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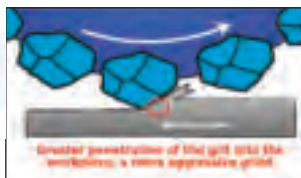
A guide to what's new on CTEPlus

Smart phone benefits

You can now use your smart phone—a free application is available at get.neoreader.com—to scan the quick response (QR) matrix bar code images below and instantly access the respective reports on our Web sites. You can also access the reports by entering the URLs listed.

Grinding Doc's latest episode

Dr. Jeffrey Badger helps a grinding shop weigh advice from two wheel salesmen. One says the sweet spot of a wheel is all about material-removal rates, while the other keeps talking about wheel speed. Who's right? ctepus.delivr.com/151nu



Nuclear reactor parts

For an overview of the Westinghouse AP1000 nuclear reactor and how it represents opportunity for U.S. machine shops, check out this brief video and the accompanying report on the nuclear energy industry. ctepus.delivr.com/14fui



Micromilling Webinar

Cimatron Technologies Inc. recently teamed with MICROmanufacturing, CTE's sister publication, to present a 46-minute Webinar covering milling new materials, using special mold coatings, milling parts with 0.1mm-dia. tools and achieving submicron accuracy. micro.delivr.com/151o2



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IS #42

*By Alan Rooks, Editorial Director*

Washed away

News of natural and man-made disasters typically follows the same pattern. The first reports indicate something major has happened, but details are sketchy and the impact unclear. Each successive hour reveals more. As the news rippled out from the March 11 earthquake and tsunami in Japan, the scope of the disaster seemed almost unfathomable, with videos looking like special effects in a science fiction movie. But for the survivors in northern Japan, the news is all too real, with their homes and lives literally and figuratively turned upside down. The human catastrophe has morphed into a nuclear disaster into an ongoing economic crisis.

As of mid-March, it is hard to gauge the full impact of this disaster on Japan and the rest of the world. Based on experience, the direct economic impact of these events is pronounced for about 6 months, and felt mostly where the disaster occurs. Gradually, the reconstruction effort boosts economic growth. But the historic scale of Japan's 3/11 earthquake and tsunami, given the profound damage to Japan's electrical grid, means the economic problems could increase.

Because Japan is a key player in global supply chains, there may be significant ripple impacts on industries such as automotive, aerospace and machine tools—all of major interest to the U.S. metalworking industry. All automakers depend on complex global supply chains, and even GM, Ford and Chrysler cars built in the U.S. use some Japanese components. Also, if Boeing's Japanese suppliers for the 787 Dreamliner are disrupted for more than several weeks, the company could face new production problems.

Japan's seven largest automakers experienced nationwide production shutdowns after the earthquake due to supply chain interruptions, power shortages and shipping problems. Many of the automakers were unable to make contact with parts makers in the earthquake zone. These automakers' U.S. production could be hurt as well if plants can't get parts normally imported from Japan.

Japanese machine tool builders—which play a large role in supplying U.S. metalworking operations—may also be affected by the disaster due to supply

chain disruptions. Fortunately, three of the largest Japanese machine tool builders—Makino, Mori Seiki and Mazak—reported that they had mostly escaped direct damage from the earthquake and that all of their employees had been accounted for. Mori Seiki reported only minor damage at one plant. Mazak noted that there was relatively minor damage only at two technology centers in the earthquake zone. Makino reported that its facilities remain undamaged. Mitsui Seiki Kogyo Ltd., a builder of ultraprecision machine tools, also reported its plants and staff to be safe.

While the U.S. is not likely to experience direct economic problems from the disaster, the effect of the Japanese nuclear crisis will almost certainly have a chilling effect on the development of new U.S. nuclear plants—and the parts makers that would supply them. Just last month, CTE's cover story explored the revival of new U.S. nuclear power plant construction, which had been largely dormant since the Three Mile Island nuclear accident in 1979. Prior to the earthquake, I had been working on a column about the possibility of developing small-scale nuclear power plants in the U.S., a growing concept that had gained the support of the U.S. Department of Commerce. Most of those plans will likely be put on hold indefinitely.

If there are any positives from this disaster, it's that Japan is a highly resourceful and hard-working country, and will make an all-out effort to recover and rebuild. With a substantial portion of the U.S. manufacturing base in earthquake-prone California, we would be wise to study how Japan orchestrates this recovery, because we may be in the same situation at any moment.

Human civilization's hold on this planet is tenuous, as we've relearned in recent years from natural and man-made disasters such as Hurricane Katrina and the flooding of New Orleans, the Southeast Asia earthquake and tsunami, the Haitian earthquake, the Gulf oil spill and now the Japanese earthquake and tsunami. The Earth teaches hard lessons, and we need to pay attention.

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IS #10

■ Venture capital firm targets machine shops

Why would a venture capital company buy a machine shop? Some feel that investing in manufacturing is investing in the past. Not so, says Blackland Group LLC, Dallas. The venture capital company bought controlling interest in Kessington Machine Products Inc., in early March. The Elkhart, Ind., job shop produces parts for various industries, including aerospace, laser-guided munitions and motion control. Kessington has been in business for more than 30 years.

