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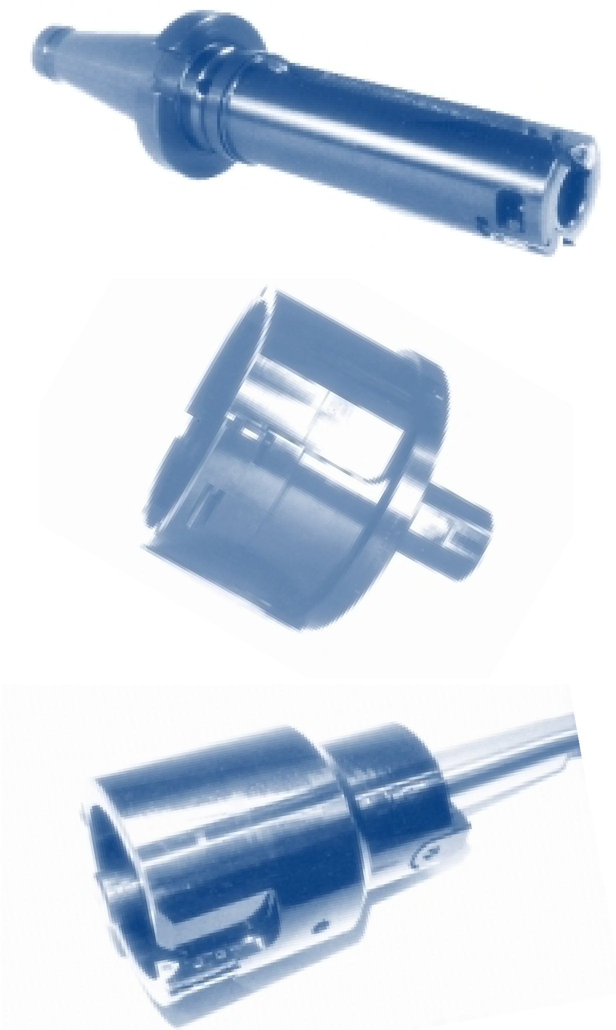
BY JOHN SHAFFER

Trepanning—another way to produce deep holes.

DEEP Done Differently



A few examples of trepanning tools. During trepanning, a hole is cut with the hollow rotary tool and a center core, or slug, is removed in one cylindrical piece.

Over time, many methods have been utilized for deep-hole drilling. Most of them, including drilling with solid or indexable-insert drills and interpolating with a center-cutting endmill, consume excessive machine power and waste material. A more cost-effective and accurate method is trepanning.

During a trepanning operation, a hole is cut into a workpiece with a hollow rotary tool and a single center core, or slug, is removed. This differentiates trepanning from conventional drilling, where all the material removed is in the form of chips.

Deep-hole drilling is defined as an operation having a depth-to-diameter ratio greater than 5:1. While the principles are the same, this article will focus on holes with depth-to-diameter ratios up to 3:1 and diameters to 12".

Large Holes, Tool Design

Trepanning is the most efficient way to create large-diameter holes and may be the only way to produce an adequate deep hole. The constraints of other drilling methods often do not allow for the accuracy required in deep-hole drilling.

Generally, trepanning is the most economical, accurate and efficient method for creating holes measuring over 2" in diameter. Because trepan cutters don't remove all the metal from a hole and leave a slug, less horsepower is needed to make the hole. The narrower the width of cut, the less horsepower is consumed, the less pressure is exerted and the larger the slug. But there are practical limits. As the cutting thickness narrows, the risks rise that either the cutter body or insert will fail.

The center slug cut during a trepanning operation can be used for core-sample testing or to produce other parts, which is especially important when machining expensive, exotic alloys.

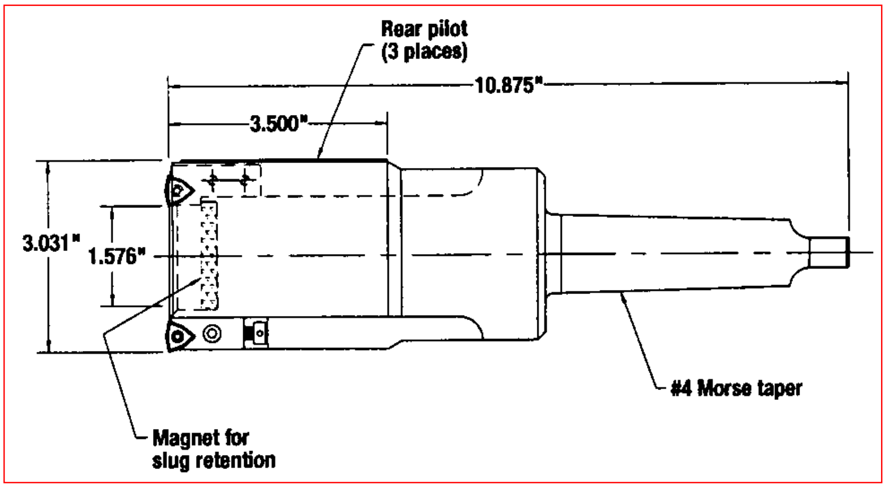
Trepanning is usually done on general-purpose equipment, such as horizontal lathes, machining centers and boring mills. Special-purpose machinery may be necessary for creating holes that are very deep and/or have extremely large diameters.

Trepanning tools are essentially hole saws with one or more cutting blades. Most often, two opposing stations are utilized: one performs an interior cut and the other cuts on the outer diameter of the core. Opposing guide bushings, or wear pads, typically are used to reduce tool deflection and create a straight, precise hole.

