JULY 2001 / VOLUME 53 / NUMBER 7

▸ BY ALAN RICHTER, MANAGING EDITOR

Looking at the advantages of button cutters, particularly for high-speed machining.

TaeguTec

Shapely and Strong

Q. The circle isn't just another pretty shape when it comes to indexable inserts; the round, or button, shape offers the greatest geometric strength for indexable cutting tool inserts.

As the included angle of an insert increases, so does its edge strength, until the strength reaches its theoretical apex with the round shape. At this point, the round insert's inscribed circle equals the cutter's diameter (Figures 1a and 1b).

Based on the design and geometry of the round insert, cutting tool manufacturers have been steadily promoting and selling milling cutter bodies that accept round inserts as a way to reduce costs and increase productivity. As a result, die and mold makers are applying more round-insert button cutters, replacing their ballnose endmills, said Paul Chen, marketing manager for the mold and die industry at Ingersoll Cutting Tool Co., Rockford, Ill.

"From a roughing standpoint, the use of ballnose endmills has been reduced dramatically and has been replaced by the use of round-insert facemills," said Chen. "But I don't see it completely replacing the ballnose because of the valleys and grooves that a button cutter cannot get to; you still need a ballnose endmill."

Richard Walker, senior application engineer for Dijet Inc., Plymouth, Mich., concurred that a button cutter with two round inserts can replace a ballnose endmill only up to a certain point. He added that unlike a ballnose, a button cutter cannot cut on its center tip—because it doesn't have one. This makes it impossible for a button cutter to be applied correctly in a tight, convex application. But that doesn't stop end users from applying button cutters where they make sense, which typically means high-speed machining. He said the button cutter is designed for a lighter DOC at higher speeds than a ballnose endmill.

"I believe 80 to 85 percent of the time, customers who are going into higher-speed machining will go for a button cutter, because it's easier on the spindle. It exerts half the tool pressure compared to the old-style indexable ballnose," Walker said.

The button cutter's reduced tool pressure is especially critical when running at higher speeds and feeds on newer, lightweight, high-speed machining centers, which are becoming prevalent, he said. "The reason for the growth in the popularity of button cutters is that there are a lot of start-up shops that are buying the lightweight, high-speed machines, which are less expensive. The spindles are a lot lighter and button cutters are a lot easier on those spindles."

He added, "A lot of machines being made can't handle a 2"-dia. ballnose, but they can handle a 2"-dia. button cutter."

The applications for two-insert button cutters and ballnose endmills overlap when the tool's diameter is ½", with button cutters being more economical from ½" on up and the ballnose's realm being in the opposite direction, said Stephen Jean, milling systems manager

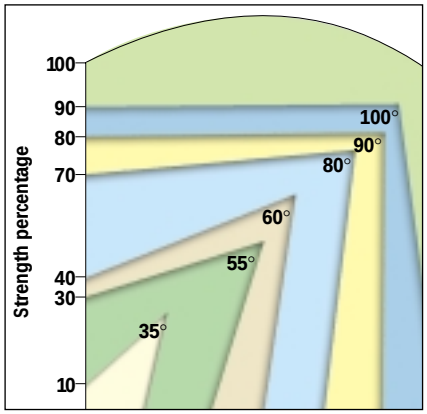

Figure 1a. An indexable insert's relative edge strength increases as its included angle increases.

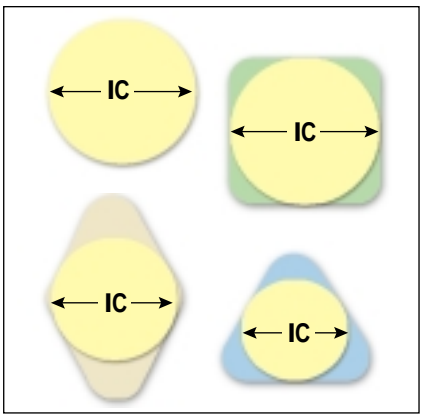

Figure 1b. An insert's size is determined by its inscribed circle, with a round insert's IC equal to its diameter.

for Emuge Corp., Northborough, Mass.

"Both ballnose endmills and button cutters are necessary, because at a certain diameter it becomes impractical to use round inserts," he said.

Jean noted that the die and mold industry is a primary target for button-cutter manufacturers because the 3D shapes moldmakers create out of hardened materials—45 HRC and harder—lend themselves to being machined with round inserts. He added, with button cutters, the speeds and feeds are tailored to where the cutting is actually taking place.