Blackland Group's history is a bit shorter. It was formed by Michael L. George, president, and C. Scott Shedd, managing director, a little more than 2 years ago. However, George noted that they have extensive experience in the machining industry and rely on a network of experts.

A main reason Blackland Group targeted Kessington is the markets the manufacturer serves, according to George. "We feel the aerospace and general defense markets are poised for growth in the future," he said, adding that companies that serve those markets offer "tremendous growth opportunities."

Blackland Group is "looking for other companies in aerospace," George said. "We like that market a lot." Other niches of interest include oil and gas and medical instruments, he noted. "We look for companies in those markets that do \$2 million EBIT (earnings before interest and taxes) and have [annual] revenue from \$10 to \$50 million," he said.

"We look for companies that work with close tolerances and are in the niches we find most competitive," Shedd added.

What a venture capital company does with its acquisitions is a question with as many answers as there are firms in the business. For Blackland Group, it's a matter of "structuring a deal by making sure we have our interests aligned with existing management," George said. "We would then want to supplement their needs with our capital expertise."

George and Shedd believe U.S. man-

ufacturers are very competitive. (Blackland Group reports that it only acquires U.S. companies because those outside the U.S. are difficult to work with.) "We are very optimistic about the companies that remain because they are not in the 'commoditized' sectors of manufacturing," George said.

Blackland Group is also a good fit for Kessington, according to Russ Golden, company president. "We looked for someone we would be comfortable with and that brought what we needed to the

Shedd added.

Other precision part manufacturers are welcome to present themselves to Blackland Group as candidates, Shedd noted. "If you think you fit."

—George Weimer

■ Net-shape blow molding of bulk metallic glasses

Materials scientists have long sought a material that could be molded into parts with the same ease and low ex-



Yale University

By reducing heat losses during deformation, blow molding of bulk metallic glasses produces net-shape parts in less than 1 minute. Inset: Jan Schroers and his research team at Yale University have developed processing methods to shape novel metals like plastics.

Jan Schroers

table," Golden said. "To get to the next level, we needed a partner."

Kessington's philosophy is to have minimal separation between management and other employees. "In job shops, we all wear multiple hats. They are comfortable with our philosophy," Golden said about Blackland Group.

"It's hard for a small business to keep up with customer demands without help," Golden continued. "You have to ask what's best for the company, the customers, the employees and yourself."

Blackland Group has a "target list of 180 companies that we are looking at, and an investment bank is helping us,"

pense as plastics, but without sacrificing the strength and durability of metal. Recently, a team led by Jan Schroers, an associate professor of mechanical engineering and materials science at Yale University, has shown that bulk metallic glasses can be blow molded like plastics into complex shapes, the university reported. In addition, by blow molding the BMGs, the team was able to combine three separate steps in traditional metal processing—shaping, joining and finishing—into one, allowing them to perform previously cumbersome, time- and energy-intensive processing in less than a minute and create a variety of

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IS #55

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complex parts, including seamless hollow ones with low symmetry. Those include biomedical implants, bottles and miniature resonators for MEMS (micro-electromechanical systems) devices.

In contrast to conventional metals, which have a crystalline structure where the atoms are arranged in fairly orderly arrays, BMGs have an amorphous struc-

ture where the arrangement of atoms is random yet homogenous. That structure allows BMGs, which are a subset of amorphous metal alloys, to flow under a low pressure of a few atmospheres and a temperature of about 160° C to 450° C, depending on the alloy. The alloys are made of different materials, including zirconium, nickel, titanium and copper.

With a viscosity comparable to thermoplastics, BMGs flow as easily as plastics during blow molding and a fast cooling rate prevents crystallization, or nucleation, during solidification. "It becomes denser and at some point falls out of metastable equilibrium and forms a glass," Schroers said in a *Materials Today* interview.

According to Schroers, it's the low temperatures and low pressures that allow his team to shape BMGs with unprecedented ease, versatility and precision. To control and maintain the ideal temperature for blow molding, the team shapes BMGs in a vacuum or fluid.

"The trick is to avoid friction typically present in other forming techniques," Schroers said. "Blow molding completely eliminates friction, allowing us to create any number of complicated shapes, down to the nanoscale."

BMGs are stronger than "typical" steel, with a zirconium-based one having a yield strength of 2,000 MPa vs. 700 MPa for typical steel, Schroers noted in the *Materials Today* interview. He added, however, that a zirconium-based BMG costs about \$60 per kg, which is two orders of magnitude higher than steel. In addition, a 10cm x 10cm sheet is about the largest one that can be created when blow molding a BMG.

Nonetheless, bulk metallic glasses offer the promise of fabricating durable parts quicker than conventional metals at a low processing cost. "This could enable a whole new paradigm for shaping metals," Schroers said. "The superior properties of BMGs relative to plastics and typical metals, combined with the ease, economy and precision of blow molding, have the potential to impact society just as much as the development of synthetic plastics and their associated processing methods have in the last century."

