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    □ 332 Fabricated Metal Product Manufacturing
    □ 333 Machinery Manufacturing
    □ 334 Computer/Electronic Product Manufacturing
    □ 335 Electrical Equip/Appliance & Component Manufacturing
    □ 336 Transportation Equipment Manufacturing
    □ 337 Furniture and Related Product Manufacturing
    □ 339 Miscellaneous Manufacturing
    □ 423 Wholesale/Trade/Durable Goods
    □ 999 Other Manufacturing NEC

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4. Number of employees at your company:
   □ A 1-9 □ B 10-19 □ C 20-49 □ D 50-99 □ E 100-249 □ F 250-499 □ G 500+

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So, without further ado, here’s all it takes to view CTE video reports:

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You may have seen machine tools with the same names before. But you’ve never seen anything like the new generation D series vertical machining centers from Romi Machine Tools Ltd. in Erlanger, Kentucky, said Regional Sales Manager Steve Reeves.

He said although the latest D series machines kept the names of their predecessors, “they are brand-new machines from top to bottom.”

In the U.S., Romi Machine Tools sells three D series models: the 6,577 kg (14,500 lbs.) D 800, which offers 787 mm (31”) of x-axis travel; the 6,895 kg (15,200 lbs.) D 1000, which offers 1,016 mm (40”) of x-axis travel; and the 6,985 kg (15,400 lbs.) D 1250, which offers 1,270 mm (50”) of x-axis travel. Maximum travel for all three models is 610 mm (24”) along the y-axis and 635 mm (25”) on the z-axis.

“In most cases, Reeves said, the fact that the D 800 provides as much y- and z-axis travel as its larger counterparts is an advantage because customers usually want more travel distance along those axes. On the other hand, this also makes the D 800 a larger machine. “If you need to get a machine into a very tight space,” he said, the D 800 “may not physically fit while some of our competitors’ smaller machines will.”

Like all Romi machine tools, D series machines feature Romi-made cast-iron beds that absorb vibration. In addition, all the machines are equipped with big-bore, 40-taper, direct-drive spindles. The company points out that direct-drive technology offers low maintenance and improved accuracy and repeatability, plus the big-bore 40-taper boosts stiffness and allows increased depth of cut during machining.

Compared with the previous D series versions, the new machines show cutting depth increases of up to 133% before vibration occurs, according to testing by Romi. In machining operations, Reeves said, the result is fewer passes and shorter cycle times.

D series spindles operate at speeds of 10,000 or 15,000 rpm, which he said is too low for minting and other applications that require very high spindle speeds. He noted, however, that the addition of a speeder head could boost the speed of D series spindles to 60,000 rpm.

Reeves said the new machines are the first in North America equipped...
with the Fanuc 0i-MF iHMI CNC, which includes a 381 mm (15”) touch screen and a high-speed, high-quality package. The latter, he said, presents a variety of machining speed and surface finish options in a grid-style arrangement of boxes on the screen for operators. This makes it easy to determine the proper trade-off between cycle time and surface finish for a particular application.

“The vertical column is speed,” he explained, “and the horizontal column is surface finish. As you (increase) speed, generally you will sacrifice surface finish. So this allows users to exactly choose their priorities. For example, you don’t need the utmost accuracy when roughing, so you can (opt for more) speed for roughing cycles.”

Other key features of the new machines include sensor-based thermal compensation, linear roller guides that facilitate feed rates up to 40 m (1,575”) per minute and a 30-tool automatic vertical toolchanger.

Still, Reeves said the machines aren’t unique in the sense that they provide many things that competitor machines lack. Instead, “we’re unique because we offer extremely well-equipped machines at a much better price,” he said, adding that shops might have to spend 50% more to get other machines with the same features as these new offerings.

Reeves said part of the dramatic price difference stems from Romi Machine Tools owning a 139,355 m² (1.5 million sq. ft.) facility in Brazil, where the company pours its own castings and does a lot of other manufacturing work that competitors outsource.

“They buy components and assemble machines,” he said. “We actually build machines.”

about the author
William Leventon is a contributing writer for CTE. Contact him at 609-926-6447 or wleventon@gmail.com.
In this article, I’ll show a method to make a modular fixture for mill applications. The fixture uses an off-the-shelf mechanical clamp and a novel work stop.

Holding parts for machining on a milling machine can be challenging. For our purposes here, the problem is machining a long, skinny part. It is a tool steel machine knife that must have an array of countersunk holes installed. The part has dimensions of 4.75 mm by 19.05 mm by 469.9 mm (0.187”×0.75”×18.5”). Marks on the edges of the part are not allowed. The batch has 50 parts to process, so quick part change is in order. Figure 1 shows the fixture and the part unmounted. Figure 2 shows the part mounted on the fixture. Figure 3 shows details of the fixture hardware.

The fixture base is 38.1 mm by 127 mm (1.5”×5”) aluminum bar stock that is 533.4 mm (21”) long. The top and bottom faces of the bar stock are finished flat and parallel. The bottom face has two T-slot keys installed that fit into a T-slot on the milling machine table. Two counterbored holes are provided on the top face of the fixture to accept T-slot clamping nuts. One of the counterbores is finished with a boring bar so that hole can be used as an index when installing the fixture on the machine. The two T-slot keys and two T-slot clamping nuts all use the same T-slot on the milling machine table.

The fixture uses an array of five hex head pins and five edge clamps to hold the part being machined. One round dowel pin at the end of the
part sets the length dimension. The hex pins are made from 12.7 mm (0.5") steel hex stock turned to 12.7 mm/12.675 mm (0.5"/0.499") dia. on one end. They fit into 12.725 mm (0.501") dia. reamed holes on the fixture. (See Figure 3.) The hex head pins are free to turn in the holes. This ensures that the part is clamped squarely against a hex face and there is an adequate clamping surface against the part. Using this method, marks are not made on the part edge. If round dowels were used, they would make a mess of the knife edge.

