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# SUPERTOOL

for SUPERIOR GEAR BLANKS

By Fritz F. Greul

**With benefits  
including no  
heat buildup or  
chip problems,**

**I**t stays cool, it doesn't produce problematic chips, it cuts with ease...it's the Super Tool! Well, not really. It's simply a rotating circular saw blade. But the circular saw blade is too often overlooked as a possible tool when making parts turned from bar stock, such as gear blanks. Screw machine operators have forever struggled with fine-tuning their single point tooling and set-ups in an attempt to produce better quality parts, to increase tool life, and to reduce cycle times. Now, let's be radical for a moment. What if we could use a rotating tool with multiple cutting edges?

Well, that's not so radical, as it turns out. Rotary Saw Cutting (RSC) has been around for a long time, but has been slow to gain popularity. Of course, a circular saw needs a mechanism to drive it. Over the years the attachments driving the saw have become more reliable, consistent, self-sufficient, and powerful, and attachments are available to fit a wide range of turning machines, so RSC is now more viable. Also, the advent of live tooling capability on CNC machines makes RSC a possibility without an additional investment; simply mount a circular saw and go.

Not only is RSC a viable reality, it is also far superior to single point tooling in its capabilities. The multiple cutting edges of a circular saw eliminate the problems of high heat buildup, undesirable chip formation, and high chip load. The result is a myriad of technical advantages that increase production levels, improve quality, and lower production costs: more parts per hour, more parts per bar, better finishes, increased tool life, easier and less costly scrap handling, and increased machining capabilities.

A rotating circular saw cutting through a rotating bar of stock builds up very little heat for a number of reasons. First, saws are ground with side clearance. Clearance reduces the friction between the workpiece and the cutter. Second, cutting with a rotating circular saw is an "interrupted" cut, since each tooth cuts for only a brief moment. Third, as a single saw tooth makes a cut, the chip (and heat) is immediately removed from the cutter by the strong coolant flow and the centrifugal force of the rotating saw. Finally, each cutting edge is removing only a small amount of material, keeping the chip load low.

What benefit is it to have no heat buildup? The lack of heat buildup allows the circular saw blade to be used more aggressively than a single point tool. Feed rates can be increased from one and a half to four times that of single point tooling. Increased feed rates reduce the cutoff time and, therefore, increase the number of parts cut per hour. Less heat buildup reduces the stress to the saw and material. Tool thickness can be reduced; the common saw thickness is 0.045", which is approximately one third the thickness required for a single point tool. Tool life is longer, since a saw lasts two to 10 times longer per grind than a single point tool. These application improvements reduce the time needed to cut parts and the costs associated with raw material, tooling, and tool maintenance.

Another constant struggle for machinists is the chip. The resulting sharp, stringy, coiled chips of single point tooling are especially problematic. The chips can have a tendency to get caught up in the workpiece or the tool. If dragged across the workpiece, chips may leave undesirable markings on the part surface. The chips are cumbersome to remove, transport

rower than single point tooling so the kerf is reduced. There is less material waste with which to contend. Cutting with a circular saw is also an interrupted cut, therefore, absolutely impossible for a circular saw to produce a sharp, stringy, coiled chip. The chips formed by a circular saw are coarse granules of material—they are not stringy. They are compact, so removal, transport, and storage are easy and safe. Chip problems are eliminated.

Other than no heat buildup and no chip problems, another factor largely impacts the success of rotary sawing is chip load. The chip load is negligible when using a circular saw because the workpiece and the saw rotate simultaneously. Because the workpiece also rotates, the saw is always cutting a convex shape, so only one tooth cuts at a time and each tooth removes only a small amount of material. The low chip load also helps to accommodate the higher feed rates attainable while rotary sawing. These high feed rates are possible without taxing the saw, so saw life is longer than single point tooling life. More importantly, however, the low chip load accounts for better finishes, better tool control, and increased capabilities.

Part finishes are so dramatically improved when rotary sawing that secondary operations are often not needed. The burr completely through the piece for a clean, smooth surface. The cutoff nib is virtually eliminated, and burr is significantly reduced. Low chip load also affects tolerances. Tool and workpiece deflection are negligible, so surface squareness and flatness are typically within 0.002" and often within 0.001".