One problem with a ballnose endmill is that the tool's center-axis tip provides no surface speed, but exerts a high force on the workpiece, causing the tool to push material away rather than cutting it, he said. In contrast, a button cutter doesn't have a zero-surface-speed point, therefore, the cutter's surface speed is more constant. In addition, its life is increased, since it doesn't experience severe rubbing.

Jean said Emuge promotes a "step-down" approach to machining. This means the machining process starts with the largest-diameter tool to quickly remove most of the metal, leaving the least amount of residual material on the workpiece as possible for the next milling tool to remove.

"The round insert leaves the least amount of material of any geometric shape," Jean said. He added, "Faster is always better, as long as the quality is there."

Increased Indexability

In addition to increased edge strength and reduced spindle pressure, another advantage a two-insert button cutter has over a ballnose endmill is that the round insert can be indexed many more times than the ballnose insert, which can only be indexed once or twice. This, of course, significantly reduces a shop's tooling cost.

Chen explained, "If, for example, you take a 0.100" DOC with a round-edge insert with a ½" IC, you may have eight indexes. And if you take a 0.050" DOC or less with the same insert, you may have 12 indexes or more.

"With an indexable ballnose endmill, you only get two indexes, and for some small-diameter ballnose tools, you may only get one."

Jean also noted that round inserts can be indexed more times than other types. He added that the number of indexes can be calculated by dividing 360 (the number of degrees in a circle) by the insert's center-point angle to where it interfaces both sides of the workpiece. For example, if the center-point angle is 38°, then the number of available indexes is 9 (360/38=9.47). In addition, the number of possible indexes varies depending on the insert's DOC. For example, more indexes are possible when machining hard steel, because the DOC is minimal.

Therefore, the per-index cost of a round insert is less than a ballnose insert with up to two indexes, because the button cutter's insert can be indexed eight or more times.

"With a round insert, you can control the number of indexes that you want in terms of the effective depth of cut you take per operation," Chen said.

Coolant Issues

When producing mold and dies with button cutters, dry or near-dry machining isn't an option—it's generally a necessity.

"You can push the button cutter a lot faster, because the heat stays in the chip, leaving the part cooler," Walker said. "For 95 percent of the roughing and semiroughing applications, you want to run dry, with maybe a misting of oil."

Chen said he doesn't recommend ap-

Helical Interpolation Shop Practices

▸ BY EARL WILKERSON

The following practices are followed at my shop when helical milling with round inserts.

We mill holes 3.00" in diameter or larger with a copy mill.

We stock three basic types of copy mills, which accept 0.472"-, 0.750"- and 0.787"-dia. round inserts. When helical interpolation is needed, the copy mill with 0.787"-dia. inserts is the first choice, the copy mill with 0.750"-dia. inserts is the second choice followed by the copy mill with 0.472"-dia. inserts.

When helical milling to produce a hole in a solid material, the depth per revolution should be equal to 10 percent of the insert's diameter. For example, when the 0.787"-dia. insert is applied, the depth per revolution is 0.0787".

Refer to the following guidelines when helical interpolating a cored hole:

- For a 1-mill-diameter deep hole, feed 50 percent of the insert diameter per revolution;
- For a 2-mill-diameter deep hole, feed 30 percent of the insert diameter per revolution;
- For a 3-mill-diameter deep hole, feed 20 percent of the insert diameter per revolution; and
- For a 4-mill-diameter or deeper hole, feed 10 percent of the insert diameter per revolution.

About the Author

Earl Wilkerson is technical services manager for General Tool Co., Cincinnati.

plying coolant when running button cutters or for most steel-cutting applications, unless the shop is machining specific types of stainless steel. "When working with steel, I do not recommend coolant at all. The reason is that when you're cutting, for instance, at up to 500 sfm with a 0.150" DOC, you could be generating over 1,000° F of heat as the carbide insert is engaging the work material," he said. Chen added that if coolant is sprayed on the cutter as it comes out of the cut, the insert experiences a rapid temperature fluctuation—a thermal shock.

"You're not going to get the tool life you want because of the thermal shock. And the coolant is a mess and costly to maintain. Usually, I recommend blowing the chips away with air," Chen said. "In any application, you certainly don't want to recut chips."

Toward the Finish

It's no secret that double-insert button cutters typically outperform ballnose endmills when roughing and semi-roughing. According to Walker, "On a standard roughing application, a good speed for a ballnose is 35 to 60 ipm, where it's right around 100 to 120 ipm for a button cutter, with a lighter DOC. In some applications, the button cutter can go up to 150 to 250 ipm, while improving tool life."