Other trepanning tool designs include inserted-blade types and ones that accept indexable inserts, usually mounted in cartridges. The cutting tool material is either solid HSS or solid carbide.

Several manufacturers produce standard trepanning tools, from 1¾" to 10" in diameter. These cutters are comprised of standard inserts and cartridges. Many manufacturers also offer special-purpose trepanning tool bits to fit their particular holder designs. In all trepanning applications, a high point on the cutting tool must start the cut.

For unique trepanning applications, cutters can be designed around standard components, be produced in many configurations and incorporate different drive mechanisms and coolant-delivery systems. A "load meter" often helps monitor down-hole conditions, detecting insert wear or chip packing before damage occurs to the tool or workpiece—or both.



A trepanning tool with a magnet for retaining the metal slug after its been cut.

Process Fundamentals

As with other special-purpose operations, trepanning is part art and part science. There are several factors that may impact tool performance, including the condition of the machine and workpiece, rigidity of the fixturing and quality of the tooling. However, the most important considerations when trepanning are chip formation and control. Ignoring these aspects of the operation could degrade tool performance or workpiece finish.

The feed and speed rates should be adjusted to control chip formation. The goal is to create small, uniform chips in the shape of a "6" or "C." Cutting blades or inserts should have preformed or ground chipbreakers, which help create a uniform chip. Long, stringy chips—the kind commonly produced during standard drilling procedures—have a tendency to pack up. But by maintaining a constant feed rate throughout the cut, a consistent chip shape is formed, thereby enhancing chip evacuation.

A chip-disposal system also may aid in controlling chips. These systems typically have a chip conveyor or a chip cart with baskets to move the discarded chips without interfering with the cutting action. The operator should be sure to address the chip-handling issue prior to beginning an operation, because of the high rate of chips produced during trepanning.

Because of the blind nature of the cut, applying coolant is critical to effective trepanning. Although oil-based coolants help impart the best finishes, they tend to be messy and costly to dispose of. Conversely, synthetic coolants extend tool life, disperse heat more effectively and allow faster operating speeds than oil.

Whether the trepan tool removes chips internally or externally, coolant must be applied in sufficient volume (as measured in gpm) and pressure (as measured in psi) to cool both the workpiece and cutting tool, lubricate the tool/workpiece interface and flush away chips.

Greater volumes of coolant should be delivered at higher pressures as the hole diameter and depth increase. Very wide and/or deep holes may require delivery rates of several hundred gallons per minute and extremely high pressures. For most applications, the recommended coolant temperature is about 100° F.

A coolant filter removes chips and other foreign materials from the coolant before it's returned to the coolant tank. Since it's important to maintain a film of coolant between the tool and workpiece, it's vital that the filtration system removes all particles so they don't enter the cutting zone.

Working Methods

There are three different ways to trepan. Each offers benefits and advantages. The operator should choose the method that best suits the application.

The first method involves a stationary tool and rotating workpiece to produce straight and accurate bores. This method is primarily for machining long, symmetrical workpieces where the diameter of the desired hole is nearly the diameter of the workpiece.

The second method involves a rotating tool and stationary workpiece. This method is recommended when drilling irregularly shaped workpieces. However, the level of accuracy is not as high as the stationary-tool/rotating-workpiece method.

The third method is a counter-rotation strategy, with both the tool and workpiece rotating in opposite directions simultaneously. When accuracy is vital and the workpiece can be rotated, this is the method of choice. Counter-rotation is excellent for trepanning irregular-shaped workpieces and for producing small holes in workpieces with abnormally large ODs. It's also ideal for machining aluminum alloys, in which trepanning can only be accomplished at ultrahigh surface speeds.

Core removal is an issue regardless of which method is applied. The capture and removal of the "hanging" core is vital for all trepanning operations—not just when the hole is extremely deep. In horizontal operations, the weight of the core can press on the inside of the cutting edge or, if the core is left unsupported, can drag along the tool's ID and damage the cutter and/or machine. There is usually no problem in vertical machining, since the core drops freely.

About 10 hp is recommended for each 1" of cutting diameter. Often the success of the operation depends on the design and quality of the machine tool. When choosing trepanning components, evaluate the machine, cutting tool, the cutter's supporting and guiding accessories, and coolant requirements. Only a skilled operator with a firm grasp of the operation's principles can produce acceptable trepanning results.

For trepanning guidance, consult the manufacturers' feed and speed charts for various diameter sizes and materials.

American Heller Corp.

Trepanning tools come in many sizes. This large cutter was developed to cut a ½" depth off of a 22"-dia., 22'-long shaft and a 1" depth off of the gear bore for a mining operation's drag-line, hoist-drum bull gear.

Benefits

Among the benefits of trepanning as a method for producing deep holes are:

- Cycle-time improvements of up to 75 percent vs. conventional drilling.
- Reduced wear and tear on the machinery, since the operation requires less horsepower.
- Reduced product waste—the removed core can be used for other purposes.
- The creation of wide, deep holes with optimum chip formation and disposal.
- Hole-straightness accuracy to 0.001 to 0.002 in./ft. of depth.
- Surface finishes to 32 rms.
- Easy machining of irregular and bulky workpieces.

For deep-hole drilling projects that demand a high level of productivity and accuracy, trepanning—clearly—is a cost-effective approach.

About the Author

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