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STAYING SHARP
manager's desk

By Keith Jennings

Think globally, machine locally

Earlier in the year, Mazak Corp. invited me to travel to Japan. It was a trip with two other shop owners and two OEM managers. The primary purpose was to tour the machine tool builder's Japanese factories and brainstorm with its engineers on improving Mazak machines for the U.S. market.

The trip was 5 days of incredibly beneficial conversations and tours. We saw Mazak manufacture its CNC machines with its own CNC equipment, and the brainstorming sessions and numerous conversations with fellow shop owners and managers were particularly encouraging and helpful. As a result, the trip was every bit as beneficial for us as it was for Mazak. Ultimately, I came home thinking strategically and contemplating the many issues discussed about how I can improve my operation.

It's important to get out of the shop and network with peers, which can be incredibly motivating, particularly when those peers aren't direct competitors and you can freely discuss down-and-dirty details.

It's natural to become immersed in one's own shop activities and nearly forget about the outside world. But it's important to get out of the shop and network with peers, which can be incredibly motivating, particularly when those peers aren't direct competitors and you can freely discuss down-and-dirty details. For example, I learned how some companies have started recruiting outside of the U.S. to fill critical positions. I also heard how some shops are implementing price increases without losing customers.

Discussions with the OEM managers were also valuable because they explained how and why they choose to give work to one shop over another. The bottom line is that understanding where they're coming from makes it easier for me to develop an enticing proposal and earn their business. You can bet these matters will be considered next time I'm securing work with a new customer.

Another aspect of the trip that generated excitement was learning how machine tool builders are incorporating new, innovative features into their equipment. For example, I learned how builders are incorporating wireless networking technologies into machines to directly distribute critical information in real time to the people who need it. By integrating networked PCs into machines, operators can quickly and efficiently locate critical drawings, specification worksheets, equipment manuals and other relevant information, separate from the CNC. This can keep operators out of the office and at their respective machines.

Also, preventive maintenance alerts can be set up to automatically notify the operators and maintenance technicians, ensuring an alert is issued before incurring preventable downtime. Another growing technology is CNC multitask machines, which will certainly improve the machining operations of those shops that embrace advanced technology.

As for our comments to Mazak, we recommended the further simplification of controls. The Japanese tend to include so many options and buttons that a CNC starts to get rather complex and overwhelming. And, of course, we spoke about training, training and more training. It's essential that operators, maintenance technicians and even engineers receive adequate training for complete understanding of a machine and how to utilize it most effectively. In other words, end users must have access to resources after the sale. Shops must have confidence that the machine tool vendor is going to be there when needed.

Our hosts listened intently, took copious notes and respected our candor. As a result, our trip paid dividends in ways not listed in the itinerary. CTE

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The ‘route’ to fine finishes

By Dr. LaRoux K. Gillespie

Router bits are commonly applied for edging or trimming aluminum, plastic and composite materials. Printed circuit boards, for example, are cut with high-speed routers to create the outer shape and large mounting and clearance holes. Aluminum and composite parts are often routed to produce smooth sides.

When coated with diamond, routers can even finish ceramic tile, marble and granite.

Routers are profile cutters—essentially high-speed endmills. Routers are applied at speeds up to 50,000 rpm and feed rates up to 150 ipm. The high speeds and feeds result in smooth surface finishes.

Router tool life follows the same “laws” as for any milling cutter and varies according to a machine’s spindle speed and the tool material. Routers are made of tool steel, HSS, cobalt-HSS and carbide. According to industrial supplier Abbeon Cal Inc., Santa Barbara, Calif., the protective paper on plastic sheet stock is abrasive enough that these materials should be routed with carbide tools rather than HSS to extend tool life. A carbide router can cut up to 15,000 linear inches in some epoxy-glass laminates.

Routers come in two basic configurations. The first utilizes dozens of shapes for finishing edges with chamfers, rounded edges or aesthetic features. The second configuration is a cylindrical design that has several different flute or tooth configurations.

Piloted ball bearing cutters are an example of the first configuration and are used in manual routing operations. The bearing makes contact with the side of the part to follow the part’s contour. The bearing diameter determines how deep horizontally the router cuts into the part, while the tool’s vertical positioning in the collet determines the Z-axis DOC. The pilot is not needed when CNC machining because tools follow programmed toolpaths. Chip-limiting router bits add extra material in the tool’s inner core so that the amount of material fed into the cutter is limited to reduce kickback.

