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Increase ROP with PID

Particle impact drilling promises to dramatically increase rate of penetration in hard formations and make more oil and gas bearing formations economically viable.

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The primary purpose of particle impact drilling (PID) is to dramatically increase the rate of penetration (ROP) through intervals where progress is typically very slow and expensive because of the hard or abrasive nature of rock intervals being drilled. These hard or abrasive intervals may only represent a small percentage of the total depth drilled but often account for the majority of the time and expense of the well. An improvement in ROP through these intervals has a significant impact on the economics of drilling in hard rock areas, which include many geologic basins in the United States and around the world. Particle Drilling Technologies believes this level of improved drilling efficiency could open drilling and exploitation of many oil and gas bearing formations in areas previously believed to be uneconomic, including economically deepening current wells to intersect more producing intervals.

There are several other related benefits to using the PID system. The system uses very little weight on bit (WOB) — only 5,000 to 10,000 lb. Most other conventional drilling processes in the target formations require weight on bit ranging from 20,000 to 60,000 lb. Because the PID system drills with relatively low WOB, this greatly reduces torque, drillstring vibration and buckling of the drill string, which can significantly reduce the tendency of well bores to deviate. In conventional drilling, the prevention and correction of deviation problems can be a large additional segment of drilling costs in typical hard rock. We also believe the lighter WOB will ultimately extend bit life, increase footage and reduce time consuming bit trips.

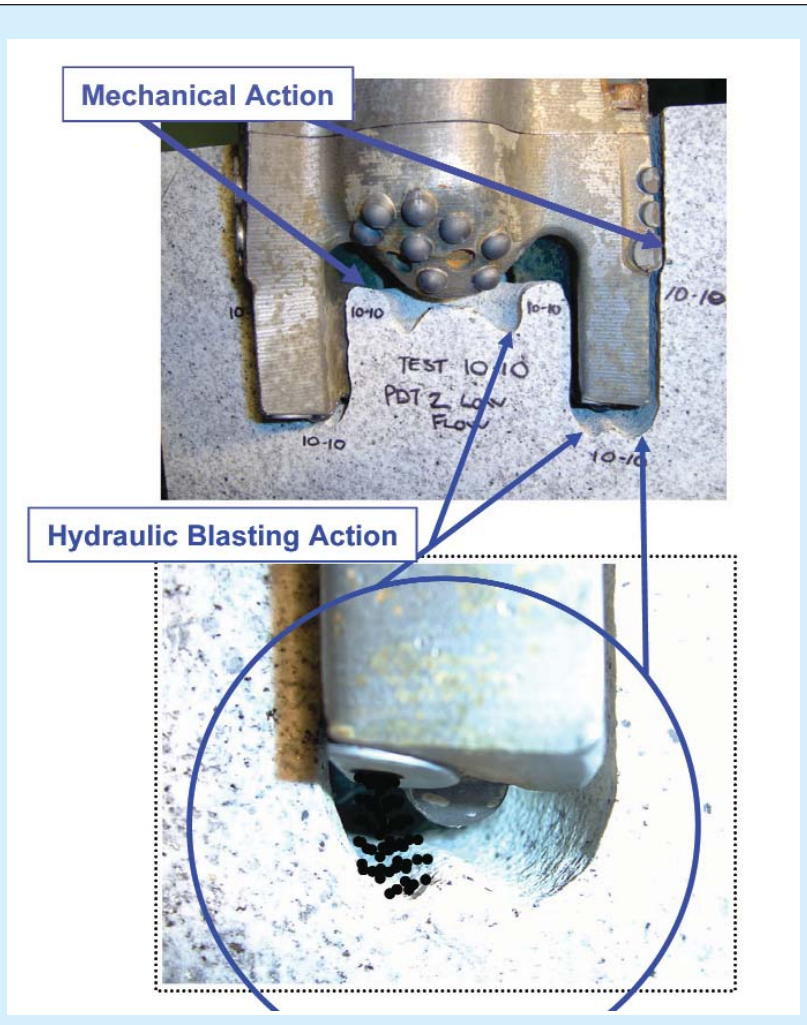

Figure 1. The PID system removes hard rock by blasting it away with small hardened steel particles entrained in the drilling fluid. A center cone breaks the unsupported rock ring in the center portion of the hole by mechanical action. (Images courtesy of Particle Drilling Technologies Inc.)

Current hard rock tools

Rock bits: require high WOB, high torque and low to moderate rotary speed. These drilling conditions typically lead to deviated bore holes, limited bit life and low ROP.

Impregnated bits: require moderate to high WOB, moderate to high torque, high rotary speed (downhole motors and turbines). In most cases the small depth of cut and high rotary speed still only provide low ROP.