■ EMAG to host Technology Days

Machine tool builder EMAG L.L.C. will showcase productivity-enhancing technologies at its 2011 Technology Days event, to be held Tuesday, May 10, and Wednesday, May 11, at its headquarters

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in Farmington Hills, Mich. The event will include 2 days of presentations and live demonstrations (see schedule opposite page 18). On Tuesday, Douglas K. Woods, president of AMT—The Association For Manufacturing Technology, will present the keynote address on the future of manufacturing. On Wednesday, Paul Traub, business economist for the Federal Reserve Bank of Chicago, will present his outlook for the U.S. economy. To register, visit www.technology-day.emag.com, e-mail event@emag.com or call (248) 477-7440.

■ Bradford Machine moves to new site

Bradford Machine Inc., Brattleboro, Vt., has moved to a new facility in the Brattleboro Business Park. To help fund the renovations, in December the Brattleboro Development Credit Corp., a nonprofit economic development organization that owns the business park, secured a \$500,000 loan through the Vermont Economic Development Authority. Bradford Machine worked closely with the BDCC to design the new workspace.

—*Brattleboro Reformer*

letters

■ The following letter is in response to Edmund Isakov's "New Mill" article in the July 2010 issue about his concept for calculating the required machining power when milling.

I completely agree that the formula to calculate machine horsepower has been a much too "simplified" formula for many years. You have really explained the shortfalls, how to overcome them and arrive at a much more accurate HP estimate. Regarding your formula:

$\sigma = 506 \times 229 - 3,456 = 112,418$ psi
what does 506 stand for and where was it found?

SCOTT TIEHEN

I developed that formula using linear regression analysis. This formula approximates a straight line, with the

correlation coefficient equal to 0.9991.

The number 506 is a slope of the line, and 3,456 is an intercept. Slope 506 shows that a given Brinell hardness number (between 195 HB and 580 HB) multiplied by 506, minus intercept 3,456, gives the ultimate tensile strength value. For example, if the hardness of AISI 4140 alloy steel is 302 HB, the

ultimate tensile strength is:

$$506 \times 302 - 3,456 = 149,356 \text{ psi}$$

The ultimate tensile strength value from the *Machinery's Handbook* is 148,000 psi (accuracy in calculating the value is 99.1 percent).

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IS #39

To receive additional information about the products described here, refer to the Product Information form on page 3. Suppliers can send press releases about new metalworking products to *Cutting Tool Engineering*, 40 Skokie Blvd., Ste. 450, Northbrook, IL 60062; or by e-mail to alanr@jwr.com.



DRILLS FOR COMPOSITE MATERIALS. Sandvik Coromant Co. has introduced CoroDrill 452 drills for producing rivet and bolt holes in carbon fiber-reinforced plastic and metallic stack materials. Each CFRP material has its own demands, which increases the risk of delamination and splintering. The drill geometries reduce those risks, the company reports. The line includes tools with reamer geometries and a countersink with a microstop for chamfering.

Sandvik Coromant Co.

www.sandvik.coromant.com/us

IS #400

GRINDING SPINDLES. Dynogrin spindles from Dynomax Inc. are for robotic grinding of abrasive materials, such as composites, ceramics, glass and forged materials. The spindles offer a maximum speed of 18,000 rpm and feature a power management/interconnect system that protects against slurry, dust, water and other potentially damaging materials. According to the company, the interconnect system is flexible to handle robotic applications. A closed-loop cooling system improves spindle performance and extends spindle life, the company reports.

Dynomax Inc.

www.dynospindles.com

IS #401



BORING SYSTEM. BIG Kaiser Precision Tooling Inc. says it optimized its Kaiser 318 tool system for twin-cutter rough boring, finish boring and OD turning of aluminum and steel components. The standard tools bore diameters from 7.87" to 13.39" and are for ISO 40/HSK-A63 tapers, and the ones from 7.87" to 24.41" are for ISO 50/HSK-A100 and larger tapers. Special components allow boring of diameters up to 118". The system supports speeds up to 6,600 sfm, according to the company.

BIG Kaiser Precision Tooling Inc.

www.bigkaiser.com

IS #402

DRAG CONVEYOR. PRAB offers a lighter-duty version of its drag conveyor that integrates under machining centers to remove chips. The conveyor has a grated end plate to allow metalworking fluid from chips to exit the conveyor and collect in a liquid-tight trough. The conveyor offers zero carryover to improve productivity, the company reports.