The clamps are fixture clamps by Mitee-Bite Products LLC in Center Ossipee, New Hampshire. These clamps have a brass nut mounted on a steel threaded bolt and are available in a variety of sizes. In this application, the size with 3/8”-16 thread is used. The clamps have an eccentric arrangement, so when the bolt is turned with a hex wrench, the nut moves radially on the bolt, clamping or unclamping the part. They are quick and easy to use.

This type of fixture using edge clamps and hex head pins has the advantage of positively locating horizontal dimensions. This way also can be used to clamp round or irregularly shaped parts with accuracy and repeatability. For a round part, using four clamping points works well. Use two hex pins to set X and Y position and two edge clamps to push the part against the hex pins. One hex pin at 0° and another at 90° and one edge clamp at 180° and another at 270° will do it. I hope that this helps.

about the author
Brandt Taylor is owner of Berlin, Massachusetts-based Taylor Engineering, a machine shop and manufacturer of lathe chuck jaws. He can be reached at 978-838-2979. For more information, visit www.stopjaws.com.

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about the author
Brandt Taylor is owner of Berlin, Massachusetts-based Taylor Engineering, a machine shop and manufacturer of lathe chuck jaws. He can be reached at 978-838-2979. For more information, visit www.stopjaws.com.
Dear Doc: We struggle with grinding burn. There’s talk of putting in a coolant refrigeration system. Will that fix the problem?

The Doc replies: Probably not. There are good reasons to install a refrigeration system, but eliminating grinding burn isn’t one.

Let’s assume you’re talking about rehardening burn, in which a workpiece becomes hotter than approximately 750° C (1,382° F), resulting in phase change in the steel, or “white layer.” A coolant at 20° C (68° F) sucks out only slightly more heat than coolant at 30° C (86° F) because the rate of convective heat transfer depends on the temperature differential between the coolant and the hot workpiece. Coolant at 20° C sucks heat out of a 750° C workpiece only 1.4% faster than coolant at 30° C [(750-20) / (750-30) = 1.014 = 1.4%]. In other words, if you burn with hot coolant, you’ll almost certainly burn with cold coolant.

The exception is if you experience burnout in creep-feed grinding. Here, you get large-scale coolant vaporization and lose almost all your cooling effect, causing a surge in grinding power and sudden, catastrophic burn. But this is very rare. In the vast majority of cases, you should fix your burn problem some other way, likely by dressing sharper (and using a smaller-grit wheel if surface finish becomes too rough), improving cooling velocity and aim (especially in creep-feed operations) or changing machine parameters.

Dear Doc: When we arrive on Monday mornings, we cycle machines without workpieces to warm up things. Some operators do it with coolant on, and some do it with coolant off. What’s your take?

The Doc replies: I’m a fan of doing it with coolant on. Your grinding machine is a giant heat generation system, and all that heat eventually has to go somewhere. When you cycle without coolant, almost all the heat ends up in the metal of the grinding machine, increasing the temperature. And hot things like to expand.

So far, no problem. You dress your wheel, grind a part, find the size, make adjustments and start your long batch run. But now you’re running with coolant on, which starts sucking out heat from everywhere. The temperature increase is no longer 2° C but 1° C. The linkage stuff gradually will shrink by 0.013 mm (0.0005”), bringing your wheel closer to your workpiece. Taken on diameter, that’s a 0.026 mm decrease. Can you live with that? It depends on your tolerances.

This is all a gross simplification, but you get the idea. So, I say cycle with coolant on. It’s not that a colder machine is any better. It’s that we want the temperature to stay more constant. In fact, that’s a main discussion point when speaking with my customers about whether they need a refrigeration system. The question is not whether they need lower temperatures — it’s whether they need more consistent temperatures.

**CTE**

**Holiday 2020**

**Ask the Grinding Doc**

COOLANT QUESTIONS

**About the author**

Jeffrey Badger, Ph.D., is an independent grinding expert who now is giving his grinding course online. For more information, visit www.TheGrindingDoc.com.
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On Oct. 21, 1948, the ninth meeting of the General Conference on Weights and Measures, also known as CGPM, adopted the joule as a unit of energy, work and amount of heat from the force of a newton acting to move an object through a distance of 1 m in the direction in which the force is applied.

Mathematical expression of the joule is: \( J = N \times m = (kg \times m/s^2) \times m = kg \times m^2/s^2 \). Expression of the joule in terms of SI base units is: \( m^2 \times kg \times s^{-2} \). Expression of the joule in terms of SI-derived and base units is: \( N \times m \).

James Prescott Joule (1818-1889) was an English physicist. His experiments and measurements allowed him to estimate the mechanical equivalent of heat. The joule is named after him.

Note that the calorie is a pre-SI metric unit of energy. Cal\(_{15}\) is the amount of energy needed to warm 1 g of water from 14.5\(^\circ\) C to 15.5\(^\circ\) C at the standard atmospheric pressure of 760 mm of mercury.

On Oct. 21, 1948, the ninth CGPM adopted the watt as a unit of power. Power is the rate at which work is done or the rate at which energy is expended. This unit is used in both mechanical and electrical terms. In the former, a watt is equal to a power rate of 1 J of work per second. In the latter, a watt is the power produced by the current of an ampere flowing through the electric potential of a volt.

Mathematical expression of the watt is: \( W = J/s = (N \times m)/s = [(kg \times m/s^2 \times m)]/s = kg \times m^2/s^3 \). Expression of the watt in terms of SI base units is: \( m^2 \times kg \times s^{-3} \). Expression of the watt in terms of SI-derived and base units is: \( J \times s^{-1} \); \( N \times m \times
s⁻¹; A × V.

James Watt (1736-1819) was a Scottish inventor and mechanical engineer renowned for his improvements of the steam engine. The watt is named after him.

