▶ BY JIM KENT, TECHNIDRILL SYSTEMS INC.

THREE DEEP

Tooling and equipment options for deep-hole drilling cost-effectively.

Any hole with a depth-to-diameter ratio of more than 4:1 is generally considered "deep."

To drill that deep with a conventional drill, such as a twist drill, several cycles, or pecks, would be required to clear chips from the flutes of the drill. This is because a twist drill augers chips out of the hole by cutting and pulling them out using the tool's spiral flute. Pecking is necessary to clear chips from the hole and flutes.

With drilling tools designed specifically for producing deep holes, a hole can be produced in one pass. This is because a deep-hole drill allows high-pressure coolant to flush chips from the hole being machined. Depth-to-diameter ratios of up to 300:1 can be achieved in one pass.

The three main methods of deep-hole drilling are gundrilling, BTA and ejector.

Musket Making

Gundrilling is the most-established process for producing deep holes. It was first used more than 100 years ago to make, as the name implies, gun barrels. Although numerous manufacturers still gundrill deep holes with antiquated equipment because the machines are paid for, today's refined machinery and cutting tools have made gundrilling a reliable high-production method for drilling deep, as well as shallow, holes.

All images: TechniDrill

This counter-rotating gundrill has a 48" stroke and machines 1.25"-dia. holes.

The gundrill consists of a hollow tube with a V-shaped groove, or flute, along its length. The flute area equals 22 to 26 percent of the hole area. Because this area is greater than the flute area on a twist drill, a gundrill cuts three to five times faster.

The gundrill's carbide cutting tip is designed to serve as its own guide bushing and be self-piloting as it drills. High-pressure coolant—2,000 psi or higher—is introduced via a variable-volume, pressure-compensated pump into the center of the drill tube through the spindle of the gundrilling machine to break and forcefully eject chips from the hole. The coolant also lubricates and dissipates heat.

In terms of relative motion, there are three possible gundrilling methods: The gundrill rotates and the workpiece is stationary, the workpiece rotates and the gundrill is stationary, and both the tool and workpiece rotate.

The first method is used when the workpiece's shape is not suitable for rotating. The second is appropriate when the workpiece has a shape that allows it to be accurately clamped and

rotated at a high speed.

With the third method, the workpiece and gundrill normally rotate in opposite directions. This approach usually is chosen when gundrilling with small-diameter tools or to reduce runout (by half) when producing tight-tolerance parts. There always will be some runout with gundrilling because the tool wants to climb high and to the right. By counter-rotating the tool and workpiece, the tool's tendency to climb in one direction is eliminated because the relative position of the tool to the workpiece is always changing.

A gundrill can produce holes as small as 0.031" in diameter. This holemaking technique can provide tight-tolerance, straight holes with fine surface finishes, which may eliminate secondary reaming or honing operations.

Turn to the Tube

Initiated in the 1930s in Germany and named after that country's boring and trepanning association, BTA is also known as the single-tube system for deep-hole drilling. With BTA drilling, coolant is introduced to the drill tube at the pressure head, and chips are evacuated through the center of the drill.

The amount of area in the BTA tool to clear chips represents more than 60 percent of the hole's area. With more area to clear chips than a gundrill, a BTA drill offers a higher penetration rate into the workpiece and, therefore, is able to drill seven to 10 times faster than a gundrill.

A 0.032"-dia. x 1.25"-deep gundrill was applied to make this dental drill.

The detachable drill head is comprised of individual carbide inserts and guide pads. Holes from 0.500" to 15.000" can be produced with this type of system. In general, it's not recommended to machine holes smaller than ½" in diameter with a BTA drill because the required tool would be too delicate.

When BTA drilling, the workpiece is pushed tightly against the drill bushing, creating a seal that holds in the high-pressure cutting fluid. Minimum fluid pressure, as the drill head enters the workpiece, is about 225 to 250 psi. The constant-volume pump automatically increases the pressure, in some cases above 1,400 psi, as the tool drills deeper.

A BTA machine has many times the horsepower of a gundrilling machine and, not surprisingly, costs 25 to 35 percent more. Depending on the application and number of parts being produced, a single BTA machine—with its increased holemaking productivity—can replace a number of gundrill spindles.

Third Generation

The ejector, or two-tube, drilling machine is similar to a BTA system ex-

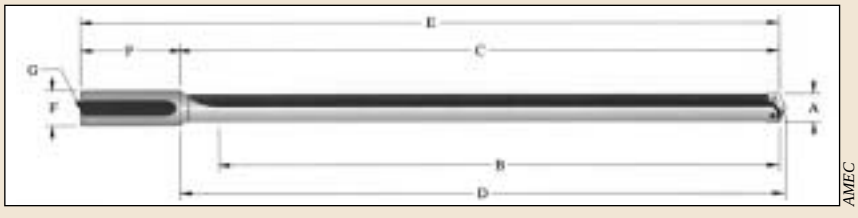
Boosting penetration with spade drills

Some wouldn't consider using a spade drill for deep-hole drilling.