Cylindrical routers are used for machining printed circuit boards, metal, plastics and composites. Onsrud Cutter LP, Libertyville, Ill., for example, offers 16 different designs for routing composites and other materials. Most are 2-flute tools, but 3- and 4-flute cutters are also available. Compression routers (left-hand spiral) push the material against the worktable to prevent tearing or delamination. Up-cut routers (right-hand spiral) evacuate chips up and out of the cut rather than down into the table. The up-cut/down-cut design is a third type. These routers look like skinny herringbone milling cutters and cause the cutting force on the bottom of a stack of material to go up into the stack to prevent delamination, while the top of the stack is pushed down for the same reason. This also minimizes burr formation.


Onsrud Cutter

Onsrud's CG router is for cutting carbon graphite and carbon fiber panels.

Some routers have a diamond-like rotary bur configuration to better shear fiber materials. An open-flute geometry for routing annealed and hardened aluminum lets chips exit faster with less drag. This prevents chip packing in the flutes.

When smooth edges are required, single- or 2-flute routers are applied. Some routers have polished flutes to enhance chip evacuation. Straight-flute designs are for routing extremely hard materials or for use in machines with slow spindle speeds. Some routers are specifically designed to cut carbon-fiber composites, while others are designed for aramid fiber composites, such as Kevlar. Several designs have a drill point configuration, which allows the user to drill into a composite panel, for example, and then rout contours. **CTE**

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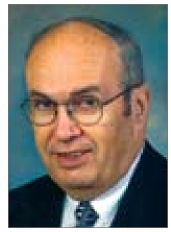

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hard material matters

What candidates need to know

By George Weimer

This year, as even hermits must know, is an election year, and therefore U.S. citizens are being subjected to one oversimplification after another. Washington politicians cause our problems; the solution is more Washington politicians. The public is over taxed; they need new taxes. The U.S. needs more free trade; free trade is ruining U.S. industry.

What's the truth? How can we sort through this rhetoric and determine what's clear and important about this election year? There is at least one important issue that needs serious attention, but it is lost in all this rhetoric. That issue is the relationship between the U.S. industrial base—particularly the machine tool and related industries—and national defense.

For decades now, the U.S. has been losing to other countries not only its leadership role in many industries, such as electronics, numerous consumer goods, steel, machine tools and construction equipment, but its respect and admiration for industry in general.

Other countries now lead the world in the production of machine tools, electronics and steel. China and India have entered the automobile industry, and many other countries are well ahead of the U.S. when it comes to per capita consumption of machine tools.

Some can rightly note that many countries have learned lessons from the U.S. about free enterprise and free trade, and it's only natural that some of them will become more successful and competitive. I agree. However, it is the peak of nonsense to believe that such international developments mean the U.S., as a nation, should leave certain industries largely to others—especially machine tools and other manufacturing technologies.

Yes, the U.S. is still a major player in the machine tool industry even though many domestic producers are foreign owned. But, as the U.S. Air Force recently did with its purchase of aircraft refueling tankers from the European Aeronautic, Defense and Space Co. instead of from Chicago-based Boeing, more and more of U.S. military procurement of crucial weaponry and related equipment is purchased on the world market.

These military purchasing issues are complex and sensitive in many ways, such as U.S. jobs lost or gained, readiness compromised or not and quality increased or decreased. They require careful analysis and balanced thinking.

Federal politicians often seem largely ignorant of manufacturing's special problems and remarkable technologies—especially their importance to national defense.

But, overall, the issue seems to be one of whether the country can rely on U.S.-produced equipment for national defense. Seemingly, the nation cannot, and more and more of its military needs are being met by other countries' manufacturing bases. Yet, who among the hundred of politicians up for election in November is mentioning this crucial issue? Even more perplexing, who among the congressional and presidential candidates seems concerned about the declining U.S. manufacturing base in terms of military needs?

There have been numerous studies and reports from the Department of Defense, its critics, industrial groups and the academic world that have pointed out with massive rivers of statistics that the U.S. is facing a serious and growing problem of being able to support its military in terms of manufacturing. Some supply difficulties in Iraq and Afghanistan illustrate this. Who reads these reports? Shouldn't the candidates for federal office at least discuss these developments? Why don't they?

