are typically 10x more accurate than the cast cutter locations in matrix body bits. This equates to improved load sharing on the PDC cutters in a steel body bit, which produces more reliable performance and more consistent dull condition. With the advanced capabilities that exist today for 3D solid modelling and 5-axis CNC machining, there are few limits on the geometry that can economically be produced in a steel body. Due to all of these advancements, there are now no performance advantages left for matrix-bodied bits over steel bodied-bits other than the longevity of the body itself in highly erosive environments.

In order to take advantage of the benefits of steel-bodied bits while also improving upon the erosion resistance of matrix bits, a proprietary body construction was developed. This new body type, called 'composite-bodied', includes a high strength steel structure and a thick tungsten carbide matrix shell. Because the primary structure of the bit is steel, composite-bodied bits enjoy all the performance benefits of steel-bodied bits. Further, because the tungsten carbide shell contains a higher percentage of carbide than a conventional matrix-bodied bit, the wear resistance of the new body construction is higher than that of matrix bits. As seen in Figure 3, even in bits of identical cutting structure design, the composite body far outlasts matrix bodies in comparable applications. The pictures shown in Figure 3 are of SHEAR BITS' Oilsands Series PDC bit designs that drilled lateral intervals in Canadian oilsands applications. This application is well known to be one of the most challenging in the world with regard to bit body wear, as is exemplified by the extreme matrix loss on the matrix-bodied bit runs.[2]

Over the last 1 ½ years, Pexus hybrid bits have proven to be successful in drilling large diameter vertical surface intervals throughout Western Canada.[1] However, there are many more applications where this technology has already proven to be of significant benefit to drilling programmes. The hybrid gouging/shearing cutting structure has demonstrated smoother drilling behaviour and greater resistance to impact damage than conventional PDC bits, and also higher ROP than rollercone bits. Therefore, in many situations where directional drillers struggle to control PDC bits, or resort to running rollercone bits in order to achieve the directional targets, Pexus technology can deliver improved ROP and durability. Additionally, in applications where the formation is either heavily interbedded or contains significant percentages of conglomerates, chert or pyrite, Pexus technology can enhance performance over conventional bit types.

Intermediate and production holes are commonly drilled with either PDC or rollercone bits, both of which have their own unique set of disadvantages. Drilling with rollercones often means compromising on ROP and commonly requires multiple trips to complete an interval, whereas PDC bits often lack steerability and suffer from durability issues in highly transitional and interbedded formations. Applying Pexus technology in these situations has produced improved performance in hole sizes from 6 ¼ in. up to 12 ¼ in. diameter. In larger hole sizes, such as 10 ⅝ in. to 12 ¼ in. diameter, directional programmes with relatively high build rates can be very challenging with PDC bits due to the torque response that comes along with shearing cutting structures. The total torque output of any drill bit is relative to the diameter of the bit as larger bits require more torque to drill. The fluctuations in torque response from a PDC bit also increase in proportion to its diameter. Therefore, larger diameter PDC bits create both more overall torque and larger swings in torque as they drill. As a result of this situation, as the diameter of the bit increases, the likelihood to perform directional work with a PDC versus a rollercone bit decreases. In other words, in larger hole sizes, it is still more common to drill challenging directional intervals with rollercone bits instead of PDC bits.

In order to tackle smaller diameter build and lateral intervals more effectively, SHEAR BITS has developed a new approach to the Pexus gouging insert layout and blade geometry to incorporate all of the benefits of the technology in bit sizes as small as 6 ⅛ in. (156 mm). Unlike the 'full gouging' layout, where there are gouging inserts in front of every blade of PDC cutters, used in larger hole sizes that has proven to be highly effective in applications that contain large gravel or conglomerates, the design strategy for smaller hole sizes only incorporates gouging inserts in selective regions of the bit. Figure 5 shows an example of one Pexus hybrid design for lateral production intervals. The 6 ¼ in. (159 mm) SHP613D has gouging inserts mounted only in front of the three secondary blades of the bit, and includes six nozzles to effectively dedicate hydraulic energy to every blade of PDC cutters. This layout improves cooling and cleaning around all of the PDC cutters to increase cutter life and ROP, while still providing the durability and behavioural benefits of the gouging cutting mechanism.