Nonetheless, many end users replace their gundrill, ejector head or BTA head with a spade drill insert held in a straight-shank tool body with a single straight flute when looking to increase the penetration rate, said Eric Tope, product manager for Allied Machine & Engineering Corp.

One such tool is AMEC's T-A drilling system. According to Tope, it "can provide increases in the penetration rate of two to three times."

The Dover, Ohio-based toolmaker offers standard tools from its T-A drilling system to drill holes with depth-to-diameter ratios up to 32:1 and has built specials to drill in excess of 60 diameters deep. Inserts are available to drill diameters from ⅜" to 4½".



AMEC

AMEC has built a T-A drill to make a hole up to 60 diameters deep. A = insert range, B = maximum drill depth, C = flute length, D = reference length, E = overall length, F = shank diameter and length, and G = pipe tap.

When using the company's extended, long, XL and 3XL holders without a support bushing, AMEC recommends using a short holder to establish an initial hole 2 to 3 diameters deep. "With our tool, no special skills are required to drill deep holes, only a competent operator [who] understands the machining parameters," Tope said. "If he can drill short holes, he can do deep holes."

High-pressure coolant is usually required to effectively flush chips out of the hole, because failure to evacuate chips is a limiting factor in increasing the penetration rate. However, Tope noted that at least one AMEC customer is running shop air through the tools to drill extremely deep holes in cast iron.

Whatever method is being used to evacuate chips, he emphasized that when deep-hole drilling, it's critical "to form the chip and get it out of the hole."

—Alan Richter

For information about AMEC's T-A drilling system, call (800) 321-5537 or visit www.alliedmachine.com.

cept that it incorporates an inner and outer tube. Coolant is introduced at the spindle via a rotary connector and passes between the two tubes. Chips exit through the inner tube.

The inner tube chip-clearance zone represents 35 to 40 percent of the hole's area. The minimum hole diameter is limited to about 0.750", because there is less room for chip removal in the smaller-diameter tube compared to a BTA drill. (Ejector drilling holes smaller than 1" is not recommended.)

The ejector system, which is often adapted for use in lathes and machining centers, performs well when the part face is irregular or not machined square. This is because the rotary connector and drill head are designed to create a Venturi effect, which causes coolant and chips to be drawn through the inner tube without a tight seal between the part and bushing, as is the case with BTA. About 60 to 70 percent of the coolant enters Venturi slots to create suction and the rest is directed toward the drill head to cool and lubricate it. In addition, ejector drilling does not require pressure as high as BTA drilling. The cost of an ejector machine is about the same as a BTA machine.

Similar to the horsepower requirements for a BTA machine, an ejector machine needs about 11 hp per inch of hole diameter. Therefore, drilling a 3" hole would require a 33-hp machine. However, an ejector machine is limited to drilling holes about 100 diameters deep.

With more area to clear chips than a gundrill, a BTA drill offers a higher penetration rate into the workpiece and, therefore, is able to drill seven to 10 times faster than a gundrill.

Which is Best?

Many factors are involved in choosing the right deep-hole machine and tooling.

In general, gundrilling is the only choice for diameters below 0.500", although some toolmakers offer BTA tooling slightly smaller than this.

For diameters larger than 2.00", BTA or ejector drilling is recommended.

For diameters 0.500" and above, gundrilling may be more economical than BTA, strictly on a cost-per-hole basis.

However, when high production rates are required, the number of spindles and initial equipment cost will be as much as three to five times higher with a gundrill. Other factors to consider are the number of operators required, time needed to change and regrind tools, and the amount of floor space required.

When it comes to selecting the tooling for drilling deep holes, an end user has options. The most profitable machine and cutting tool for the job is determined by running tests to find the number of parts that can be produced per tool, combined with the cycle time and the quantity required.

Even an ancient gundrill machine has its place if, say, only 50 parts are needed each month. But if thousands are needed, it makes economic sense to use a BTA machine.

However, because an ejector drilling machine does not require pressure as high as a BTA machine, cost savings can be realized. This is based on a lower machine price and reduced operation/energy costs.

A 2.00"-dia. x 50"-stroke BTA machine was used to drill alternator shafts for power generators.

About the Author

Jim Kent is president of TechniDrill Systems Inc., Kent, Ohio. For more information about the company's deep-hole drilling machines, call (800) 914-5863 or visit www.technidrillsystems.com.