Federal politicians often seem largely ignorant of manufacturing's special problems and remarkable technologies—especially their importance to national defense. They live in a city that makes nothing and only consumes. Industry is not up front in their minds, but it wasn't always that way.

In President Dwight D. Eisenhower's second autobiography about the Korean War, he discussed supply line problems during the war and asked, "When will the politicians of this country come to recognize the importance of the machine tool industry?" Perhaps we should ask our many candidates who are looking to live or remain living on the Potomac exactly that. CTE

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One operator, one machine

By Bill Kennedy, Contributing Editor

Rearick Tooling Inc., Apollo, Pa., performs prototype and production machining using a range of metal-removal and -forming technology. Plant equipment includes 4- and 5-axis multitask machines and machining centers, wire and sinker EDMs, laser machines, CNC grinders and CNC presses. The shop makes parts ranging from tiny medical implants to components for Harley-Davidson motorcycles, military applications and steel mills. A major focus is designing and machining dies for Rearick's sister company, stamping provider JIT Global Enterprises.

Owner Sam Rearick said the company complements the use of high-tech equipment with old-fashioned dedication to fulfilling special customer needs. A good example was a 2.7"-long, 2"-dia. 1018 steel pipe fitting that was reverse engineered for a gas drilling company.

Unlike some complex parts and long production runs that move from machine to machine through the shop, nine copies of the replacement fitting were produced by one man at one machine.

Like many of the parts the shop makes for well drillers, the fitting was brought to Rearick without drawings or other information. "When they break it, they run in here and hand us a part," Rearick said.

Unlike some complex parts and long production runs that move from machine to machine through the shop, nine copies of the replacement fitting were produced by one man at one machine: "It was like the old days of machine shop work, except he used a CNC machine," Rearick said.

Operator Steve McDonald began the process by measuring part dimensions with calipers and micrometers and then using the measurements to make a pencil sketch at his workstation. Thread dimensions play a critical role in gas drilling components because the threads

must offer sufficient clearance to assure easy assembly and disassembly in the field, but must also fit closely enough to minimize movement in a high-impact drilling environment. Accordingly, before McDonald began machining the parts, he machined thread gages to match the old part's internal and external threads. He later used the gages to maximize the precision of the new parts' threads.

McDonald said gathering the dimensions to machine the gage for measuring OD threads was relatively easy. He used the three-wire measuring method, in which three wires of known diameter are placed in the thread and measured with a micrometer. Making a plug gage for the ID threads, however, was somewhat more difficult because wires couldn't be used. From basic measurements, he machined a trial gage, which he then adjusted until it fit correctly in the threads.

McDonald machined the gages and the fittings on a Mazak Quick Turn 18 SY multitasking lathe. Rearick said the 4-axis lathe can complete this kind of job faster than a 5-axis machine because machining each fitting required a relatively small number of tools that were stored in the machine's turret and changed quickly. It takes longer to retrieve tools from the high-capacity tool chain of a 5-axis machine.

McDonald machined the fittings from 2"-dia. 1018 bar stock, fed into the machine via its through-spindle chuck. First, he drilled an axial hole 2¾" deep with an Iscar 1"-dia., through-coolant inserted drill and then applied an Iscar inserted boring bar to enlarge the bore to a diameter of 1.065".

Next, he profiled 1.80" of the fitting's OD with an Iscar WNMG trigon insert. The cut began with a 1.5" diameter for a length of 0.75" and then stepped to a diameter of 1.688" for a distance of 1.05". McDonald then used an Iscar 0.130"-wide grooving tool to create two 0.187"-wide × 0.195"-deep grooves spaced 0.125" apart on the part's 1.5" diameter and a 0.187"-wide × 0.08"-deep groove at the end of the 1.688" diameter. The grooving tool plunged

B. Kennedy

At Rearick Tooling, it took one operator and one machine to reverse engineer and machine this 2.7"-long, 2"-dia. 1018 steel pipe fitting for a gas drilling company.

twice to create each groove's width and then made a finishing pass into, across and out of the groove.

