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By Keith Jennings

Glass half empty?

The U.S. presidential election is over and, thankfully, we can get back to managing our shops and making parts as usual—or perhaps not. Normally, I'm an optimist and see the glass as half full. For the first time in a while, though, the abundance of negative news is making the glass appear half empty, which can be discouraging.

As nonproducers and politicians run amok, the contribution of manufacturers continues to be drowned out as the most vocal scream for their own rescue. Unfortunately, politicians and others demand tax monies that manufacturing businesses could invest in capital equipment or a host of other beneficial expenditures. Instead, nonproducers have created a disaster that producers have to overcome without a bailout.

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Thankfully, those running machine shops and other manufacturing businesses are smart and will somehow persevere, perhaps with a few failures along the way. After all, those who create wealth by adding value to raw materials usually adjust and find a way to survive and thrive. That's the American way.

However, with the recent economic and political events, it's become apparent that successful machine shop owners and managers and those striving to get there now have even more obstacles in their path. Those obstacles include tighter credit and stricter loan requirements, making equipment upgrades and facility improvements more difficult. Also, regardless of who is president, the taxing of income and benefits may increase, causing a shop's up-and-coming CNC superstars to take home less net income even after receiving a pay increase.

As we work diligently to produce the highest-quality parts and solidify U.S. manufacturing, it's become necessary to adhere to a set of conditions that encourages less domestic manufacturing.

However, there are ways to ensure a shop succeeds and sees the glass as half full again. First, better financial controls are mandatory. Look a little deeper into expenses and minimize or eliminate ones that aren't absolutely essential.

Also consider consumables. Are you getting the most from your tools and supplies? Are your tools maintained and monitored to ensure they're performing as long as their warranties claim? Effective utilization is imperative in a tight market.

Another frequently overlooked expense is shipping and freight. A shop that frequently orders supplies and raw materials to be shipped overnight is paying big bucks for this convenience. Better planning combined with more patience can save lots of money. Developing a good relationship with a shipping company and eliminating shop-provided transportation can also reduce expenses because a shipping company typically transports goods cheaper than a shop can.

Outsourcing payroll and human resources services can help as well. At my shop, the monthly fee for outsourcing those services is about 25 percent less than employing a full-time person to handle it internally. Plus, the service provider offers backup and can be a valuable source of information.

Eliminate nonperforming advertising, marketing and sales efforts. If you're not getting a return on investment from a directory listing or trade show exhibit, eliminate it. Replacing it with good old-fashioned personal visits and networking can be more cost-effective. Consistently making sales calls can be difficult, but don't underestimate your credibility. No ad or directory listing can sell your shop better than you can.

Succeeding in a messy economy is possible—albeit difficult. In a robust market, many costs are overlooked because you have the business to cover them, but a tight market requires more oversight.

However machine shops survive, they're the economic backbone of America, and they've earned my respect. Happy Holidays to all! CTE

About the Author: *Keith Jennings is president of Crow Corp., Tomball, Texas, a family-owned company focusing on machining, laser cutting, metal fabrication and metal stamping. He can be e-mailed at kjennings@jwr.com.*

Garden-variety high performance

By Bill Kennedy, Contributing Editor

Ever wish your garden tractor had a little more get-up-and-go? How does 135 hp sound? Garden-size tractors that powerful run regularly in the National Quarter Scale Pulling Series of racing events. The 1,000-lb. NQS machines actually pull more weight, percentage-wise, than their full-size tractor-pull cousins, and weekend events can attract more than 600 entries.

Julian Stahl has competed in garden tractor pulling since 1970. In 1995, he founded Midwest Super Cub LLC, DeWitt, Iowa, to develop garden tractor performance parts. "People had the same issues I did," he said. "If you needed something, you had to go to a machine shop and get it made special, and they made one. I make a bunch of them and offer them for sale."

Today, Midwest Super Cub sells complete engines and tractors in addition to parts. Stahl's MVP engines have won the NQS Engine Builders Championship 3 of the 4 years it has been in existence. The engine in Stahl's Midwest Express tractor is based on an 18-hp Kohler unit but has essentially no Kohler parts; the methanol-burning 54-cu.-in. motor runs at 9,000 rpm, produces 135 hp and has 100 ft.-lbs. of torque.