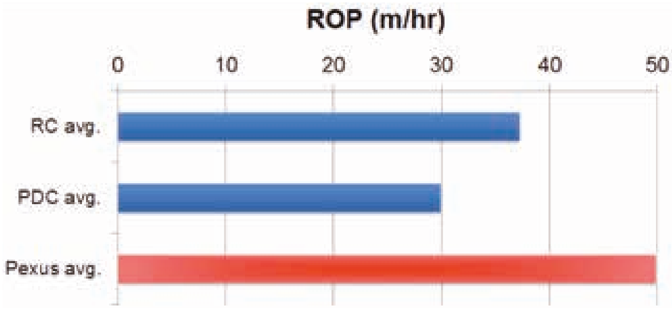

Figure 6. *ROP comparison in 12 ¼ in. oilsands build interval.*

Figure 7. *Dull condition of a 12 ¼ in. Pexus hybrid bit after completing a challenging S curve interval.*

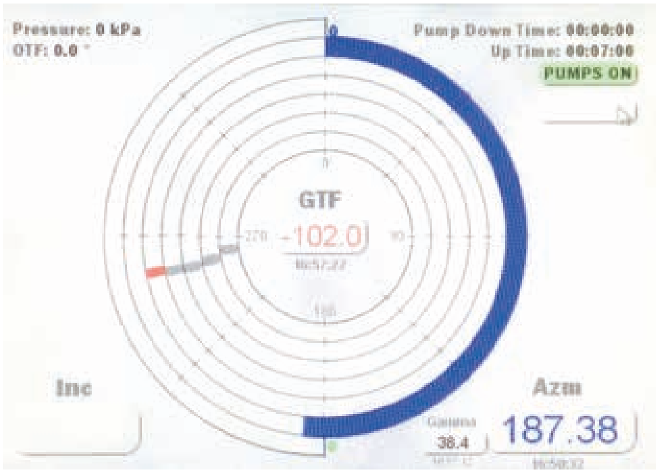

Figure 8. *Photo of toolface plot taken during a slide in the 6 ¼ in. SHP613D run.*

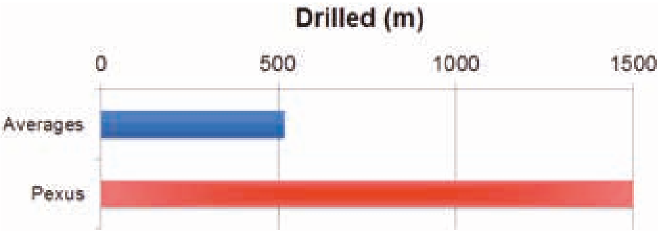

Figure 9. *Comparison of slimhole Pexus durability to close offsets.*

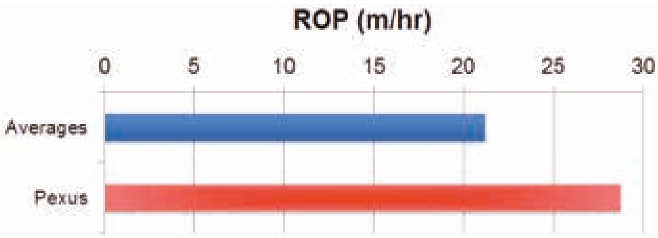

Figure 10. *Comparison of slimhole Pexus rate of penetration to close offsets.*

Case studies

An operator in western Canada drilling a 12 ¼ in. diameter intermediate build section in the Fort McMurray area landing in the oilsands (Wilrich-Bluesky formation) recently introduced Pexus technology to their drilling programme. The immediate area around these wells has been heavily developed, with hundreds of close offsets. Attempts to introduce PDC bits into this application met with very limited success – due to their aggressive torque response, it was necessary to dramatically reduce the differential pressure across the motor to help control the toolface response. Consequently, the ROP for the PDC runs were actually a low lower than the rollercone bits runs, contrary to what is typically achievable by PDC bits. However, the 12 ¼ in. Pexus hybrid bits that were used in this application were able to significantly increase the ROP through the interval while also improving both bit durability and torque response.