On Oct. 21, 1948, the ninth CGPM adopted the coulomb as a unit of electric charge, or the amount of electricity accumulated in one second by the current of an ampere.

Mathematical expression of the coulomb is: C = A × s. Expression of the coulomb in terms of SI base units is: A × s.

Charles-Augustin de Coulomb (1736-1806) was a French military engineer and physicist. He is best known as the discoverer of what now is called Coulomb’s law: the description of the electrostatic force of attraction and repulsion. The coulomb is named after him.

about the author

Swiss-style machines are attracting plenty of buyers and might be right for you.

By William Leventon

Shops that decide to add a Swiss-style lathe to their machine line-ups join a large, growing club. But what accounts for the increasing popularity of Swiss-style machines? And if a shop hasn’t jumped aboard the Swiss bandwagon, should a shop do so?

First, the basics: A Swiss-style lathe is a turning machine that feeds stock through a guide bushing. A tool cuts the stock near the bushing, which is the support point, regardless of the length of the workpiece. This makes Swiss machining a good choice for turning long, slender parts.

“The fact that the tools are so close to the guide bushing helps with rigidity,” said Application Engineer Scott Petrisko of Absolute Machine Tools Inc. in Lorain, Ohio. “On a conventional lathe, your zero point is away from the chuck and you have deflection issues.”

Swiss machines are a fine selection for making parts with length-to-diameter ratios greater than 3-1, as well as deep, small-diameter holes. Swiss-made parts are generally under 38 mm (1.5") in diameter, with 51 mm (2") being a commonly accepted threshold for Swiss machines can accommodate live tooling.
Swiss. Making larger parts would require bars so large that vibration would become a major problem at a higher machine rpm, said National Sales Manager Ed Garber of Star CNC Machine Tool Corp. in Roslyn Heights, New York.

Another limitation on the size of Swiss parts is the size of the machines, which are usually small and compact. Therefore, Swiss machining would not be suitable for parts more than 203 mm (8") long, Petrisko said.

Swiss machines are particularly good at turning out small, mass-produced parts, said Engineer Jacques Houle of Milldale, Connecticut-based Century Tool & Design Inc., which designs and manufactures inserted cutting tools. He said Swiss machines often are used to make parts less than 12.7 mm (0.5") in diameter for the aerospace and medical industries, as well as small parts in cellphones. Swiss is also suitable for parts with very tight tolerances, he said.

“The biggest boom in business for Swiss machines in the past 20 years has been in the medical market because so many of those parts are small and precise,” said Garber, who mentioned little screws for orthopedic implants as an example.

When machining medical and aerospace parts, “you don’t have a large window for tolerances,” Petrisko said.

He has seen many cases where the tolerance for these parts was 0.0051 mm (0.0002") for an OD or ID. But he said very tight tolerance requirements can be met thanks to the rigidity offered by Swiss machines.

In addition to small parts, today’s Swiss machines can tackle complex components.

Some Swiss machines are “now equipped with machining heads for five-axis work to do things that would typically require either a mill-turn machine or a multi-operational process,” said Swiss Product Specialist Chris Leclerc of Tolland, Connecticut-based CNC Software Inc., a CAM software developer.

Swiss Advantages
Swiss machines have come a long way in the nearly 30 years that Leclerc has used them.

“The first one I ran did not have a live tool on it,” he said. “It had one eight-station turret and didn’t even have a pickoff spindle. Now there are machines with three turrets, two spindles and power tools everywhere, as well as five-axis (capability). As Swiss machines keep evolving into more powerful machines that can complete a part without multiple operations and do it in faster cycle times, people start realizing they need to own a Swiss.”

Leclerc said the speed of Swiss machining is due in part to the fact that the workpiece, guide bushing and tools are contained in a small space, which speeds up tool indexing. Another important factor is that machining can be done by both the main spindle and the
Swiss machining can be a good choice for small parts. In many cases, he said, parts first machined by a conventional lathe must be transferred to a milling machine for a second operation. If a Swiss machine is used for the same parts, however, the two spindles perform both operations, finishing parts in

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‘Swiss machines keep evolving into more powerful machines that can complete a part without multiple operations and do it in faster cycle times.’

Swiss Success

less time and freeing up the milling machine for other work.

Shops can experience the cycle time reductions that come with Swiss machining even if the personnel using the machines have little knowledge of Swiss, he said. This is possible if workers use CAM software that allows them to take their knowledge of the software from programming other types of machines and apply that understanding to Swiss machines.

As an example, Leclerc points to a longtime customer of his company’s Mastercam Mill and Lathe CAM software. When the client bought CNC Software’s CAM product for a new Swiss machine from Star CNC Machine Tool, the customer had a man on staff who was familiar with Swiss machining. But the man quit, so the client’s lead man for lathes was told he would take over Swiss machining.

“Here’s a guy who knows nothing about Swiss but can program a part with Mastercam Lathe and post out good code for his machine,” Leclerc said. This man “was able to take a part off a CNC lathe, put it on the Star machine and cut 16 minutes off the cycle time of that part.”

Another factor contributing to increased use of Swiss machining in recent years is its greater versatility.

“The big trend now is convertible machines that can run with or without the guide bushing,” Garber said. “You can remove the guide bushing, run without it and put it back later. All our machine designs in the past five years have that

The Nexturn XIII Swiss-type lathe has 11 axes.
feature built in to them."

With the guide bushing out, Swiss users are back to lathe-type turning of parts with maximum length-to-diameter ratios of 3-1.

“Now you’re chucking with a collet on the main spindle,” Garber said, “but you can actually hold very tight tolerances that way.”

The reason, he explained, is that there is a bit of “slop,” or clearance, between a guide bushing and a workpiece but none between a chuck and a workpiece, so a part is held tight.

Without a guide bushing, “one of our customers is holding 0.0003" (0.0076 mm) roundness, cylindricity and diameter tolerance running around the clock,” Garber said.