Throughout, McDonald said, cutting speeds and feeds were set by the machine's conversational Mazatrol programming system, which determines correct machining parameters by analyzing the dimensions entered, the operations being performed and the material being machined. The cutting speed for this part is about 1,000 sfm and the typical DOC is 0.100".

Next, using a mirror image of the programming information generated when he machined the external thread gage earlier, McDonald cut 1.313" of $1\frac{11}{16}$-12 threads on the 1.688" diameter with an Iscar single-point threading tool.

After a part was cut off, it was flipped in the chuck. The WNMG insert cut a 45° taper, reducing the stock's 2" diameter to 1.44" at the part's end. McDonald then used a boring bar to enlarge a length of 0.705" of the axial bore to 1.105" in diameter. Using the ID thread gage program, he created 0.705" of $1\frac{3}{16}$-12 threads in the bore.

McDonald estimated that sketching the part drawings consumed 90 minutes and machining each fitting took just under an hour. Lead time for the job was 2 or 3 days, but similar parts sometimes are required immediately for emergency repairs.

McDonald's part sketch was redrawn in AutoCAD, and the file was given to the customer. Rearick knows the customer could send the file out to other shops for quotes, "but we have an advantage because we have the thread gages. They're an assurance the threads are going to go the way the customer wants them. It's a way to satisfy the customer and still retain business." Rearick added that reverse engineering is a value-added service. "We give them a better part than they gave us," Rearick said. **CTE**

contact us

If you have manufactured a part that would make a good candidate for a Part Time article, contact Contributing Editor Bill Kennedy at (724) 537-6182 or billk@jwr.com.

Filing and sawing

By Frank Marlow, P.E.

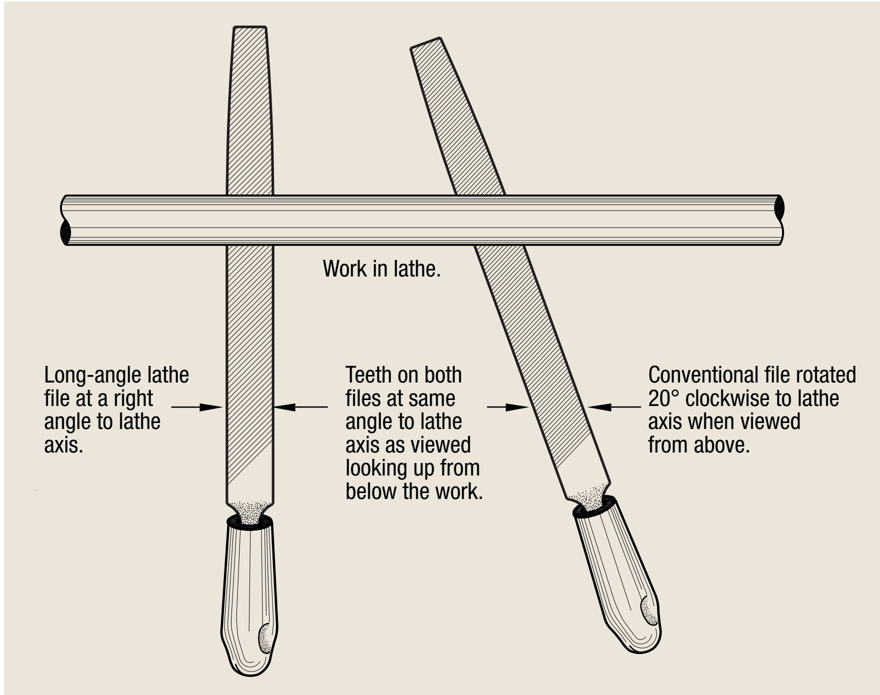
Crude files were used to sharpen tool edges since 1,100 B.C. in the form of stones with ridges running at right angles across them. Before the development of machine tools, files were the primary way to precisely cut and shape metals. Because faster metal-removal methods exist today, files are mainly used to sharpen and smooth edges, remove burrs or make small adjustments, but they remain an important and handy tool.