One part engineered to boost durability is a rear-axle gear carrier that is an upgraded version of one originally for Dodge Dart automobiles. Pullers found the Dart carriers to be strong but are not longer sold commercially and junkyard versions are scarce, so Stahl makes his own. The Dart carriers are one-piece ductile iron castings; Stahl's two-piece replacements consist of a carrier housing and a flange machined from 12L14 steel. "The steel has double the tensile strength of ductile iron," Stahl said. He also added structural strength. Where the Dart carrier had webbing between bolting points, Stahl's part is solid, and some housing walls that were 3/16" thick are now 5/16".

Super Cub subsidiary Midwest Machine Inc. manufactures the parts. To draw part prints for the new carrier, Steve Pashon, shop foreman, took dimensions from the Dodge part. "We made one and made sure we could get the gears in it," he said, "and then we had to modify it in it a couple of spots so that it could fit inside the transmission case." The finished

Midwest Super Cub

This gear carrier, a reinforced version of a Dodge Dart automotive component, is manufactured by Midwest Super Cub for high-horsepower garden tractors.

carrier and flange assembly is about 4½" in diameter and just over 5" long.

The flange is machined from 2"-thick, 6½"-dia. bar stock. On an Amera Seiki CNC lathe, the flange is turned to a diameter of 6.336", the thickness is tapered from 0.44" at the edge to 0.75" over a distance of 2", and a 1.625"-dia., 0.875"-tall hub is turned at the part's center. After Midwest Machine drills a 1.176"-dia. hole through the center, it turns the flange over and faces the other side essentially flat.

Next, the flange goes to a Haas vertical machining center for making 24 holes, with eight on a 3.75" bolt circle for fastening the flange to the carrier housing. Four of those eight are drilled to 0.374" in diameter to accept 0.375"-dia. press-fit pins, and the other four are drilled to a 0.375" diameter and counterbored to a 0.628" diameter to receive bolts. The other 16 holes are drilled and either tapped or counterbored for bolts that hold the carrier in the transmission case.

Machining of the carrier housing also begins on the lathe. After 2.375" of the OD is turned to 4.28", a 2.5"-dia. hole is drilled 2.375" deep, followed by a 1.172"-dia. through-hole. The ID then is bored out to 3.176"-dia. After the carrier is flipped in the lathe chuck, the rest of the OD is turned, including a 0.250"-wide step and a 0.8125"-long, 1⅝"-dia. hub at the top of the part.

The carrier's large end is then chucked horizontally on the mill in a Haas indexing head. A tailstock and a dead center support the part's small end "for a little stability because we mill flats on the sides close to the end," Pashon said. "We put a nut on the dead center and that holds the part flat against the chuck."

Flats 2½" long are milled 180° apart on either side of the part and then a 2"-dia. inserted ball endmill forms a 1" radius where each flat joins the carrier's tapered part, feeding at about 10 ipm.

Pashon said he doesn't run the tools particularly hard because he wants to impart a fine finish.

Pashon said maintaining the relationship among the features is challenging. One critical operation is drilling and reaming two diametrically opposed holes through the housing for a shaft that holds gears. The holes have to be precisely aligned and sized. "You don't want the fit of the shaft to be sloppy," Pashon said. He drills both holes with one pass of a 0.649"-dia. HSS drill run at 80 sfm and a 1.8-ipm feed. He reams the hole to a 0.662" diameter, also finishing both holes in a single pass.

The carrier is then indexed 90° and a 3"-dia. facemill runs across the housing, milling through the wall and creating an opening. The operation is repeated on the part's other side. After that, the part is indexed 90° and a 2½"-dia. endmill plunges down the housing's side to form a smooth radius where the milled openings meet the housing base.

The next operation produces one feature. The housing is clamped vertically, small end up. In the part's 0.250" shoulder, above one of the 0.662"-dia. holes, a 0.530"-deep hole is drilled and tapped with a ¼-20 thread for a bolt that locks the gear-holding shaft in place.

Next, the housing is flipped and clamped with the large diameter facing up. An endmill machines a 2" radius into opposite sides of the ID to match the gears' shape. Pashon called this the "biggest challenge" in machining the housing because the radii have to be centered on the 0.662"-dia. gear shaft holes. Additionally, the radii themselves are off center. "It's a 2" radius on one side, then you have to move the cutter over ⅝" or so and do the 2" radius on the other side. The original bore diameter is 3.176"; the diameter with radii is almost 3½"."