Technology Advances
The appeal of Swiss machining also has increased due to developments in chip control. Garber said Swiss machines do a good job with difficult materials, such as Nitralloys, high-nickel alloys and some newer types of stainless steel. But chips made of these materials can be very hard to break, he said, so big Swiss OEMs now offer some kind of chip breaking technology. Star CNC Machine Tool’s version is software called HFT, which stands for high-frequency turning. It decelerates the feeding process a little.

continued on Page 28
From aggressive applications to tough materials, Abrasive Technology specializes in the development and manufacturing of customized superabrasive grinding wheels and tools.

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HFT is a proprietary Star CNC Machine Tool function that aids chip control. Users program variables to produce machining-friendly chips to prevent them from wrapping around a part or tooling.

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to produce chips with thin sections that break more easily.

In addition to chip breaking technology, Swiss machining is benefiting from the general trend toward increased process data collection and analysis made possible by sensors, software and computing devices.

“It’s getting tough in the (machining) industry to find people,” Garber said, “but predictive analytics is getting to the point where machines need less operator intervention or attention.”

Rather than having operators on a shop floor monitoring machines all the time, technology can determine when employees actually need to be there — for instance, to load more material into a bar feeder or change tools — so people are on hand only when necessary. If need be, a message can be sent to the phone of a remote operator to come in and fix a problem.

Many shops install such systems so they can run machines lights-out, Petrisko said, adding that unattended machines can be set up with redundant tooling so that worn or broken tools are replaced automatically without stopping the machining process.

Put all the advantages together, and it’s a package making Swiss machining more popular than ever — even in a world dealing with the disastrous economic consequences of a pandemic.

“The whole Swiss industry is really maxing out right now,” Leclerc said. “In fact, people (working for Swiss machine OEMs) are telling me they can’t keep machines in stock despite COVID-19. I think it’s because shops are starting to realize what a Swiss machine can do for them.”

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When designing parts, considering the manufacturing process can result in a better product, reduced cycle time and lower costs.

By Frank Burke

While the primary consideration of a part designer or design team is the functionality of a part, the manufacturing process and the end product can be improved significantly by taking into account various elements related to manufacturing, including machinability, tooling, assembly, desired finish and economy of production. This is especially true as parts become more complex, exotic materials become more common and CAD systems and other design protocols become more technologically advanced. New design tools, such as those based on artificial intelligence protocols, have added demands for decision-making to the overall process.

Another challenge can arise in situations in which the design function is entirely separate from manufacturing — for example, when job shops are requested to quote based on a CAD file from a manufacturer. In some cases, the part in question cannot be made based on the initial design. Different families of parts also can...

A 3D image (above) is displayed of a specially designed cutting tool.
The main challenge in groove milling is usually chip evacuation, especially when machining deep and narrow grooves. CoroMill® QD is the first cutter of its kind with internal coolant. This, combined with optimized insert geometries deforming the chip to a shape more narrow than the groove, makes CoroMill® QD a highly reliable tool ensuring great chip evacuation and trouble-free machining.

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Design for Manufacturing

require completely different manufacturing strategies.

Design for Manufacturing

Fraser, Michigan-based Eifel Inc. knows these concerns well. It specializes in production and prototype tooling for automotive interiors, as well as advanced tooling for the medical and aerospace industries.

“We typically work with H13 and S7 steels for abrasive plastics,” said Richard Hecker, second-generation owner and CEO. “For more conventional plastic parts, we use a milder steel, such as P20. Our process typically starts when we get a 3D part design. After reviewing the design internally, we frequently consult with the customer on opportunities to reduce complexity and identify areas in which we could save money on the tooling. We also obtain background information on how the part will be used and the type of plastic that will be molded. We need to have a comprehensive understanding of the customer’s needs.”

Designing for manufacturing often includes not only the design of a part but incorporation of part fixturing. Macro Tool & Machine Co. Inc. in LaGrangeville, New York, began as a local job shop in 1968. The company now services a nationwide customer base, including aircraft and military aerospace, medical implants and tools, sporting equipment and automotive applications.

“We work in a variety of metals, ranging from sheet metal to steels, aluminum and exotics and high-temperature steel alloys,” said CEO and President Daniel Siegel. “As a job shop, we are generally unable to ask for changes to part designs except occasionally for reduced tolerances or further specifications. For instance, customers sometimes give us CAD files without the tolerances for each hole, and that’s something we have to verify.”

The inability to change the design of customer parts has resulted in the development of fixturing that delivers precise repeatability and shortened changeover times. Knowing that such challenges were not unique to his company, he developed a line of pallet-type tooling systems, indexers, single and double vises, and pallet-mounted chucks.

A mold for a steering wheel is machined using P20 steel.
marketed under the brand name STS, which stands for Siegel Tooling Systems. Created for small and midsize parts, the products aim to increase output while avoiding the high cost of customized fixturing.

The critical nature of the design function is most apparent in the development of specialized cutting tools.

“Special tools place a dual responsibility on the manufacturer,” said Engineering Manager Paul Ditosto of Mitsubishi Materials U.S.A. Corp. in Costa Mesa, California. “On the one hand, we have to be sure that the tool we design will perform its desired function for the customer. At the same time, we have to consider the most effective and economical means of producing it. This is further complicated by the ever-increasing number of carbide grades and specialized coatings, which have to be matched to achieve the optimum combination. To obtain the best results, we have to constantly keep in mind our customer’s manufacturing process, as well as our own. Although we can occasionally modify an off-the-shelf item, our prototype designs have to be extremely exact. And because our manufacturing facilities are located globally, the sequence of operations must be spelled out.”

It’s Complicated

The complex nature of many modern parts and the materials they are made from have expanded the considerations that come into play in designing for manufacturing. Machinability, finish, quality, tolerance, economy of production, eventual method of assembly and possible interface with other
components of different materials are all elements to be taken into account.