■ **Long-angled lathe files are a special file design that machinists use.** These files have teeth set at 45° to the file's length instead of the usual 65° and are designed for lathe filing of most metals and for bench filing of aluminum and copper alloys. The single-cut, bastard tooth is self-clearing when used at right angles to the work. It cuts cleanly without chatter and does not drag or tear. This file has a rectangular cross section and tapers slightly in width toward the point. In the lathe, the file should not be held rigid or stationary, but stroked constantly. A slight gliding or lateral motion assists the file to clear itself and eliminate ridges and grooves. Use a long, steady stroke across the work and move laterally about half the file's width. Lathe filing is most often used to remove sharp edges from shoulders and for sizing shafts when only a little material must be removed. When lathe filing must be performed with a conventional file (65° teeth), hold the file at a 20° angle clockwise to the lathe axis. This places the file teeth at 45° to the work like a lathe file. Dipping the file in cutting oil when lathe filing improves the surface finish. Run the lathe about 50 percent faster when filing than for turning the same metal.

> *Lathe filing is most often used to remove sharp edges from shoulders and for sizing shafts when only a little material must be removed.*

■ **Saws are also ancient tools.** It was the development of steel, its hardening techniques and finally steam and waterpower, however, that brought out saws' full potential. There are three basic types of saw applications. Cutting off or severing raw stock creates sizes suitable for machining, where limited accuracy is needed because stock is cut slightly oversized to allow for machining. Contour cutting or cutting out a part or shape, usually before more machining in mills and lathes, removes large chunks of metal in solid pieces rather than in chips. This saves electrical energy, reduces horsepower requirements, extends tool life for the chipmaking tools and lowers machining time. Slitting operations for making collets is the third application. Slitting is usually performed in milling machines, and the accuracy of slitting operations is higher than cutting off and contour cutting.

There are three primary material choices for toothed blades. Carbon steel is an economy grade for blades that



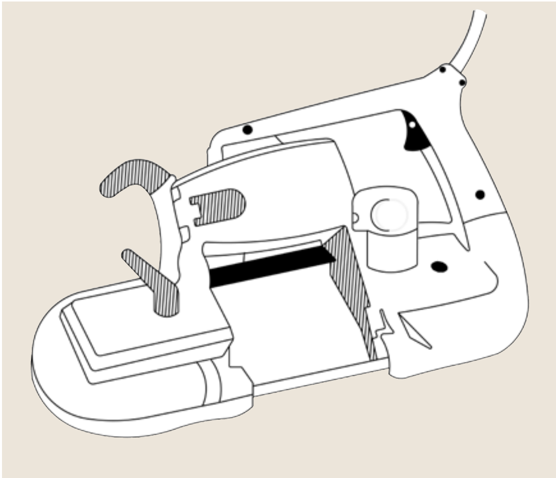
All images: Pamela Tallman

Rotating a conventional file by 20° to the lathe axis puts its teeth at the same angle as a long-angle lathe file.

saw mild steel, copper, brass and aluminum. A molybdenum-HSS blade is hardened from its teeth to the top of its back. These blades work well when cutting hard materials held securely, but the blades are brittle and likely to snap if the saw twists in the cut. Bimetal blades are more expensive but last longer than carbon steel or molybdenum-HSS blades. These blades feature hardened teeth coupled with a softer, more flexible back, which is less likely to snap if twisted. These saws last 20 to 30 percent longer than carbon steel blades and are the most economical on a per cut basis.

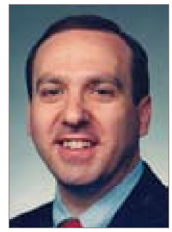
■ **Blade pitch is the number of teeth per inch.** Pitches from two to 32 teeth per inch are available. Based on the thickness of the workpiece, choose a blade with enough teeth so at least three teeth are in contact with the work at all times. For metalcutting, it is ideal to have six to 12 teeth in contact with the workpiece. More teeth in the cut will provide a finer finish.

■ **Portable bandsaws are another type of saw used in a machine shop.** This type of saw cuts raw metal stock into smaller pieces. Its geometry prevents a portable bandsaw from cutting into the center of large plates, but it cuts faster than a reciprocating saw because of its continuous cutting action. Portable bandsaws are mainly used to cut bar stock, shapes, pipe and tubing. CTE



A portable bandsaw cuts raw metal stock into smaller pieces.