The final operation involves making eight holes in the housing's bottom for the pins and bolts to attach the flange. The four holes for bolts are threaded, and the four for pins are plain. The bolt holes are drilled 0.350" deep on a 3.75" bolt circle, and then a thread mill creates a ⅜-24 thread. Pashon said he applies a thread mill because the base of the housing is only ½" thick and maximizing thread depth is important. The thread mill can cut a thread within one thread of the hole's bottom, while a tap's tapered tip prevents that.

Lastly, also on a 3.75" bolt circle, four holes are drilled 0.380" deep and reamed to 0.376" in diameter, 0.001" larger than the press-fit pins in the flange.

Pashon said the shop makes a batch of 30 to 35 carriers about every 3 months. **CTE**

For more information about Midwest Super Cub LLC and Midwest Machine Inc., visit www.midwestsupercub.net or call (888) 414-6983.

The greening of manufacturing

By George Weimer

Twenty years ago, there was some debate about industrial environmental issues—particularly the costs. At that time, machine builders bragged about how much material they could remove from a workpiece in increasingly fewer seconds, not about how energy efficient their machines were. That situation has changed. In metalworking today, less is more.

"Achieve more. Consume less. That's our motto," said Gisbert Ledvon, business development manager for GF AgieCharmilles, Lincolnshire, Ill. He pointed to wire EDMs that can save a customer upwards of $6,000 in annual energy costs and machines that use smaller diameter wire and therefore consume less wire, depending on the application. "There's basically no trim cut in those machines," Ledvon said. The company also offers twin-wire technology that allows lower-cost wire for roughing and die-sinker technology that eliminates electrode wear.

"We are focusing on how to make our machine tools more green in the future in terms of reduced power and wire consumption, less resin and other ways to reduce the carbon footprint of our customers," Ledvon said.

Other builders are equally committed to manufacturing's new green paradigm. "Some 19 years ago, we introduced auto-off, which makes sure you only use power when you're cutting, so we've been addressing these green issues for some time," said Kurt Zierhut, director of electrical engineering, Haas Automation Inc., Oxnard, Calif.

What's coming in terms of green machines? There's the increasingly popular use of MOM (Minimum Oil Machining). Haas has offered a system (almost exclusively for drilling and tapping) that keeps tramp oil away from other parts of the machining process. "Keeping the lube from the coolant is a classic challenge in machining," Zierhut said. "This 'tramp oil' can drip into a water-based coolant. The idea is to keep oil away from the spindle, which means less tramp oil."

Much of the green movement in machine tools can be summed up as "using less electricity and only when needed and using less oil," Zierhut said. He suggested the following green tips.

> Much of the green movement in machine tools can be summed up as 'using less electricity and only when needed and using less oil.'

- Automatically turn off idle machine tools.
- Design components to be near-net shape as much as possible to minimize machining.
- Incorporate MOM to apply only the amount of oil needed.
- Like a PC, try standby mode for machines, which turns off almost all power and allows quick wake-up.
- Use minimum quantity lubrication (MQL), which applies lube to the spindle based on counting rotation and applies lube to guides and screws based on travel.

Further advice comes from George Yamane, marketing manager for Mazak Corp., Florence, Ky. "Multitasking offers some advantages with done in one machining vs. two or three machines" all drawing power, he said, adding to consider linear guides instead of box ways to reduce friction so servodrives require less power.

Probably the most well-known large manufacturer dedicated to green manufacturing is Ford Motor Co. A recent example is its modernized Van Dyke transmission plant in Sterling Heights, Mich. MQL machining systems from MAG Powertrain, Port Huron, Mich., are delivering cost and environmental improvements. According to MAG, MQL saved Ford power costs in the seven figures, and the machines are producing parts at reduced variable cost. Plant air quality also improved with MQL compared to wet machining. MQL reduces fluid flow from gallons per minute to ounces per hour.

"The metalworking industry consumes several hundred million gallons of fluids each year," said Ron Quaile, MAG vice president, proposal, estimating and marketing. Switching to MQL offers a "cascade of cost savings."

Twenty years ago, the approach taken by many industrial managers concerning environmental issues was "How do I stay out of jail," said Greer Tidwell, director of environmental management for Nashville, Tenn.-based Bridgestone Firestone North American Tire LLC. Today? "It's a matter of corporate pride." But, he warned, "You don't get this attitude by pushing people."