“It’s essential that we understand what the customer is trying to do, and there are many questions that have to be asked,” Ditosto said. “These would include: Can we achieve the desired finish? Can we minimize the cycle time? What are they using now? And if this is a modification of an existing design, why do they want to alter the current design?”

Hecker also cites the necessity of extensive dialogue, not only with a customer but sometimes with its suppliers.

“We have to understand the importance of the part, as well as many of the elements of the molding process,” he said. “For instance, in the automotive industry, air bag covers have to meet specifications for appearance and — even more important — for function. We must ascertain how the part can be molded, how the cooling process works and what temperature the part will be checked at. To answer those and other questions, we sometimes must talk with the customer’s supplier about the characteristics of the types of plastics that will be molded. It’s a matter of knowing both our business and our customer’s.”

Siegel mentioned the importance of tolerances and the sequencing of operations in defining a manufacturing strategy.

“We have to ask ourselves whether a part or component should be heat-treated first or after it’s produced,” he said. “Also, if bores are required, do we do that earlier or later? There are always a lot of questions, and answering them in advance eliminates misunderstandings.”

Tooling represents a significant factor for part designers. If a part can be generated with conventional tooling, costs can be substantially less than if special tooling is required.

“There are times when it’s impossible to avoid specialized tooling,” Siegel said, “and that has to be taken into account in calculating the cost of the job and the value of the part.”

Eifel emphasizes knowing the capabilities of CNCs, EDMs and tooling and how each injection mold fits into the machining process.

“Five-axis machining provides a great amount of flexibility,” Hecker said. “We want to use the shortest cutter possible in order to achieve

A pallet is shown for a specific customer application. Macro Tool & Machine also dedicates vises and chucks on pallets to fill particular needs.
the most precise results. We also use shrink-fit tooling to reduce deflection.”

Where’s the Software?
The demand for more software features related to manufacturability is being answered in the latest versions of several CAD/CAM/CAE packages. Ditosto and his team use a number of systems depending on the task, type of design and complexity.

“Based on the complexity of the design, we choose the appropriate design software,” he said. “We have a few options we tend to lead with, and it might be dependent on how close the design is to one of our standard tools. We would tend to stay with the design system which the standard product was developed with. On the CAE side, we have a couple of products we use depending (on) if it is a structure (design) or optimization (manufacturing) process. AutoCAD, Autodesk Inventor, Creo/Pro/E, Mastercam, Esprit, Solidworks CAM, Siemens NX, 3D Systems, hyperMill, Vericut and Production Module all have their place when it comes to CAD/CAM and CAE. CAM systems have really changed in the past 10 years. Visualization and simulation with many of these products is quite impressive. We partner with all of the above CAM software brands at our MTEC (Materials Technology and Education Center) in North Carolina to help solve manufacturing challenges. It’s amazing what these products can do, and we look forward to any new features that may be introduced down the road.”

Siegel sees the benefits of versatility in software selection.
Eifel continually invests in the latest high-tech machining capabilities.
‘We have to constantly keep in mind our customer’s manufacturing process, as well as our own.’

Design for Manufacturing

“Although we’re aware of the newer softwares, we frequently work in 2D for the sake of simplicity,” he said. “One design that appeared at first to be simple but wasn’t was a bar of pure iron that needed to be plated. The tolerance was 0.0001” (0.0025 mm), and it was ultimately used for its magnetic properties.”

Software can enhance the process by providing valuable tools.

“We perform a draft analysis on the molds we produce in order to anticipate challenges before they occur in the machining process,” Hecker said. “The wrong draft angle on a cavity can cause scuffing. And if we discover that in the early stages of the process, we can determine whether to revise the tooling or the toolpath or go for more detail.”

The advent of such technologies, including generative design and 3D printing, as well as the demand for microparts capable of assembling themselves, continues to magnify the importance of incorporating manufacturability at the design stage. Likewise, the increasing array of options for materials and manufacturing techniques will heighten demand for analytics software and AI-based tools that can evaluate the choices inherent in part design, manufacturability, part performance, economy of production and — in an age of greater ecological awareness — predictable part life and recycling/disposal considerations.

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CTE
Microengraving requires balancing cutting tool characteristics and machine capabilities.

By Alan Richter

Traceability from start to finish is essential for mission-critical components, such as ones machined for medical and aerospace applications. And when parts are small, microengraving tools frequently are needed to permanently create serial numbers and letters.

“Anything that needs traceability, they will put an engraving on it,” said Solution Sales Manager Kevin Jackson of Kyocera Precision Tools Inc. in Hendersonville, North Carolina. “Almost everyone I know of is using engraving for serial numbers.”

For micromachining, the toolmaker offers three series of solid-carbide engraving tools: EGR, HR (half-round) and SPD, or spade. Although the spade tools are suitable for engraving, especially the version with a 30° included angle, they are designed primarily for spotting and chamfering, he explained, adding that they see limited use.

However, that’s not the case for the other two series, Jackson said. The two-flute EGR engravers have a 1.27 mm (0.05”) diameter, have a V-shaped bottom and are available with a 30°, 60° or 90° included angle while the single-flute HR tools have a flat at the end as small as 0.127 mm (0.005”) to produce a letter height up to 1.59 mm (0.0625”).

Having a two-flute tool is often an attractive option when microengraving, particularly when it is run on a machine tool with limited rpm.

“The EGR is one of our bigger sellers because it’s a two-flute,” Jackson said. “If you are OK with a V bottom on your lettering or engraving, especially the version with a 30° included angle, they are designed primarily for spotting and chamfering, he explained, adding that they see limited use.

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Having a two-flute tool is often an attractive option when microengraving, particularly when it is run on a machine tool with limited rpm.
ing, you will be able to feed it twice as fast.”
On the flip side, he said the flat on the bot-
tom of a half-round tool produces a more pro-
nounced, aesthetically pleasing engraving
than a tool with a sharp point does.
“I used to work in a machine shop,” Jack-
son said, “and most of the time we used the
half-round with the flat because it looks better
when painted.”

