▶ BY KIMBERLY R. PONTIUS

New Veins of Application

The use of PCD-veined drills on difficult-to-machine materials has expanded beyond their initial applications in the aerospace and electronics sectors.

In the late 1980s, the world was introduced to such future successes as Federal Reserve Board Chairman Alan Greenspan, baseball slugger Mark McGwire, aerobics and Rogaine. In the same timeframe, the metalworking industry witnessed the debut of PCD-veined drills. Like Greenspan and McGwire, there were strong hints of promise for the technology, developed and patented by Precorp Inc., Spanish Fork, Utah, under the tradename Dia-Edge. And like aerobics and Rogaine, years passed before the tools attained a level of credibility in peoples' minds.

Today, drills constructed with powdered polycrystalline diamond sintered into grooves along their flute lengths are more recognized. However, what may be less familiar is the expanded application of these tools. From initial sporadic use in the manufacturing of aerospace and electronics parts, PCD-veined drills now are regularly implemented in those as well as the automotive and medical industries, and the types of applications are increasing daily.

"Diamond is known for being the hardest material," explained Rich Garrick, president of Precorp, "but it also has the lowest coefficient of friction, which makes it a wonderful cutting tool material."

Photos: Precorp Inc.

An excellent application for PCD-veined drills is machining of 390 aluminum, which is used in transmission valve bodies.

Times Change

Though the PCD-veined moniker may be a little misleading at first blush, end users of the product are hard-pressed to come up with a better name. The drill starts as a carbide blank into which a small groove or slot is formed. PCD in its pure powdered form is then mixed with a binder and sintered into this void during a process that compresses the powder at a reported 2,700° F and 876,000 psi.

To create PCD-veined drills, standard grinding practices are married with an orientation process that generates the helix and flute designs. Precorp says this process allows the production of rotary tools down to 0.0157" in diameter. These processes make the drills suitable for high-speed, high-throughput machining operations, particularly in the composites industry.

The finished PCD-embedded blank, referred to as a nib, is then brazed to a carbide blank a good distance from the cutting edge, depending on the drill diameter. This creates the specified length of the tool to be completed.

The spacing of the braze interface keeps it away from the heat generated in the cutting zone, thereby aiding the integrity of the bond. This strategy is key since the Achilles heel of a diamond tool is the integrity of the braze. This feature alone can be reason enough to explore the application of a PCD-veined drill against a more common PCD-tipped variety.

A conventional PCD drill is fashioned by pocketing the drill tip and brazing a piece of PCD film, backed with carbide and cut from a puck using a wire EDM, in the pocket. There were very few shops—Precorp being one—that would attempt such a tool in the late ’80s. Those that could do it successfully were even fewer.

In the early ’90s, this writer applied PCD-tipped tools to drill locator holes in automotive pistons that were foundry-molded from a hypereutectic aluminum alloy (12 percent or higher silicon content). PCD had to be employed to achieve an acceptable tool life.

Drilling 3,500 pairs of drive holes before resharpening was common. In fact, drilling 10,000 pairs of holes was possible.

Precorp uses a seven-step process to produce its DiaEdge tools. The process begins with a solid-carbide blank, which is then slotted. Diamond powder is inserted into the slot of the blank. The blank is then placed in the company’s press and subjected to 2,700° F and 876,000 psi to compress and sinter the powder into what is now called the nib. The nib is then brazed to a solid-carbide shank. The geometry is then ground to produce the finished PCD-veined tool.

However, lead times for the tipped drills were considerable. So was the cost per unit.

In addition, failure of the brazing due to heat buildup at the cutting edge was not uncommon. Total destruction was almost always assured when a failure did occur. These latter problems could have been rendered moot had PCD-veined technology been employed.

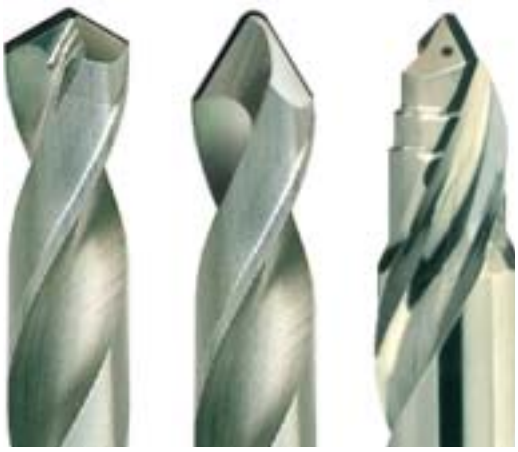
Taking Flight

Precorp’s DiaEdge PCD-veined drills were originally designed for the electronics and aerospace industries, but further application testing has brought this technology to the attention of other industries. The tools now drill green carbide, aluminum MMCs, reinforced-ceramic composites and various grades of aluminum. Applications for the drills include automobile engine blocks and transmission bell housings and wing spars for advanced tactical fighter jets.