About the Author:



Frank Marlow, P.E., has a background in electronic circuit design, industrial power supplies and electrical safety and has worked for Avco Missile Systems, Boeing, Raytheon, DuPont and Emerson Electric. He can be e-mailed at orders@MetalArtsPress.com. Marlow's column is adapted from information in his book, "Machine Shop Essentials: Questions and Answers," published by the Metal Arts Press, Huntington Beach, Calif.

By Dr. Jeffrey Badger

Archives MNATP, Collection Meillassoux

Dressing wheels quickly

Dear Doc: I form grind hardened steel with vitrified-bonded Al_2O_3 wheels. The forms are intricate, so I plunge dress with rotary diamond rolls. Whenever I get a new wheel, it takes a long time to dress it. My spindles aren't very stiff, so if I increase the plunge rate from, say, 0.8 mm/min. to 1.6 mm/min., the dresser starts to scream in protest. I dress with the typical +0.8 ratio to create a sharp wheel. That ratio represents the dressing roll's surface speed divided by the grinding wheel's surface speed when moving in the same direction at the point of contact, i.e., synchronous. What can I do to reduce dressing time?

The Doc Replies: The +0.8 ratio provides the sharpest wheel, but it also creates the highest forces acting on a dresser, and high forces cause chatter and vibration when dressing. Therefore, you have to compensate by plunging timidly.

Here's what you can do. During dressing, change the ratio from +0.8 to -0.8, i.e., from synchronous to asynchronous. This will decrease the normal forces acting against the wheel and diamond roll by about 50 percent, enabling you to double the plunge speed. In addition, increase the wheel speed to the maximum allowed by the wheel. This will also decrease the normal force, allowing you to plunge faster.

Keep in mind that a -0.8 ratio gives a dull wheel, something you definitely don't want during grinding. So, when you get close to having the form fully dressed into the wheel, leave about a one-grit diameter depth and switch to the standard +0.8 ratio. That way, you'll have a sharp wheel for grinding.

This will require you to change the direction of rotation of the diamond roll. On the vast majority of machines, this requires rewiring. So, install a switch with one setting for asynchronous and the other for synchronous, or one for initial dressing and one for dressing during grinding.

Finally, the 0.8 mm/min. plunge rate may be cause for concern. If a wheel is running at, say, 3,600 rpm, that rate gives a plunge depth of only 0.2μm per wheel revolution. That low depth dulls a wheel just as much as dressing in the asynchronous mode. To get a sharp wheel, increase the plunge rate to about 1.0μm per revolution. Of course, if you do that, the dresser will start screaming again.

To overcome that, decrease the wheel speed and dresser speed by a factor of, say, five during regular dressing during grinding. Then, you'll keep the same +0.8 ratio but will decrease the wheel-removal rate during dressing. More importantly, the plunge depth will increase from 0.2μm to 1.0μm per revolution, providing a sharp wheel.

The downside is a longer dressing time during the regular grinding cycle. But, with a sharper wheel, you'll be able to grind at higher material-removal rates without increasing the risk of grinding burn.

Dear Doc: My company is building a new grinder that will plunge grind casehardened steel with Al_2O_3 wheels. How can we size the motor based on the mrr?

The Doc Replies: The formula you're looking for is:

Grinding power (watts) = mrr (mm^3/sec.) × specific energy (Joules/mm^3).

The equation for mrr is: DOC (mm) × WOC (mm) × table velocity (mm/sec.).

Determining specific energy is the tricky part. Specific energy can range from 25 J/mm^3 to 400 J/mm^3 depending on, among other things, the grit size and type, the dressing conditions, the mrr, the coolant, the workpiece material and wheel dulling.

For example, a sharp-dressed, 25mm-wide, 80-grit wheel grinding 0.1mm depth with a table speed of 40 mm/sec. gives 6kW of power after dressing (0.1 × 25 × 40 × 60 = 6,000w) and 12kW after it's been grinding a while.

Now, let's take the power when the wheel is dull, 12kW, and work in a safety factor of, say, two, and you'll need a 24kW motor. CTE

About the Author: *Dr. Jeffrey Badger is an independent grinding consultant. His Web site is www.TheGrindingDoc.com. The Doc will be presenting a paper on aggressiveness in grinding at the CIRP Conference on High-Performance Cutting, to be held June 12-13 in Dublin, Ireland.*

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