Spirits of Ancient Egypt
BIG KAISER Precision Tooling Inc. is another
manufacturer of microengraving tools. The
Hoffman Estates, Illinois-based company of-
fers Sphinx single-flute engraving mills with a
flat or radius tip. The flat-tip tools have a diam-
eter range from 0.02 mm to 0.15 mm (0.0008”
to 0.0059") and are available with a point angle
of 30°, 40°, 50°, 60° or 90°. The other style is
available with a radius range from 0.04 mm to
0.1 mm (0.0016” to 0.0039”) and the same se-
lection of point angles.
The tools are targeted at machining envi-
ronments that require a high level of precision,
said Sphinx Product Manager Cory Cetkovic.
“With regards to engraving, it’s important to
use a precision tool because they are used in production and prototype applications to create logos or informative markings on a workpiece, and those are used for visual recognition,” he said. “So it’s important to maintain a high level of consistency and minimize variations from part to part.”

End users frequently engrave with a ballnose or another type of endmill, but even tiny ones won’t necessarily achieve the required result when the engraving is difficult if not impossible to see clearly with the naked eye.

“The challenge with a precision tool like this is finding the applications where someone simply can’t do it with a conventional tool,” Cetkovic said. “If you’re producing a workpiece that ends up in the human body and you need to engrave it with your company’s name or a serial number, that’s where a tool like this is critical because you can create a very consistent but very small feature on the workpiece.”

National Sales Manager Todd White of Scientific Cutting Tools Inc. concurred. He said a microengraver with a flat at the bottom, for example, provides better engraving definition than a ballnose endmill, which generates a radius form in the workpiece.

“It might not stick out as well,” he said about an engraving made with an endmill.

The Simi Valley, California, tool manufacturer offers single-flute engraving tools with tip diameters from 0.127 mm to 0.381 mm (0.015”) and included angles of 30°, 40°, 60°, 90° and 120°.

Slick and Sharp

To minimize the amount of workpiece material that sticks to a tool, White pointed out that SCT provides a polished finish on the face of its engravers.

In addition, cutting edges must be sharp to create a clearly visible, consistent engraving. That is generally not an issue for uncoated engraving tools but can be for coated tools if the appropriate coating technology isn’t employed.

“In the old days, the coatings were pretty thick because they were CVD coatings,” White said. “Now, the modern PVD coating is thin: 1 to 2 μm (0.00004” to 0.00008”). You can put it on a really sharp tool and still keep a sharp cutting edge.”

He said the toolmaker uses Platit coating equipment to deposit SCT’s AlTiN+, or AlTiSiN coating, which includes silicon in addition to the recipe’s typical ingredients of aluminum, titanium and nitride. Coated tools are applied mainly to engrave ferrous materials. But because the heat and friction generated when machining enhance an AlTiN-based coating’s protective characteristics through oxidation, coated tools are also effective for engraving nonferrous materials, such as plastic and aluminum. This enables an end user to engrave both aluminum and steel workpieces with the same tool.

In contrast, because BIG KAISER Precision Tooling doesn’t coat tools smaller than 0.2 mm (0.008”) in diameter, Cetkovic said all the company’s engraving tools are uncoated.

“They are far below the minimum for a coated tool,” he said.

Likewise, all of Kyocera Precision Tools’ standard

A Happy Medium

Alan Richter is editor-at-large for CTE. Contact him at alanr@ctemedia.com.

about the author

Engraving tools and engraved workpieces are shown.
engraving tools are uncoated, but the toolmaker does offer coated engravers, primarily AlTiN, as specials to enhance lubricity and tool life, Jackson said. However, in addition to a lead time of 10 to 15 days for coated tools, he said a coating might double the cost of a relatively inexpensive engraver.

“The user would have to look at (it) and ask, ‘Am I going to get enough tool life out of it to justify the expense of the coating?’” he said. “If engraving all day long and if it was up to me, you are going to get your money back.”

Besides metal, plastic and even wood, Jackson
said a significant number of customers engrave graphite for EDMing a steel die used for moldmaking.

“Then when you form a molded part inside that steel die,” he said, “the numbers are already built in to that part.”

Ramp or Plunge

Because SCT’s engravers are small, relatively delicate tools that feature a small flat, White recommends ramping, or arcing, into a workpiece material to help avoid snapping or chipping the tool.

“It is easier on the tool,” he said. But if an end user chooses to plunge-mill into a part, SCT suggests reducing the chip load 50%.

Cetkovic agreed that ramping is the preferred method, especially considering that an engraving tool takes a DOC of less than 0.15 mm (0.0059”).

“You are going to be feeding very fast with very light depths of cut,” he said, “so when you are ramping downward, you are not ramping down at a very high angle.”

However, because microengraving does not go deep into a workpiece, Jackson said plunging is more common than ramping.

“If they ramp in, that means they have to go back over it and ramp back out,” he said. “When you are plunging, you are technically drilling.”

Jackson concurred that when plunging, a chip load should be half of what is appropriate for ramping.

“I always back it off to make sure the small tips do not have any chance of chipping or breaking,” he said.

Coolant application or lack thereof is another aspect of microengraving that requires consideration. Jackson primarily recommends clearing chips with an air blast, but flood coolant directed

Sphinx single-flute engraving mills are displayed.
at the tool/workpiece interface through the collet or workholder can extend tool life and enhance lubricity to reduce built-up edge, depending on the workpiece material.

“If you are engraving aluminum, brass, copper, anything that is sticky, you are going to get less chance for it to stick on the tool,” he said about flood coolant. “If it sticks on the tool, you start smearing the engraving.”

Flood coolant also effectively evacuates chips.

“Everything is so small that anytime chips build up in your engraving, you will start double cutting them,” Jackson said, adding that the result will be a low-quality engraving.

