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NEW HIGH STRENGTH AND FASTER DRILLING TSP DIAMOND CUTTERS

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Abstract

The objective of this project is to develop advanced drilling systems which employ thermally stable diamond (TSP) drill bits. New TSP diamond cutters are to be capable of reducing overall system costs by increasing rates of penetration and bit life in abrasive and hard rock applications. Improved performance of unique TSP diamond cutters has been demonstrated in the laboratory, and field tests are planned. The CSS (continuous shelf sharpening) cutter design produced under this DOE FETC project has demonstrated the potential to double both rate of penetration and bit life. Abrasive and hard rock drilling costs could be reduced by about 15%, and the overall drilling project cost could be reduced by 7.5%. Thus, there is the opportunity to allow economic development of remaining natural gas and oil resources in the U.S., and strengthen the development of the U.S. Drilling Industry.

Summary

The Chinese in the year 1700 BC learned how to drill several hundred feet through very abrasive and strong limestone to reach fresh water supplies. They were able to use natural diamond hand-held cutters developed with new metallurgy. It was the ability to pound a single diamond stone into a suitable brass alloy which composed a tool holder. With this invention, they had a method to hold the diamond and manually impact the rock without shattering the brittle diamond. Many workers would excavate man-sized holes several hundred feet down to gain access to fresh water.

Hundreds of years ago, hard rock was drilled in Pennsylvania using cable drilling tools. Several hundred feet of rock was fractured by the repetitive dropping of a cable suspended steel bar on the formation. Hard rock drilling can be defined as rock which is drilled at penetration rates of less than 3 feet per hour. More definitively, hard rock is formations with a compressive strength in excess of 25,000 psi. Soon after the introduction of cable tool drilling, softer rock was drilled in Texas by rotary drilling using a fishtail drag bit. Custom heat treatments of steel fishtail blades at the rig site created a cutting element suitable for a variety of rock types. Tungsten carbide steel hardfacing replaced steel cutting edges for longer life. After the onset of the Hughes tricone bit 50 years ago, up to 98 percent of the drilling was performed with a more robust roller cone bit. The introduction of the natural diamond bit 40 years ago resulted in up to 2 percent of the petroleum footage being drilled with relatively small diamond cutters.

Twenty-five years ago, the much larger polycrystalline compact diamond (PCD) was introduced as a machine tool. General Electric Superabrasives (G.E.) introduced machine tool grade cutters to the engineering departments of the petroleum drill bit companies and said, here, "make it work." However, no one knew how to satisfactorily attach the PCD to the drill bit. It took years for G.E. to learn how to make the attachment to tungsten carbide, and improve the impact properties for what is now called the polycrystalline diamond compact (PDC) drill bit. Again, it was new material science that created a truly revolutionary new drilling product.

Twenty years ago, the thermally stable (TSP) diamond was introduced by G.E. Just as with the PCD diamond, the petroleum drilling industry did not have a suitable TSP diamond attachment technique in combination with suitably impact resistance. When the TSP diamond became available, the potential advantages were recognized. The TSP has a 1200 degrees C thermal stability compared to 350 degrees C for the PDC. At temperatures greater than 350 degrees C, the PDC wear rate increases exponentially with temperature. PDC diamond is no longer thermally stable at 700 degrees C. Therefore, one limiting factor for the use of PDC drill bits is petroleum drilling applications with higher cutter temperatures associated with drilling abrasive and hard formations.

Today, 65 percent of the petroleum footage is drilled with a roller cone bit and 35 percent with a PDC diamond cutter. About 20 percent of the drilling is using carbide insert roller cone bits. There is over 5,000 kilometers of hard rock drilled a year worldwide. Eighty percent of abrasive and hard rock drilling is done in the continental U.S.A. and 11 percent in Canada. The current hard rock drill bit market forecast is a 7 percent annual growth rate to 2002.

TSP diamond drill bits can potentially increase the rate of penetration in abrasive and hard rock by a factor of two. Resulting efficiency savings could produce a potential drilling product value to the petroleum industry in the range of $200 million to $500 million a year. So, there is a high incentive to develop hard rock drilling technologies in terms of the economy and in terms of what we need to do to reduce petroleum drilling costs.

Currently, Technology International, Inc., with financial support by the U.S. Department of Energy and GRI, has created a unique TSP diamond cutter. The cutter features proprietary MicroWave™ TSP-to-tungsten carbide attachment and wear resistant continuous self-sharpening CCS cutter designs. Current project work is focused on the development of a more fracture resistant TSP diamond cutter.

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