PRAB

www.prab.com

IS #403



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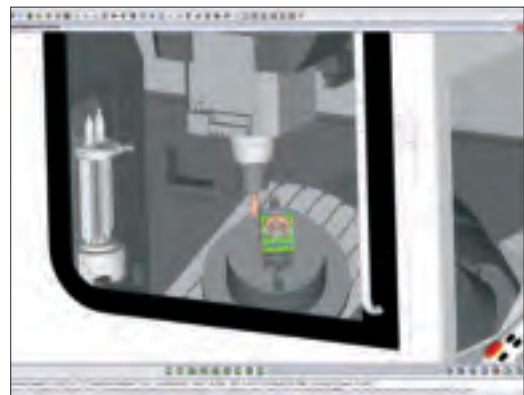


THROUGH-COOLANT DRILLS. Precision Dormer's Elect S drills are for machining heat-resistant superalloys. The through-coolant drills have a body back taper, which reportedly promotes a free, continuous cutting action to minimize workhardening. A self-centering 140° point angle, cylindrical margin and positive cutting geometry also minimize frictional cutting forces and workhardening. The tools, which feature a Smooth-Flow coating, are available in lengths for drilling holes 3 and 5 diameters deep.

Precision Dormer
www.precisiondormer.com
 IS #404

SIMULATION SOFTWARE. Vericut 7.1 is the latest version of CGTech's CNC machine simulation and optimization software. Vericut Reviewer is among the enhancements to reduce the time required to develop, analyze, inspect and document the CNC programming and machining process. Reviewer incorporates the functionality of NC Review mode in a stand-alone viewer that does not use a license. It can play forward or backward while removing and replacing material. Error messages and NC program texts are highlighted when a collision on the stock or fixture is selected.

CGTech
www.cgtech.com
 IS #405



TOOL GRINDERS. Drill and tool grinders are available from Rush Machinery Inc. In addition to grinding a variety of HSS and carbide drill points, users can grind step drills, taps, reamers, countersinks and endmills with minimal setup change, the company reports. The standard workload can be exchanged in less than a minute with an optional air-bearing attachment for grinding endmill ODs. Manual benchtop and automatic-infeed floor model machines are available with capacities of 0.080" to 1¼", ¾" to 2" and ¾" to 3½".

Rush Machinery Inc.
www.rushmachinery.com
 IS #406

PRECISION TOMBSTONES. Stevens Engineering Inc. offers tombstones up to 40" square x 60" high. Shapes include rectangular, triangular, hexagonal and octagonal. The steel tombstones have a higher tensile strength and are more rigid than cast iron or aluminum ones, according to the company. Tombstones are available with the company's standard hole pattern, alternate patterns or plain, and come finished or unfinished for users who prefer to machine application-specific features in them.

Stevens Engineering Inc.
www.stevenseng.com
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Dillon Manufacturing Inc.
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Eriez
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IS #409



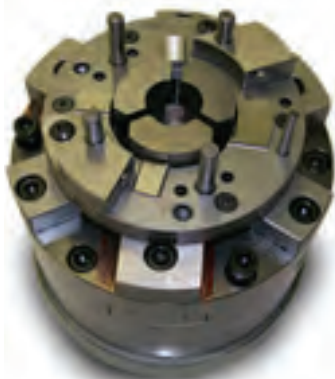
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Northfield Precision Instrument Corp.

www.northfield.com

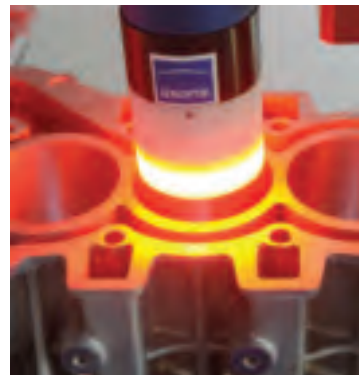
IS #410

BORE INSPECTION SENSOR. Hommel-Etamic America has introduced the IPS 100 bore inspection sensor system. It rapidly and automatically inspects the surface of 75mm- to 110mm-dia. surfaces in a single pass and delivers a 360° panoramic view of a bore. The sensor detects surface defects such as blow holes, scratches and porosities to any depth, the company reports. In operation, a 360° circular optical device advances into the bore to generate surface images. Circular scanning reportedly generates an undistorted image of the ID. Typical applications include engine blocks, transmission cases, connecting rods, steering gear cases and cylinder liners.

Hommel-Etamic America

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By Keith Jennings

When it rains, it pours

One weekend when I was in college, I went to visit my then girlfriend—now wife of 22 years. While returning home on a rural stretch of road, I inadvertently drove into the path of an oncoming pickup truck at a two-way intersection and caused a moderately bad wreck in which, thankfully, no one was seriously injured. Unfortunately for me, I received several citations because it was my fault.

As I sat nervously in the state trooper's car waiting for him to write up everything, he politely made a comment I'll never forget: "Well, Mr. Jennings, when it rains, it pours, doesn't it?" He was right and knew the accident would be an expensive lesson for a college kid, although not an insurmountable obstacle. His simple, truthful words had impact.

Recently, the trooper's words rang aloud once again during a tumultuous 2-week stretch at our shop, when, if something could go wrong, it did. Thankfully this didn't include work-related

injuries, but it was an unexpected series of events that was tough to deal with. The events tested my ability to manage the shop and still go home and smile to the wife and kids, do my family chores and read insightful business material, among many other responsibilities.