Finally, low chip load greatly increases the host machine's capabilities, cutting irregular shapes, cutting exotic materials, cutting thin-walled tubing, grooving, forming, and extruding. Irregular shapes such as hex, square, extruded, and pinion stock usually present a problem for a single point tool due to the interrupted nature of the cut. Rotary sawing, however, is an interrupted cut anyway. Non-round shapes are not an additional challenge for those using rotary sawing for cutoff. Exotic materials (hard rubber, plastic, teflon) and thin-walled tubing are often difficult to cut with a single point tool due to cutter and workpiece deflection, ripples in part surfaces that are not square. Again, because of the low chip load while rotary sawing, cutter and workpiece deflection are eliminated. Part surfaces remain square and flat within 0.002"—even when cutting these difficult materials.

Rotary sawing is not limited to parting off. It can be used for grooving and forming applications. Of course, when grooving and forming with a circular saw, the profile of the saw must match the profile of the resultant part. When grooving and forming with a saw, the application has the same technical advantages as cutting off with a saw.

As an example, deep grooving is a great application for a circular saw rather than a single point tool. Due to the low chip load, grooves stay square to the part, and thin walls between grooves do not deflect. Coolant delivery is improved when cutting deep grooves because the chips are immediately eliminated, allowing coolant to easily flow into the grooves. Grooving and cutting off can often be done at the same time by mounting multiple saws onto the same arbor. The saws must be supported appropriately by using spacers ground to the needed

A “gang” saw arrangement is also possible for combined forming and cutoff, or for multiple cutoffs. The negligible saw and part deflection minimize the problems usually encountered when attempting single point gang cutoff since the saws themselves act as guides to eject the cut part. Some saw users cut off as many as five or six parts at a time. Of course, saw configuration tolerances are more critical when performing multiple cuts simultaneously.

Much time has been—and is still being—spent on improving the performance of single point tooling. Understanding how to apply rotary sawing is no more complicated than initially learning to apply single point tooling. However, a little training and effort toward the use of RSC will virtually assure superior results to those of single point tooling.

## RSC Setup

As with single point tooling, RSC setup is application specific. The following discussion is a general starting point, which must then be refined based on the host machine, part configuration, part material, and part finish specifications.

RSC utilizes a self-contained motorized attachment, which drives the circular saw. This setup mounts in the standard cutoff position of the host machine, replacing conventional cutoff tooling. The attachment is wired directly into the host machine, so the saw is switched on and off with the main spindle of the host machine. Common host machines include Acme-Gridley, New Britain, Conomatic, Davenport, Wickman, Gildemeister, Schuette, Warner & Swasey, Brown & Sharpe, Traub, and Index screw machines, as well as Bardons & Oliver and Modern cutoff machines. The attachment can also be

adapted to fit other turning machines and custom machines. As mentioned earlier, if the host machine has live tooling capability, an attachment will probably not be needed.

The sawing attachment and saw must be positioned parallel to the workpiece, just as with single point tooling. The centerline of the saw and the centerline of the workpiece should be the same, although cutting on center is not a problem with RSC. The cam (stroke) should be set to the depth of the cut plus 0.05". The saw must not engage the workpiece in “overcut” conditions.

The circular saw can rotate in either direction. The most desirable cutting dynamics are achieved in an “opposed” cut, which the saw and the workpiece are rotating in opposite directions at the point of their intersection. During an opposed cut, both saw and workpiece rotate in the same direction at the point of intersection. Because an opposed cut delivers the best cutting conditions, a climb cut is only recommended when cutting high carbon materials with high speed steel saws. In these cases, the parts cannot be easily ejected during an opposed cut.

Speeds and feeds are faster when cutting with a saw. Set the feed rate at double that of the single point tooling. From there, rates can be adjusted higher until cutting starts to deteriorate. Feed rates can be as much as 400% higher than single point tooling. Depending on the application, workpiece rpm is usually the same or slightly higher than with single point tooling. Set the saw speed to 150% higher than the workpiece. Feeds and speeds can be adjusted depending on cutting objectives (for example, parts per hour versus part surface specifications) and tool life.

Proper coolant type and coolant flow are critical. The lubricating qualities of the coolant are more important than



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the cooling qualities. When using high speed steel saws to cut ferrous metals, it is necessary to use an oil coolant with a heavy concentration of active sulfur. Active sulfur prevents galling at low cutting temperatures (under 350° F). Water soluble coolant can be used with carbide saws, or when cutting aluminum or brass parts. Coolant flow must be strong and directed to the point where the saw enters the material. The coolant flow must also be distributed equally to both sides of the saw to promote even saw wear and to easily flush chips from the workpiece as the saw rotates through the work.