“We used to drill 65' of spar in 16 hours with carbide,” explained Ken Kuhlman, a process design and test engineer for a domestic aircraft manufacturer. “Now, we do the same in 4.5 hours.”

Wing skins constructed out of a very tough resin composite must be drilled. One set for the F-22 fighter jet can require 3,500 holes per wing surface. Considering both upper and lower surfaces, this equates to 14,000 holes per set of wings. Cost per hole and drill uptime are key cost factors in seeing the advantage of PCD-veined drills.

Because engineers love a “bullet-proof” application, the PCD-veined drills were added to the programs for the B-2, A-6 rewing and 777 Stabilizer/Empennage aircraft.



Examples of the intricate drill point geometries possible with Precorp’s PCD process.

Cost per hole is always a major consideration when it comes to diamond drills. Diamond drills—many times the cost of conventional carbide drills—can only be cost-justified by the extended life of the tool and the machine uptime they afford. This same criteria holds for a PCD-veined drill when compared to a conventional PCD-tipped unit. If the possibility of tool failure can be reduced considerably, then the veined drill becomes a distinct improvement in the process. Since both technolo-

gies are driven by customer need, it is difficult to ascertain which direction, veined or tipped, would be the most cost-effective. A thorough examination of the material and the integrity of the process is vitally important. Working closely with the tooling manufacturer to establish needs is the best way to achieve customer satisfaction.

For instance, Honda Transmission Mfg., Russell's Point, Ohio, had success with a PCD-veined drill/reamer Precorp now calls the One Shot in honor of the productivity improvements the automaker realized from its use. The tool has allowed what was formerly a three-step process to be reduced to one.

At last count, the tool machined over 300,000 holes for the transmission manufacturer, lowering production costs and improving quality and uptime.

The Mother Lode?

Precorp's primary market for the PCD-veined drill traditionally has been in the aerospace industry, where the drilling of carbon-fiber-reinforced plastics proliferate. In such processes, edge sharpness is critical. A dull tool could lead to tearing out of the fibers, thereby deteriorating the integrity of a hole's edge. Using a relatively sharp point angle with veined technology lowers the thrust of the drill and allows the cutting edge to cleanly trim fibers at the hole exit.

Recommendations for the speed and feed for CFRPs come straight from extensive application knowledge. Fairly light feeds (0.001 to 0.002 ipr) to prevent delamination and excessive speeds (more than 300 to 600 sfm) will generate heat, causing an undesirable melting of the resin. Flood coolant is favored, but drilling dry with a good vacuum system yields positive results, too.

And the proof is in the pudding. Compared to a standard 118° PCD-tipped tool, the PCD-veined design produces three times the number of holes. It delivers six times more holes than a PCD insert drill, and 100 times that of a carbide tool.

As new applications for high-speed machining are implemented in the marketplace, further use of PCD-veined drills and other rotary tools will emerge, since spindle speeds in excess of 10,000 rpm have little effect on diamond in a rigid machine.

Numerous CFRP automotive applications seem to be emerging by the day. For example, General Motors Powertrain Div., Willow Run, Mich., is running a drill it refers to as a "free drill." The tool drills a cross hole in a transmission bell housing. When the carbide drill dulled, it left a burr. Though five times more costly than the carbide drill it replaced, the PCD-veined drill only gets changed once a year vs. replacement of the old drill on a nearly daily basis. A GM engineer on the job asserted that an individual PCD-veined drill could be used to make even more holes. The cost savings of the changeover from carbide renders this point moot.

Precorp's high-temperature, high-pressure press can achieve pressures of 3 million psi and temperatures of 3,632° F.

Robert E. Morris Turbine Group, a Farmington, Conn.-based company that machines carbon-carbon aircraft brakes, just finished a successful run of a machine operation tooled with a PCD-veined product. In fact, drilling MMC braking materials is becoming a major application for this tool technology in the automotive sector.

Alcan, a leading manufacturer of MMCs, recommends the Precorp drill by name in its machining guidelines for its Duralcan USA division, San Diego, Calif., composites. While silicon-carbide or aluminum-oxide particles improve the composites' mechanical properties dramatically, they also accelerate tool wear during machining. Alcan says the most effective tool "by far" is diamond. "The unique construction (of Precorp's tools) offers the ultimate in abrasive-resistance, dimensional accuracy and surface finish. Reaming is not usually required after using these drills," the guidelines stated.

Kuhlman, the engineer at the aircraft manufacturer, added, "We have been using (Precorp's) products since 1990. They are the baseline against which we test all others."

Machine shops of all sorts may start thinking in that same vein.

For more information about PCD-veined drills and other tools, call Precorp Inc. at (801) 798-5425, visit www.precorp.net or circle ***Information Services #325****.*

About the Author

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