White said although many shops apply flood coolant, some find that a coolant mist, or minimum quantity lubrication, is effective.

“You don’t see much dry cutting anymore,” he said. “It’s a trend that isn’t continuing.”

Cetkovic noted that MQL is often adequate, depending on the workpiece material, but using air to clear chips might be necessary, such as for medical applications to help avoid coolant contamination.

While microengraving continues to gain ground in numerous industries, including medical, aerospace and defense, it remains a relatively niche market.

“We have a few customers who use a lot of them, but they are not incredibly common,” Cetkovic said. “What we have is very successful products for the types of customers that need them.”
Grinding is a machining process found at almost all shops. Some grinding operations, such as snagging castings, grinding welds or bench grinding, are relatively simple. Other grinding activities can be complex like those used to hold very close tolerances or machine difficult materials. Grinding has a broad range of applications in manufacturing. As with many procedures, selecting the best tool is critical.

Although the cutting edges are much smaller and arranged in a random order, grinding wheels are cutting tools and perform the same job as endmills, drills and turning tools. Whether snagging castings or grinding gears, wheels are similar.

Abrasives

Grinding wheels are made from several types of abrasive materials, from aluminum oxide — the softest and most common — to diamond, which is the hardest and most expensive. Most wheels are manufactured by mixing the abrasive material with a bonding agent and then placing the mix in a mold to achieve the desired shape.

A vitrified wheel is formed under pressure and then baked at a very high temperature, which turns the bonding materials — for example, clay — to glass, giving strength and rigidity to the wheel. Resinoid-bonded wheels use the same sort of abrasives with a softer resin bond that often is reinforced with other materials like fiberglass to add strength. Resinoid wheels can operate at higher cutting speeds than vitrified wheels and are less likely to fail, with uneven loading making resinoid wheels ideal for use on hand tools or machines, such as chop saws. Vitrified wheels hold their shape better and are stiffer than resin-bonded wheels, making them best suited for close-tolerance work performed on rigid machine tools. Both kinds of wheels can break and fragment during use, but vitrified wheels are more susceptible to catastrophic failure, which is another reason they typically

Grinding Wheel Safety

Grinding wheels can be dangerous. I have worked at two companies where people died as a result of catastrophic wheel failures. Eye and hand injuries are common with abrasive hand tools and bench grinders. It is imperative for everyone using grinding wheels or equipment to be thoroughly trained. Simple tasks like ringing wheels, using blotters, properly torquing wheel flanges, standing and working in safe zones and incorporating appropriate personal protective equipment are critical to maintain a safe environment. The Occupational Safety and Health Administration, the American National Standards Institute, wheel manufacturers and machine builders all have detailed publications that outline safety requirements for grinding wheels and machines.
are not used for hand work.

Super-abrasives like diamond and cubic boron nitride are expensive. To reduce the amount of abrasive needed to make a usable wheel, an abrasive is bonded to the periphery of a metallic disc. Diamond and CBN bonds can be vitrified, resinoid or metallic. Metallic-bonded wheels use metal powder, such as cobalt and copper, mixed with an abrasive. Using a process known as sintering, the mixture is formed around the periphery of a wheel. The abrasive and metal powder are baked at a high temperature, causing them to bind together.

Super-abrasive wheels have better performance characteristics but a narrower range of applications as the wheels do not perform well on softer materials. CBN wheels are used most often on hardened ferrous materials and can be found in machines like tool and cutter grinders, camshaft grinders and gear grinders. Compared with Al₂O₃ wheels, CBN wheels run cooler, last longer and can function at higher speeds. Diamond is used to grind carbides, glass and other extremely hard nonferrous materials. Super-abrasives are more productive but expensive. They frequently cost 10 times more than other types of wheels, and their applications are typically very specific.

Other Factors

Picking the proper wheel is obviously important for grinding operations and can be challenging for even an experienced machinist or engineer. The selection process is often one of trial and error working to optimize the combination of machine, cutting fluid, cutting parameters and grinding wheel.

After the abrasive material and wheel shape, main factors for wheel selection are grit size, bond type and bond hardness. Workpiece material dictates the abrasive, wheel shape and type of bond. Grit size and bond hardness usually are chosen based on surface finish requirements and the hardness of material. Low-volume environments generally use one type of wheel and adjust grinding parameters to succeed as the variation in cycle times and wheel wear is not an issue. High-volume production work like that found in automotive manufacturing requires repeatable performance that can be achieved only with significant development time.

At a previous employer, we had seven centerless grinders, which produced about 2 million parts a year. Grinding wheels were 610 mm (24") in diameter and 508 mm (20") long. It took a full shift to remove an old wheel and mount a new one. This majorly disrupted production, so precisely controlling wheel wear was critical to manage costs and meet production requirements. It was a big blow to us when our wheel manufacturer discontinued the particular wheel we had used for years — we were the sole company using it — and the lone replacement had a harder bond. This seemingly minor change resulted in unpredictable wheel wear and unplanned wheel changes.

Because the new bond was harder, the wheel dulled faster and would cause part geometry to deviate from specifications. The only way to recover was to redevelop the grinding process. Although we had many years of experience and several experts on centerless grinding, it required a few weeks to arrive at the ideal set of grinding parameters.

Choosing a grinding wheel can seem mysterious, and developing grinding parameters is iterative. As with all machining operations, however, experience, knowledge and skilled craftspeople are the key to selecting and using the right grinding wheel.

Nice Wheels

Curvic grinding is performed with a vitrified wheel not much different from the wheel found on a bench grinder.

about the author

Christopher Tate is engineering manager of advanced manufacturing engineering and machining at the Savannah, Georgia, facility of Mitsubishi Hitachi Power Systems Americas Inc., Lake Mary, Florida. Contact him at chris23tate@gmail.com.
After a machine tool is a decade old, it’s history at J&R Machine Inc. The Shawano, Wisconsin-based Tier 1 manufacturer caters to OEMs and other Tier 1 companies and targets the industries of oil and gas, fire protection, heavy vehicle, defense and aerospace. Typical part runs are from 500 to 5,000.