For example, Walker said one end user was burning up his button cutters when machining P-20 at 125 ipm, but found that tool life tripled after he increased the cutting speed to 158 ipm.

But button cutters also are being applied in finishing operations, depending on the application and specification requirements. Although ballnose endmills are still primarily used for finishing and button cutters perform most of the roughing, Earl Wilkerson, technical services manager for General Tool Co., said the shop's button cutters can impart up to a 32 R_a surface finish, which covers most of the company's work requirements. He added that the Cincinnati-based shop produces precision parts primarily for the power generation and aerospace industries, but does little mold work.

For one job, Wilkerson said the shop applied a 2"-dia. copy mill with round inserts to machine a box made of 6061 T-6 cast aluminum. The tool extended 16" and removed ⅝" of material per side, running at the machine's maximum spindle speed of 8,000 rpm at a rate of 393 ipm. A speed of 800 ipm was achieved, but he said he didn't sustain it out of fear of tearing up the machine. The round inserts were applied for the finishing operation.

Wilkerson noted that round inserts provide the "double bonus" of both radial and axial chip thinning. This allows higher feed rates and less chatter, because the insert eases into the cut. "The light DOC the round inserts take doesn't kill us with chatter," Wilkerson said.

Because a button cutter takes a bigger step-over, where the cutter is moving perpendicularly (Y-axis) to the cutting direction (X-axis), Ken Pannunzio, sales for Depo Milling Technology Inc., Oakville, Ontario, said button cutters can produce a higher quality of surface finish than ballnose endmills when machining certain surfaces, such as flat areas, without the need for end-polishing of the workpiece. He added that a ballnose endmill is still required for finishing contours.

Cutter Aliases

The term "button cutters" is often used to describe any cutting tool body that accepts round inserts, but the name also is being applied to other styles of cutters. Kennametal Inc., Latrobe, Pa., offers button-head cutters with one cutting edge for endmilling airframe cavities and other aluminum or nonferrous workpieces, said Tom Hofmann, the company's senior product manager of the milling team.

He said the button-head cutter, with its four-component assembly, replaces solid-carbide, integral-shank ballnose and radiused endmills. When machining cavities with these long-reach, solid-carbide tools, Hofmann said aerospace manufacturers generally cut with only the top 1" to 1½" of the tool, thereby wasting expensive carbide.

To alleviate this waste, the button-head cutter system has a replaceable, carbide cutting head along with the system's nondisposable components: a steel sleeve, carbide shank and toolholder. Hofmann added that the components are shrunk-fit together, which pro-

The round, or button, shape offers the greatest geometric strength for indexable cutting tool inserts.

Kennametal

Kennametal's button-head cutter system has a replaceable, carbide cutting head along with the system's nondisposable components: a steel sleeve, carbide shank and toolholder.

Dijet

Double-insert button cutters can reduce costs and improve productivity for manufacturers of aerospace parts, as well as die and mold makers.

Suppliers of button cutters that contributed to this article:

Depo Milling Technology Inc.
(905) 337-9917
www.depomilling.com

Dijet Inc.
(734) 454-9100
www.dijetusa.com

Emuge Corp.
(508) 393-1300
www.emuge.com

Ingersoll Cutting Tool Co.
(815) 987-6600
www.ingersoll.com

Kennametal Inc.
(724) 539-5000
www.kennametal.com

TaeguTec
(248) 624-4566
www.taegutec.com

duces a dampening effect to relieve chatter, while providing a rigid and accurate cutting tool.

Unlike button cutters with two round inserts for die and mold makers, Kennametal's button-head cutter has through-coolant capability. Hofmann noted that the company is developing round-insert cutting tools to replace ball-nose endmills for die and mold making.

In addition to moldmaking, another application for button cutters is helical milling, according to Wilkerson. He said that producing holes by helical milling with a round-insert copy mill directs the cutting pressure through the spindle's axis instead of creating the side pressure—and corresponding chatter—that drilling generates. This helical-milling technique also requires less horsepower than drilling, he added.

For example, Wilkerson said that General Tool is able to produce 6"-dia. holes in 4140 with an older machine's maximum rpm of 1,000 at 79 ipm. "We're able to maximize the speed on slower machines and avoid having to buy newer machines," he said. "Copy mills with round inserts are part of our high-speed machining plan."