More large manufacturing companies expect their contractors and suppliers to "come green" as well. "All contractors who come to our sites go through our environmental and safety programs before they go to work for us," Tidwell said.

Going green has come to mean using fewer materials and less energy per unit of production. It also means less air and water pollution. The result is lower-cost products and a cleaner environment. It seems to be a win-win situation for end users and machine tool builders. CTE

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Rough milling titanium

By Edward F. Rossman, Ph.D.

For the past 40 years, end users have applied positive-rake cutters made of cobalt-HSS, usually M-42, for nearly all rough milling of titanium alloys. Roughing at speeds up to 60 sfm and chip loads of 0.005 ipt provides a minimum of 1 hour of tool life even when the cutter is buried in the workpiece. Chip loads vary from 0.002 to 0.012 ipt. If the chip load is less than 0.002 ipt, there is danger of workhardening and overheating.

End users apply cobalt-HSS cutters because carbide does not effectively withstand the uneven surfaces of castings and forgings. The exception is carbide inserts when facemilling flat and even plates.

The following parameters for rough milling with uncoated M-42 cobalt-HSS cutters minimize distortion and chatter. Use 40 percent of cutter diameter for radial engagement. Use 100 percent of cutter diameter for axial DOC. This ratio of diameter to axial DOC minimizes tool distortion or bending during machining.

- The chip load is 0.004 ipt for a 4-flute, 0.250"-dia. cutter.
- The chip load is 0.005 ipt for a 4-flute, 0.375"-dia. cutter.
- The chip load is 0.005 ipt for a 4-flute, 0.500"-dia. cutter.
- The chip load is 0.006 ipt for a 4-flute, 0.750"-dia. cutter.
- The chip load is 0.006 ipt for a 6-flute, 1.000"-dia. cutter.
- The chip load is 0.008 ipt for an 8-flute, 2.000"-dia. cutter.

Using those parameters, tests show that a solid cobalt-HSS cutter lasts approximately 30 minutes at 72 sfm, 60 minutes at 60 sfm, 90 minutes at 45 sfm, 5 hours at 38 sfm and 8 hours at 30 sfm.

When cutting pockets in titanium with a vertical mill, recutting chips can be a problem. With the pocket filled with coolant, it is often difficult to see what is happening. Based on tool life tests under these conditions, cutter life was reduced about 35 percent when chips were recut. Normal flood coolant cannot flush away the chips. In one shop, two 0.500"-dia. tubes applying a heavy coolant flow are positioned next to the vertical spindle. This acts as a "fire hose" and frees the operator from performing the task. Two of these coolant lines are used at each spindle, and the coolant is supplied using a separate pump.

When chatter is encountered while milling titanium, the chip-removal speed is usually limited to impart the required surface finish and achieve acceptable tool life. Vibration within the part, fixture and tombstone causes chatter. Detecting and eliminating harmonic vibrations in the spindle, toolholder and cutter is effective to overcome chatter when machining aluminum at high speeds, but these strategies do not usually help when milling titanium. The solution is to use rigid milling machines and fixtures and to dampen and stiffen the fixture, part and tombstone. Sometimes applying cutters with an uneven division of cutting teeth also helps minimize chatter.

Plunge roughing also brings carbide inserts into the rough milling picture for titanium alloys. Plunge roughing is done with cutters as large as 4" in diameter. Cutters for plunging should have as many inserts as possible. Inserts are on their side for end cutting, and through-the-spindle coolant is desirable when vertical milling to help evacuate chips. Flood coolant can also be effective. The plunge cut is usually performed at a feed rate in the Z-axis of 20 to 40 ipm, which reduces roughing time by nearly 67 percent compared to conventional roughing with cobalt-HSS cutters.

The rule of thumb for coolant flow through the spindle is 0.5 gpm/hp. A radial DOC of about 0.5" and a 0.65" to 1.250" step sideways is appropriate.

Use a modified drill cycle with a slight radial move before retraction. The radial move from the cut will reduce tool wear by about 35 percent because the move prevents the inserts from rubbing during tool retraction. An option to the radial move is to reposition the plunge radially for the next lower step on waterfall-type cuts. The cutting speed is from 400 to 600 sfm. With six inserts, this removes about 18 in.^{3}/min. of material.

The machine's horsepower comes into play. Allow at least 1.4 hp per cu. in. of titanium being removed per minute to avoid stalling. To minimize cutter breakage, use a programming feed code that relates the feed rate to the feed per revolution. This might save a cutter if the machine begins to stall or slow.