Changing saws is easy and takes only a few minutes. The operator needs to make sure that the saw is securely clamped, is running in the proper direction, is running true, and that all arbor and support spacers are in good condition. Adjustments are rarely necessary because height settings repeat every time. Location settings may need occasional adjustment, but only to maintain the tightest length tolerances.

## Saw Blade Configuration

To utilize RSC to its fullest potential, proper saw configuration is vital. Decisions on several items must be made, including saw material, saw diameter, saw thickness, number of teeth, tooth angle, rake angle, and surface treatment.

Circular saws for rotary sawing are commonly available in two materials: solid carbide and high speed steel. S.f.m. of the job will usually determine which is to be used (carbide surface feet rates require solid carbide saws). Carbide saws also cut more cleanly, resulting in better surface finishes and less burr or reduced nib. Cuts with carbide saws are less demanding on

the equipment, and tool life is five to 10 times better than that of high speed steel tooling. Heat sensitive materials and geometries also require the use of carbide saws.

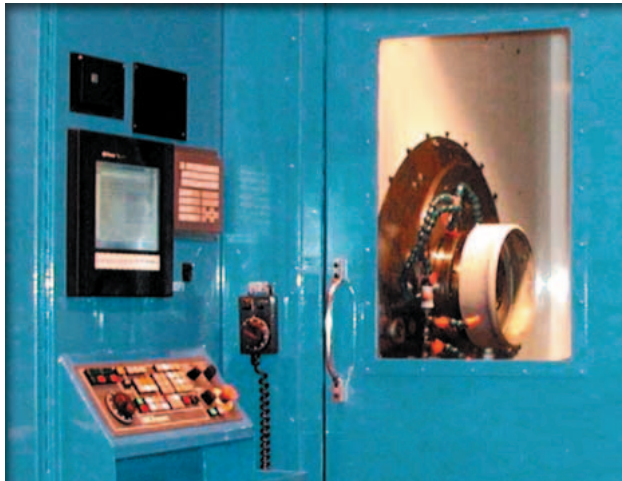
A good starting point for saw thickness is one half the thickness of the single point tool (often one third the thickness is enough). Aggressive cutting, deep cuts, and larger diameter materials might require a thicker saw. For softer materials, smaller diameters, and thin-walled materials, narrower saws are used. The goal is to use the thinnest saw blade possible.

The distance to the cut, the depth of the cut, the diameter of the tooling zone, and other attachments determine the diameter of the saw. Saws for rotary sawing range from 1/2" to 6" in diameter—the most common is 4". Use the following formula to calculate the saw diameter.

*Diameter = 2(distance from center of saw arbor to outside of tooling zone + depth of cut + tooling clearance needed for attachment + approach + breakthrough + 0.025" minimum per inch of cutting) + 2(regrind stock, which is application specific)*

The number of teeth on a saw requires careful consideration. A coarser tooth configuration should be used for workpiece diameter is 1.5" or larger, when the workpiece has a hole, when doing deep cuts, or when feed rates are 0.003" i.p.r. As an example, a 4" diameter saw with 7 teeth per inch (seven teeth per inch, 0.140" tooth gap) is considered a coarse configuration. A finer tooth configuration is used for small diameter workpiece (1" diameter), cutting to center, thin-walled tubing, and feed rates up to 0.003" i.p.r.

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TABLE 1

	CARBIDE SAW	HIGH SPEED STEEL SAW
12L14, 1215, aluminum, brass	No treatment	LN (Liquid Nitride) or TiN
1010-1026, high carbon steel alloys, SS	TiN (Titanium Nitride) or TiCN (Titanium Carbonitride)	LN or TiN
52100	TiCN or TiAlN (Titanium Aluminum Nitride)	N/A

Tooth angles are the last consideration for saw geometry. Cutoff angles reduce burr or the nib, produce better surface finishes, and control ring problems. Use the smallest cutoff angle possible to gain the desired results because larger cutting angles can affect tool life. A good starting point is 7° for a carbide saw and 10° for a high speed steel saw. The standard rake angle is a positive 2-4°.

Finally, saw surface treatments must be considered. Surface treatments increase tool life and produce better surface finishes. Generally, the same treatments used on single point tools apply to the saw. Use Table 1 as a guide.

With the many technical advantages rotary sawing offers over single point

tooling, this "super tool" must not be overlooked. Cutting off is the one operation common to all parts turned from bar stock. Technical improvements in the cutoff can significantly affect a company's productivity, capability, and costs. Add to this the possibility of grooving and forming, and a company can then truly revolutionize the way it manufactures turned parts. 

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