It started when a production manager was suddenly out for a week with a kidney stone. Then two employees who are brothers were placed on medical leave so one could donate a kidney to the other. Two production machines were down for repairs, causing us to fall behind schedule; a key mill machinist was terminated, a server crashed and disrupted our operation, and sales levels were inconsistent to boot. Add my dad—our retired CEO—who was happily traveling with no knowledge of this stuff, but still was calling for regular updates. It was a stressful mess.

We got through the rough patch, but the events took their toll and it took us several weeks to recover. Nothing can prepare a manager for this type of

scenario except experience. Inevitably, some dramatic event will suddenly occur, requiring shop owners or managers to step up, lead, and instill confidence in employees that they can handle it.

When I was growing up, it was my parents' responsibility to handle these issues and my turn seemed a long way off. I can remember as a kid hearing them discuss the roller-coaster of shop life, at times sounding unsure if they'd survive or not. Sometimes, their stress even concerned me, but in every instance, they somehow developed a strategy to deal with the problems and persevered. It was always a relief to hear them finally say, "Everything is going to be OK."

Now that I'm the one handling these situations, I've realized how important it is to maintain professionalism and confidence, even when the task seems overwhelming. Many situations require effective management on the fly. Learning to manage and handle them effectively will certainly increase your chances of success.

There's no doubt running a machine shop is a serious responsibility and the expectations are high. I'm sure many of you have already had similar unexpected and unpleasant experiences, maybe even worse than mine. (Send me an e-mail if you'd like to share your experiences.) Even so, it was eye-opening and my worst 2 weeks so far. It rained, it poured, and it won't be forgotten.

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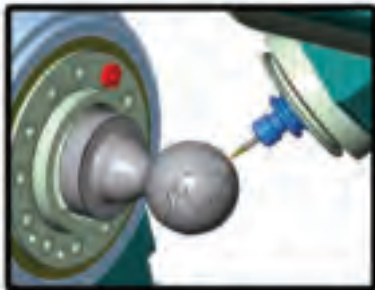
Inevitably, some dramatic event will suddenly occur that'll require shop owners or managers to step up and lead, instilling confidence in employees that they can handle it.

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.

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IS #16

Managing multiple milling constraints

By Dr. Scott Smith, University of North Carolina at Charlotte

Milling is a complex process bound by multiple constraints. Successful milling requires selection of cutting parameters that respect the constraints. Presented here are explanations about six of those constraints.

Bending moment. The bending moment equals the cutting force times the distance from the cutting zone to the toolholder/spindle interface. If the bending moment is too great, the shank of a slender tool may break or separation can occur where the toolholder face contacts the spindle, allowing the toolholder to pull out of the spindle. That's especially problematic for HSK holders because they derive their stiffness from the face contact. The bending moment can be reduced by shortening the tool or by reducing the cutting force, which requires reducing the axial DOC, radial WOC or the chip load. For most tools, the chatter limit is reached long be-

fore a shank breaks.

Chatter. Chatter generation is a limiting factor when milling, particularly when the objective is to have the metal-removal rate as high as possible. Chatter arises due to insufficient dynamic stiff-

If the bending moment is too great, the shank of a slender tool may break or separation can occur where the toolholder face contacts the spindle, allowing the toolholder to pull out of the spindle.

ness, which, in turn, is caused by long slender tools, small-diameter spindles (due to the DN limitation, where D is the diameter of the main bearing bore, and N is the spindle speed), thin workpieces (although a good machining strategy can usually avoid this) and the low-damping characteristics common in mechanical systems. Strategies to avoid chatter without changing the machine or tooling

configuration include selecting the cutting conditions based on a stability lobe diagram, reducing the axial DOC and/or radial WOC and choosing a low spindle speed to enhance the process damping effect. Strategies that change the machine and tooling configuration include adjusting the tool length (usually shorter is better, but not always) and applying tools with nonproportionally spaced teeth.

Tool/workpiece wear mechanisms. The strength of the cutting edge limits the chip load, and this limit is usually specified by the manufacturer. Edge strength does not limit the axial DOC because, as the tool cuts deeper, there is more cutting edge to carry the load. Several tool wear mechanisms, including diffusion and oxidation, are strongly temperature-dependent, and this kind of tool wear places a surface speed limit, which is a spindle speed limit, on milling. Similarly, some tools exhibit thermal softening at high temperatures, increasing the abrasion and attrition wear mechanisms, again limiting

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spindle speed. Strategies to avoid this limit include lowering the spindle speed, changing the tool material, adding a coating or using a small radial WOC.

Available power. The power consumed in the cut is proportional to the mrr. Each workpiece material has a specific power (power per mrr), which can be experimentally determined or found in a reference source. A cut that consumes more power than the machine can deliver will stall the spindle. If the combination of machine, tool and workpiece is dynamically stiff enough, it is possible to reach the power limit in stable milling. However, even for the stiffest machines, there are usually some tools that are not power limited. Strategies to avoid this limit include reducing the size of the cut or softening the workpiece material, such as in laser-assisted machining.