Note that torque doubles when cutter wear approaches 0.005" wide on the cutting edge. The horsepower will double as well. For example, 30 hp becomes 60 hp, which can stall the machine. **CTE**

About the Author: *The late Edward F. Rossman, Ph.D., was an associate technical fellow in manufacturing R&D with Boeing Integrated Defense Systems, Seattle. Rossman's Shop Operations column is adapted from information in his book, "Creating and Maintaining a World-Class Machine Shop: A Guide to General and Titanium Machine Shop Practices," published by Industrial Press Inc., New York. The publisher can be reached by calling (212) 889-6330 or visiting www.industrialpress.com.*

Thread grinding

By Dr. LaRoux K. Gillespie

Grinding threads provides one of the most precise classes of threads, having high strength and a fine surface finish. In addition to producing a high-quality thread, grinding can be the most productive approach for certain part configurations. For long threads, such as ballscrews or lead screws, the volume of material to be removed typically becomes prohibitive for cutting tools, but not for grinding. Because the diameters of thread grinding wheels are much bigger than tools applied to machine threads—the surface area is as much as 50 times larger than a cutting tool—grinding wheels do not wear as quickly. In addition, some machines allow grinding in both forward and backward passes to enhance efficiency.

There are three basic approaches to thread grinding: Feed the part past a single-rib wheel, feed the part past a multiple-rib wheel, and plunge a multirib wheel into the part.

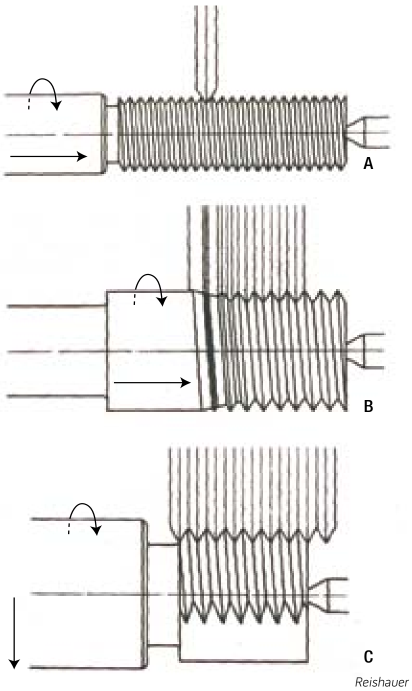
The single-rib wheel is the most versatile and provides the highest degree of dimensional accuracy. It can produce fine and coarse threads, unconventional and typical shapes and threads interrupted by other features. Single-rib wheels do not produce parts as fast as multirib wheels because only a single groove is produced per revolution.

When traverse grinding, a multirib wheel feeds along the part axis. Such a wheel has six to eight threads formed into its surface. The wheel can be fed to full or partial thread depth. The wheel's leading edge is tapered so the wheel feeds gradually into the workpiece. Some wheels have a tapered thread where only the third or fourth thread is at full depth.

Multirib plunge grinding uses wheels that are about 1½ threads wider than the workpiece threads. The wheel is plunged into the work and a thread is completed after about 1½ turns, making it much faster than traverse grinding. Because the wheel only has to be a few thousandths of an inch wider than the part's threads, it allows threading close to shoulders or other part features that cannot be produced with traverse grinding. Normally, the longest length produced with plunge thread grinding is about 1½ times the part diameter.

Multirib wheels are typically trued with a crush wheel or diamond-impregnated form roll.

A skip-rib wheel can be used for fine thread pitches, where every other thread is produced on the wheel. Two plunge passes are required to produce a workpiece thread. The second pass indexes over one thread and grinds the part's previously untouched area with a slight overlap to blend the two passes. To produce threads this way, 2½ turns of the



workpiece are required.

Thread grinding can produce threads as large as 16" in diameter and ballscrew threads as long as 160". At the opposite extreme, the finest thread produced by this process has about 203 tpi. A precision thread grinder's error is usually less than ±0.0002 in./in.

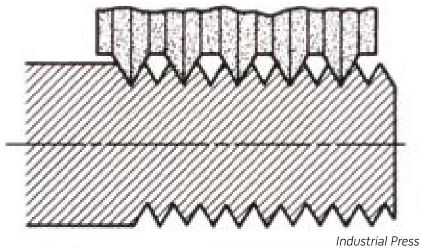


Figure 1 (left): A) Workpiece traversing past a single-rib wheel; B) workpiece traversing past a multirib wheel; C) multirib wheel plunging into the workpiece.
Figure 2 (above): A skip-rib wheel produces every other thread on fine-pitch parts.