As shown in Figure 6, in addition to the cost and time savings resulting from drilling three wells with the same bit and BHA, the ROP achieved with Pexus is over 30% higher than rollercone bits, and 50% higher than PDC bits. This performance increase is a direct result of the smooth drilling behaviour of Pexus hybrid bits, which allows for excellent toolface control even at higher differential pressure and ROP.

In another 12 ¼ in. directional application with a major operator in Alberta, Canada, Pexus hybrid bits were selected to drill S curve intervals where achieving one run from shoe to shoe was proving very challenging. In this application it was not uncommon to require two rollercone bits to complete the interval, and most PDC bits that were tried in these formation were damaged beyond repair. Each Pexus 12 ¼ in. SVP616 hybrid bit that was used in these applications drilled the entire interval in one run at a high ROP, and the resulting dull condition was excellent. As seen in Figure 7, a photo taken at the rig site soon after the run, the dull condition of one particular Pexus hybrid bit was excellent after completing the interval.

To date, over 400 runs have been completed with these hybrid bits, but most have been in larger hole sizes. The vast majority of applications that have experienced this new technology so far have been intervals of 10 ⅝ in. up to 24 in. diameter. This is mainly due to the complexities of downsizing the RNG components. Because each gouging insert is free to rotate as the bit drills, the mechanical aspects of each RNG assembly must be considered when changing to a smaller hole size. The large RNG assemblies used in large diameter Pexus hybrid bits have undergone extensive development since the technology was first introduced to the industry in order to assure excellent consistency, and that same effort is now underway for small RNG assemblies.

In one of the very first runs ever completed with a small diameter design, the 6 ¼ in. SHP613D shown in Figure 5, the resulting performance was impressive. In a lateral application known for significant deposits of chert and pyrite that commonly damage or destroy PDC bits, the Pexus hybrid bit was able to complete the entire interval in one run at the fastest ROP yet recorded by the operator in this area. The directional team on location commented that the Pexus "steered like a rollercone bit" while it drilled further and faster than any PDC bit in the offsets. As shown in Figure 8, the toolface response of the bit was extremely smooth, which allowed consistent directional response to geosteering requirements.

As seen in Figure 9, again mostly due to the presence of chert and pyrite randomly located throughout the interval, the average PDC bit run was barely over ⅓ the length of the interval. However, the Pexus hybrid bit was able to drill the entire section in one run, and was pulled with no damage at all to any PDC cutters.

In addition to drilling nearly three times further than the average of close offset runs, the SHP613D also drilled over 30% faster than the average offset ROP (see Figure 10), and recorded the fastest ROP achieved by any bit that drilled over 1000 m in this formation in the area.

Conclusions

Especially since PDC bits were introduced to the market, the oilfield drill bit industry has experienced rapid technological change that has resulted in continuously improving performance. However, despite some incredible developments in the field of PDC cutters over the past five years,[3] it appears that the market shift between rollercone bits and PDC bits has slowed. Up until very recently, every year brought with it another significant increase in the percentage of rock drilled around the world by PDC bits compared to rollercone bits, but the industry may be approaching the technical limit of what conventional PDC bits can achieve.

Hybrid drill bit technology is creating a new environment for the industry. Similar in many ways to when PDC bits were first introduced back in the mid 1970s, the proliferation of hybrid bits is now creating a step change in performance in many challenging applications. It will be very interesting to see what the next 40 years has in store for drill bit technology.

References

1. Beaton, T., 'A Hybrid Solution', Oilfield Technology, (November, 2014), pp. 45 - 49.
2. Beaton, T., Cyre, J., Isnor, S., and Herman, J.J., New Technologies Eliminate Drill Bit Wear in Oil Sands Applications, SPE 167133 presented at the SPE Unconventional Resources Conference, (November, 2013).
3. Beaton, T., 'When the going gets tough, the tough get going', Oilfield Technology, (February 2014), pp. 20 - 25.