Tool geometry. Clearly, it is not advisable to choose an axial DOC larger than the length of the cutting edge, or to choose a chip load so large that there is not enough room for the curled chip between the tool's teeth. Other geometry limitations are more subtle. For example, selecting a chip load smaller than the cutting edge radius generates a large plowing force, almost like burnishing. Similarly, tool orientations that result in cutting close to the tool center on a ballnose endmill result in surface speeds close to zero, and plowing rather than cutting occurs.

Workpiece geometry. The required surface finish limits the chip load. Even if the tool and workpiece were absolutely rigid, the surface created by the periphery of an endmill is produced by a series of nearly circular arcs at the tool radius, separated by the chip load. Even a perfectly created surface will have a series of cusps that define its roughness. Their height can be limited—producing a smoother surface—by limiting the chip load. In a similar way, surface roughness limits the step-over when ballnose endmilling. The cutting edges at the end of a ballnose tool create the as a series of grooves with nearly circular cross sections. For a “perfect” tool and workpiece, the height of the cusps between the grooves defines the surface finish, and the finish can be improved (and the machining time increased) by reduc-

ing the step-over between passes.

Additional constraints exist, and successful milling requires managing all the constraints simultaneously. Knowledge of the constraints is the first step in managing them.

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About the Author: Dr. Scott Smith is a professor and chair of the Department of

Mechanical Engineering at the William States Lee College of Engineering, University of North Carolina at Charlotte, specializing in machine tool structural dynamics. Contact him via e-mail at kssmith@uncc.edu.



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IS #1

Storing and handling raw material

By Tom Lipton

Because labor is typically the most expensive component of any job, anything you can do to shorten the labor path during a job will have a short payback period. A good example is in materials storage.

Every shop must store some raw materials. The trick is to store workpieces in such a way that you can get to the desired piece with minimal effort. Here are some tips to effectively handle and store raw material.

Cut 20' bars in half for easier handling. It depends on the type of work a shop performs, but rarely are full 20' bars utilized without cutting. In small shops, 20' lengths can be difficult to handle and it is time consuming to cut off a short length. This challenge continues until the material is short enough to be efficiently handled. The time to cut the bar is when it comes in the door from the supplier.

Carts used for moving bar stock around the shop should be the correct height for the horizontal bandsaw so material can be pushed into the saw as soon as it is unloaded. Support tubes should also be set up so you can load and unload bar stock with a forklift directly from the delivery truck.

Organize material drops by length, such as full bars, partial bars and stubs. Most people will try to use the material with the easiest access before pulling out the full-length materials. If you provide and maintain a system for finding the optimal stock in the speediest manner, you shorten the job. This is proven time and again when we filter our racks and bins.



All images: T. Lipton

Carts for moving bar stock around a shop should be the correct height for the horizontal bandsaw so material can be pushed into the saw as soon as it is unloaded.



Indicate the material type directly on the bar end for easy identification.

The size of the keepers gets smaller and smaller until they just disappear.

Occasionally inventory and organize the material storage area. This job allows apprentices and helpers to get acquainted

with the shop's raw material inventory.

Beware of packrats. Machinists and welders are natural scrounges. Want proof? Look under the workbenches and in the nooks and crannies of their work areas. Some materials and leftovers really need to be scrapped to run an efficient shop.

Get rid of materials that cannot be easily identified. If you don't know what it is, how can you use it? When in doubt, toss it out.

Certain forms of scrap and material drops are virtually useless. Long, thin strips of sheet metal and triangles cut from almost anything are two examples that can hit the scrap bin right out of the gate.

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On the other hand, almost all circles and discs are valuable. Unless your processes generate a large quantity of disc-shaped parts, these should always be saved.

It is a challenge to maintain material identification in a job shop. Each time a piece of material is cut, there is a risk of losing the identity trail.

It's everyone's responsibility to make sure the identity chain does not get broken. Keep marking tools readily available in areas where materials are stored and rough cut. Put identifying marks on both end surfaces of bars.

Engrave or mechanically stamp the material type directly on the bar end. Tags fall off and ink smears. Labels are next to useless because they are placed on the side of the material where other material sliding in the rack can obliterate the identification. Somebody also has to remove the sticky labeling substance at some point. When you mark the end surfaces of material, it fits in collets and vises; the first cut in the machine removes the engraving.

Don't use obscure internal company terminology or secret codes for common materials. Use the same terminology suppliers use. For certified materials, include the purchase order number the material was purchased with. This information

helps when tracking down copies of test reports and conformance data.

Understand that metal supplier color codes are unreliable. There is no real color standardization in the metal supply industry. These should only be used as a generalization or identification when combined with another method.

Store flats on edge in the vertical orien-

tation. Graduate them by width to make inventory and removal easier.

Small rounds should be stored in tubes so they don't slip between rack dividers. Alternatively, you can form simple sheet metal trays for the slots that contain small materials. This keeps the more flexible materials from drooping and missing the rack supports.