Both resinoid and vitrified wheels are applied. Vitrified wheels are used for extreme accuracy, and resinoid ones last longer between dressings. Aluminum-oxide and diamond wheels are used in grain sizes of 120 to 150. Fine pitches require 220 to 320 grain sizes. Internal threads limit the size of the wheel diameter, requiring more frequent wheel dressing because there is much less surface on the wheel circumference.

Thread grinders are built for one purpose—to grind threads. The variety of thread grinders include universal machines that accommodate various part shapes for low-volume production, production thread grinders for high-volume production of precision parts, fully automatic tap grinders, machines for long workpieces, machines for internal thread grinding and special machines for unique sizes or configurations. **CTE**

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By Dr. Jeffrey Badger

Determining overstroke

Dear Doc: I surface grind 4"-long parts. My guys set the dogs on the machine for a total traverse length of 8". I tell them this length is too much, and that they're wasting time. But they say they have to overstroke because they take deep cuts (0.002") and the wheel starts cutting before it is directly over the end of the part. Is there a way to calculate how much overstroke is needed?

The Doc Replies: I see this situation all the time. I'm asked to perform some high-tech analysis to reduce cycle times. They're expecting me to come up with something sophisticated—I tell them to adjust the dogs.

I'm asked to perform some high-tech analysis to reduce cycle times. They're expecting me to come up with something sophisticated—I tell them to adjust the dogs.

The following is a quick and easy way to calculate the required overstroke. Multiply the wheel diameter by the DOC, and then take the square root of the resulting number. That's the length of the arc of cut.

So, if the wheel diameter is 8" and the DOC is 0.002", the arc-of-cut length is the square root of 0.016" (8" × 0.002"), or 0.13". That means the wheel starts to cut about 0.13" before its center is directly over the end of the workpiece. Your guys are overstroking 2". Now, unless you have an old machine that needs 1.87" to reach full speed, you're overstroking way too much. I recommend reducing the stroke length to 5". That'll give you ½" on either side, cutting cycle time nearly 40 percent.

Dear Doc: I just switched wheel suppliers. I'm using the exact same wheel specification, but can I expect the new wheel to behave the same as the old one?

The Doc Replies: Absolutely not. Even if the wheel specification is the same, the wheel grade will be different because every supplier uses vastly different bond formulation recipes.

For example, you can safely assume that a WA60KVX wheel from Joe's Grinding Wheels will be harder than a WA60JVX wheel from Joe's Grinding Wheels because the K grade is harder than the J grade. But a WA60HVX wheel from Frank's Grinding Wheels may be harder than both the H-grade and J-grade wheels from Frank's, or it might be softer. There is no way to know until you try it.

Dear Doc: I stick resin-bond diamond wheels, but I'm not sure how much to stick. Do you have any guidelines?

The Doc Replies: How much to stick depends on the wheel dimensions, type of bond, grit size and, most of all, how aggressively you dress. But, in general, I like to see people dress at least $0.3mm^3$ of stick per square millimeter of wheel area ($0.01 in.^3$ of stick/$in.^2$ of wheel area).

That can be a complicated calculation, so let's simplify it. For a straight plunge into the wheel where stick width equals wheel width and you're using ½" of stick width along the wheel, you should consume about ¾" length of stick when sticking an 8"-dia. resin-bond, 320-grit diamond wheel. That's assuming you're sticking aggressively.

Of course, some corrections are required. If you're sticking a metal-bond wheel, double that value. If you're sticking timidly, double that value again to equal four times the original value. If you're sticking a 16" wheel, again, double that value, but if you're sticking a 4" wheel, halve that value. If your stick is 1" wide (and not ½"), halve that value. If you're sticking a fine-grit wheel, stick less. Stick more for a large-grit wheel. You get the idea. CTE

About the Author: *Dr. Jeffrey Badger is an independent grinding consultant. His Web site is www.TheGrindingDoc.com. E-mail grinding questions to him at badgerjeffrey@hotmail.com. All Grinding Doc calculations can be found in The Grinder's Toolbox, available from The Doc's Web site.*