“Our strong point is in multitasking, turning and automation in the 1”-to-10”-dia. (25 mm to 254 mm) range,” said President Tim Tumanic, who added that parts are up to 711 mm (28”) in length.

Last year, two DMG Mori NLX 2500 universal turning centers hit their replacement age. Those machines had one spindle and one turret with live tooling. Because J&R Machine exclusively runs DMG Mori USA Inc. machines to have a common platform, the shop turned to the Hoffman Estates, Illinois,

J&R Machine replaced two single-spindle, single-turret machines with two NZX 2000 machines, which have two spindles and three turrets apiece.
machine tool builder for new machines.

But instead of replacing the old machines with new versions of the same model, J&R Machine decided to purchase two NZX 2000 CNC machines, which have two spindles, automated gantry loaders and three turrets with live mill/drill tool heads, said Vice President Parker Tumanic.

“The thought process was,” he said, “instead of adding more equipment long term to increase capacity, as equipment needs to be replaced we will simply put in a machine with twin spindles, automatically realizing a 100% gain while utilizing the same amount of floor space and the same operators. We are not just going to say, ‘We have this job, and this machine is all we need.’ Because if that job goes away in a year, we want to still have a machine that has the most capability and efficiency because we never know what is going to come through the door tomorrow.”

The machines were custom-ordered. Shop representatives traveled to a facility in Portland, Oregon, for a machine demonstration because that was the closest location with a machine similar to the ones that J&R Machine decided to buy.

“It took about eight months from purchase order to delivery,” Parker said.

He said after installation, which required constructing a 0.6-m-thick (2’) concrete foundation under each machine to enhance stability, the machines quickly improved the contract manufacturer’s efficiency. For instance, a part that previously needed fixturing on two lathes and three horizontal machining centers was completed in one setup on an NZX 2000.

“The part was measured in the coordinate measuring machine and came out perfect for our orientation,” Parker said.

He explained that the risk of operator error enters the picture when a part is produced on more than one machine, especially when precise orientations must be held. In addition, the gantries automatically load and unload parts.

“Not only did we just double the gain with the twin spindle and triple turret,” Parker said, “but the machine runs unattended as well.”

In another example, he said J&R Machine increased the number of parts per hour from five with the old machine to 12 with the new one.

“The setup time remained fairly neutral,” Parker said. “Where you gain is on the uptime of the machine and its efficiency.”

He said some jobs run for 100 hours or more after setup.

“Your low-hanging fruit is in the run time rather than setup time,” Parker said.

To keep coolant at the ambient temperature of the shop air, which is held to 22° C (72° F), J&R Machine added coolant chillers to the machines.

“When you have three turrets cutting, it heats up the coolant,” Parker said, noting that the company can run 69 bar (1,000 psi) coolant through all the turrets.
He expects a return on investment for the two machines in 24 months.

“This was one of our first steps into chucking automation,” Parker said. “It’s probably a good chance this will be our new platform going forward.”

Tim said everything that J&R Machine does — from its collaborative culture to rapid response times — is focused on simplifying the production of complex machined parts for customers.

“This is especially valuable now as manufacturers work to address the unprecedented challenges in our current environment,” he said. “The addition of the two new DMG Mori NZX 2000s strengthens our automation platform, increases employee efficiency and results in greater accuracy of our customers’ parts.”
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Look-Ahead

REUSABLE RESPIRATORS

The ExOne Co. in North Huntingdon, Pennsylvania, and the University of Pittsburgh have partnered to develop reusable metal filters that fit into a specially designed respirator cartridge for sustainable, long-term protection from contaminants.

ExOne’s binder jetting technology is a high-speed form of 3D printing that can produce metal parts with specific porosity levels that effectively can filter out contaminants while allowing airflow.

The company has 3D-printed respirator filters using two metals — copper and 316L stainless steel — and a range of porosity levels for use inside a unique cartridge designed by the Department of Mechanical Engineering and Materials Science at Pitt’s Swanson School of Engineering. Initial testing for airflow and filtration efficiency is underway, and the filters are being optimized with the goal of adhering to an N95 respirator standard.

“Our team has been working urgently to expedite this promising and reusable solution for medical personnel on the front lines of fighting the COVID-19 pandemic,” said CEO John Hartner of ExOne. “Our customers routinely print porous metal filters for a variety of purposes, and we are confident that we’ll have a solution soon that can enable medical personnel to sterilize metal filters for repeated reuse, eliminating waste. Once approved, we can print these filters in a variety of sizes for respirators, ventilators, anesthesia masks or other equipment.”

“ExOne’s binder jetting technology uses an industrial print head to selectively deposit a liquid binder onto a thin layer of powdered material, layer by layer, until a final object forms. After 3D printing powdered metals, the object then is sintered in a furnace to dial in a specific level of porosity. While binder-jetted metal typically is sintered to full density, some applications, such as filters, require a particular level of porosity.

To test filters using different metals and porosities, Chmielus’ research group uses CT scanners to analyze the microstructure and porosity of filters. Ansys Inc. in Canonsburg, Pennsylvania, is providing additional computer simulation support to analyze and optimize filter performance.

Since ancient times, copper has been known to possess antibacterial properties. The first recorded use of copper to kill germs was in the Edwin Smith Papyrus, the oldest known medical document, according to the Smithsonian Institution. Many studies have proven the disinfecting powers of copper. A study funded by the U.S. Department of Defense in 2015 revealed that copper alloys contributed to a 58% reduction in infections. COVID-19 research suggests that the virus dies faster on copper than on other surfaces.

For more information about ExOne, call 877-773-9663 or visit www.exone.com.

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