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About the Author:

Tom Lipton is a career metalworker who has worked at various job shops that produce parts for the consumer product development, laboratory equipment, medical services and custom machinery design industries. He has received six U.S. patents and lives in Alamo, Calif. Lipton's column is adapted from information in his book "Metalworking Sink or Swim: Tips and Tricks for Machinists, Welders, and Fabricators," published by Industrial Press Inc., New York. The publisher can be reached by calling (888) 528-7852 or visiting www.industrialpress.com. By indicating the code CTE-2011 when ordering, CTE readers will receive a 20 percent discount off the book's list price of \$44.95.



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IS #49

Productive communication

The following is an interview with Anderson Leveille, owner of Moscow Mills Manufacturing Services, a manufacturing, engineering and R&D firm located at the site of an 1820s gristmill near Stowe, Vt. The company is blending top-level machining skill and technology with collaborative engineering to produce complex parts and advanced balancing components and tooling.

In 1995, Leveille opened Moscow Mills in a 17'x20' room where he used a Bridgeport mill and LeBlond lathe to machine parts for snowshoes. Today, the 10,000-sq.-ft. operation serves customers in the aerospace, robotics, semiconductor, R&D and general industrial markets, handling projects such as prototyping large, titanium medical implants and machining small optical components. The shop's equipment list has grown to include 3-, 4- and 5-axis CNC mills, a 7-axis mill/turn machine, a 5-axis wire EDM, CNC lathes, grinders, heat-treat and cryogenic processing capability, fabrication equipment and inspection equipment, including a 5-axis coordinate measuring machine.

A year ago, Moscow Mills absorbed Vibration Solutions LLC and formed Vibration Solutions North as a new division of the company. Together, the two shops employ 14 people. In addition to Leveille, Moscow Mills principals include Tim Bullard, electromechanical expert, and George Allen, founder of Vibration Solutions.

The interview, by Contributing Editor Bill Kennedy, focuses on the company's focus, evolution and growth.

Kennedy: How would you characterize Moscow Mills' machining work?

Leveille: Prototype to short-run production of extremely high-end stuff made of all kinds of exotic materials, like titanium, Inconel and PEEK polymer. We often have to reinvent the wheel on a component, hit the ground running and get it right the first time. For example, I've been e-mailed a solid model of a reasonably complex component at 9 a.m.,



Moscow Mills

The principals at Moscow Mills Manufacturing Services are (from left to right): Anderson Leveille, owner; George Allen, founder of Vibration Solutions; and Tim Bullard, electromechanical expert.

quoted the parts by 9:15, received a purchase order by 9:30 and had the parts machined on the floor by 10 a.m. Depending on our customer's requirements, it's not unusual to go from art to part in a day. We foster an environment where preplanning is an art and a science, where all of the guys are involved.

Kennedy: How do you maintain that kind of focus within your team?

Leveille: I have a fantastic crew. We absolutely love what we are doing. They are almost artists in the way they understand and are creative. I would distill it all down to one fine point, communication, closely followed by mutual respect. Treat people how you wish to be treated. People like to be recognized for doing a good job. All of this stuff sounds simple, but 99 out of 100 people don't express to anybody else what they are really thinking.

Kennedy: What makes Moscow Mills different from other job shops?

Leveille: We also provide high value-added support services. It's not unusual

for our customers to consider us an extension of their engineering department. In this day and age there is a severe lack of manufacturing engineering thought processes. It's one thing to build a part to a print; it's another to know what it does and why it does that. Oftentimes, companies look to organizations like ours to be a partner in the manufacturing engineering piece of a product's development.

Kennedy: How has your manufacturing technology evolved from that original Bridgeport and LeBlond?

Leveille: You start learning about complex requirements and needs, and it drives you to new places. The complexity of our work has driven us to invest in all the correct tooling, all the correct hardware and the software to run it and training. You can't skimp on any of it.

We've invested heavily so that we can accomplish things that a lot of other people won't even bother looking at. There pretty much hasn't been any time when we haven't reinvested everything back into the company. It's constant growth.

We have an electronic ball bar system so we can verify our machine tools; we have a laser interferometer so we can map our ballscrews.

I have the building climate controlled, and we hold 0.0002" or better all the time. For example, we machined a 14"-dia. disc of 316 stainless steel flat to a 0.00015" tolerance with a surface finish of just a little over 4 μ in. R_a . Consistently achieving that level of tolerance is like airspeed: anything above 0.0002" is normal flight, but anything below 0.0002" requires a different set of rules, like the different set of rules that applies after the sound barrier is reached and exceeded.

Kennedy: What does Vibration Solutions North do? How does it mesh with Moscow Mills?

Leveille: The specialized tooling from Vibration Solutions North interfaces between a balancing machine and a rotating component, which could be inside a jet engine, an electric motor or in anything that spins. We have come up with some unique ways of interfacing various components to balancing machines. One of our tooling systems is trademarked Kin-Dex. It uses kinematic mounting, which indexes and locates parts on fixtures or tooling so they can be balanced to extremely high levels of accuracy and repeatability—about 0.00002" radial runout. The Kin-Dex system helps remove uncertainty from balancing operations and significantly speeds up mounting and dismounting of tooling and components for balancing.