PDC bits: better design has led to improved performance. Application areas are being expanded to include

Figure 2. In field tests the PID system drilled hard rock at three to six times faster than conventional methods.

harder formations; however, performance degrades with depth and rock strength, still requires moderate WOB and high torque. Relies on moderate to high rotary speed (downhole motors) to achieve exceptional penetration rates. Borehole deviation and cutting structure life can be problematic.

How the PID system works

PID system personnel and equipment arrive on the drilling location just before the hard rock formation is encountered. The equipment is designed to be integrated on rigs now used to drill in target formations. Primary components of the PID system are:

- Particle injection system — located inline between the rig pump and standpipe;
- PID bit — run downhole and delivers the steel particles at a high velocity to the bottom of the hole;
- Particle recovery unit — installed in the flow line near the bell nipple to recover particles from the drilling fluid before they reach the mud tanks; and
- Particle processing and storage unit — separates particles from the drilled solids and the small amount of returned drilling fluid and serves as storage for recycled particles prior to re-injection.

Once equipment and personnel are in place and the PID bit is tripped in the hole, a small volume of steel particles — representing less than 5% of the total flow — is blended into the drilling fluid by the injection system.

The particle-entrained fluid travels down the drill pipe and accelerates through the nozzles of the specially-designed PID bit, reaching a velocity of approximately 500 ft/sec. The injection rate equates to over 4.5 million impacts per minute on the bottom of the hole, which effectively excavates and removes approximately 90% of the rock being drilled. The force imparted as the steel particles strike the bottomhole occurs over a very small contact area and creates a very large contact stress, which can be orders of magnitude greater than the stresses required to fail the rock.

Cutting structures of conventional bits operate just above the threshold necessary to fail rock even with elevated WOB. This is because the contact area of the cutting structure of conventional bits is much larger and the total applied mechanical energy is limited.

The nozzles of the PID bit are designed to deliver the particles in a specified pattern to optimize the efficiency of rock removal. The PID bit uses synthetic diamond PDC cutters to trim 0.050 in. of the gauge portion of the hole and a center cone that breaks the unsupported rock ring in the center portion of the hole. The rock-ring is continuously formed and removed, and serves to enhance bit stability. Because the formation material is removed by blasting it with steel particles from around the outside and inside of the rock-ring, the rock-ring is relieved of stresses inherent with depth. The strength of the rock is reduced, which makes removal easier. Exceptionally large junk slots allow for removal of particles and marble sized rock-ring cuttings.

At surface, the particles and cuttings pass through the particle recovery unit. This device separates the particles from the drilling mud and cuttings and conveys the material to the particle processing and storage unit. Here, the particles are further cleaned and separated from the small amount of mud and cuttings that remain. At this point, the particles are held prior to re-injection down hole.

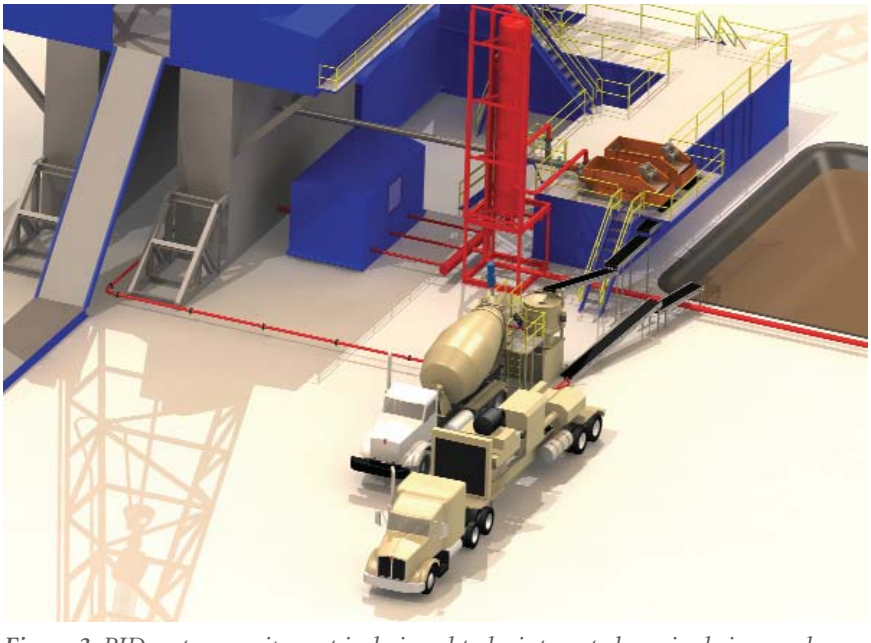

Figure 3. PID system equipment is designed to be integrated on rigs being used today in target formations.

The result

The technology is designed to significantly reduce the time and expense of drilling, which lowers finding and developing costs, improves overall drilling economics, reduces the time to connect production to sales and increases rig footage drilled. This ultimately increases the availability of economic oil and gas reserves. E&P