The balancing business and what we do at Moscow Mills are perfectly aligned from the perspective of repeatability. Removal of uncertainty is the real trick with this entire business.

When George Allen was running Vibration Solutions on his own, he discovered it was impossible to find an organization to work with that could provide the level of understanding and commitment to build tooling. Together, Moscow Mills and Vibration Systems North are heavily involved in the new generation of aero engines designed to be quieter, more fuel efficient and have

lower maintenance costs. The components of those engines require a whole new level of balance tolerancing. It requires all the years of experience that George has in balancing, the electromechanical experience Tim gained at IBM and elsewhere, and Moscow Mills' deep experience as a firm manufacturing intri-

cate parts and assemblies. It is the combination of all of us that comes up with patentable concepts and solutions for this industry. We all see things the same way. We don't look at anything and assume it is good enough. We look at things as if there has always got to be a different way, a better way.

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IS #60



Origins of chatter

Dear Doc: I cylindrical grind hardened-steel shafts and sometimes get chatter. There's a debate on the shop floor, with some saying the wheel is dull and the material-removal rate is too high, and others claiming the wheel is not true. Is there a way to tell? Our 16"-dia. wheel runs at 12,000 sfm and the workpiece at 40 rpm. I have counted about 70 waves of chatter on the workpiece.

The Doc Replies: There are two types of chatter. The first is forced chatter, where the chatter comes from some specific frequency, such as an imbalanced wheel, an out-of-true wheel or a bad bearing. The second is self-excited chatter, where "things just start bouncing around" at the natural frequency of the system. This is exacerbated by a dull wheel or a high mrr.

Here's a quick way to determine the type of chatter you're experiencing. Divide wheel rpm by workpiece rpm.

In your case, the wheel is running at 2,866 rpm $[(12,000 \text{ sfm} \times 12 \text{ in./ft.}) \div (\pi \times 16 \text{ in./wheel rev.})]$. Therefore, the wheel-revolutions-to-workpiece-rotation ratio $(2,866 \div 40)$ is 71.65. That's awfully close to your count of 70 chatter marks per revolution, indicating an out-of-true wheel.

But be careful! It might just be self-excited chatter at 47 Hz $(70 \text{ marks/rev.} \times 40 \text{ rev./min.} \times 1 \text{ minute} \div 1 \text{ min./60 sec.})$. If it's self-excited chatter, then it will always be at 47 Hz regardless of the grinding parameters. That's because self-excited chatter occurs at the natural frequency of the system, and the natural frequency is constant—it doesn't change when the grinding parameters change. If it's forced chatter because of an out-of-true wheel, it will follow the wheel rpm.

Conduct a simple test. Decrease the wheel speed to 9,000 sfm (2,150 rpm). Now the wheel-revolutions-to-workpiece-revolution ratio is 53.75 $(2,150/40)$. If you count about 54 chatter marks per revolution, it indicates an out-of-true wheel. But if it stays at 70

chatter marks, it indicates self-excited chatter.

Finally, 70 chatter marks on a workpiece running at 40 rpm correspond to a frequency of 47 Hz. If you have self-excited chatter, it's occurring at a low frequency—most self-excited chatter occurs above 300 Hz—and indicates your machine is not as stiff as it should be.

Dear Doc: I go through tons of single-point dressing tools. I've tried diamond blade tools, and our operators say they give more consistent results. Why is that?

The Doc Replies: A single-point diamond is just a large diamond rock. When it's new, the wheel contacts the tip of that rock, and the area of contact between the diamond and the wheel is small. That gives a sharp wheel.

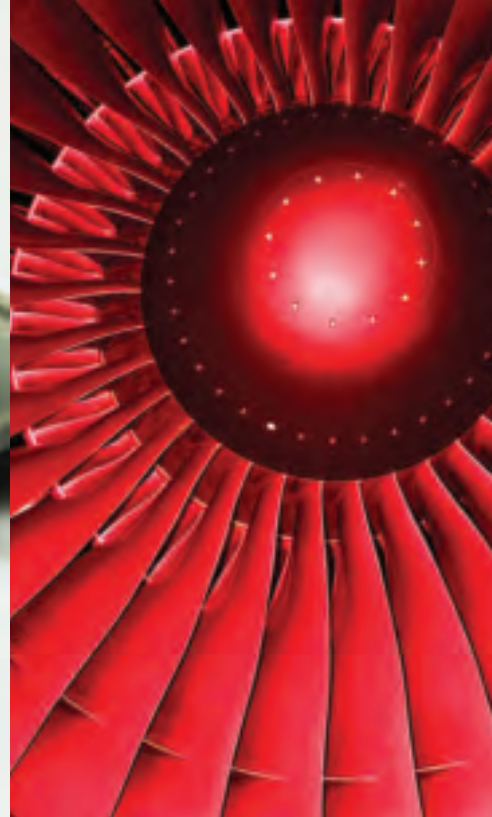
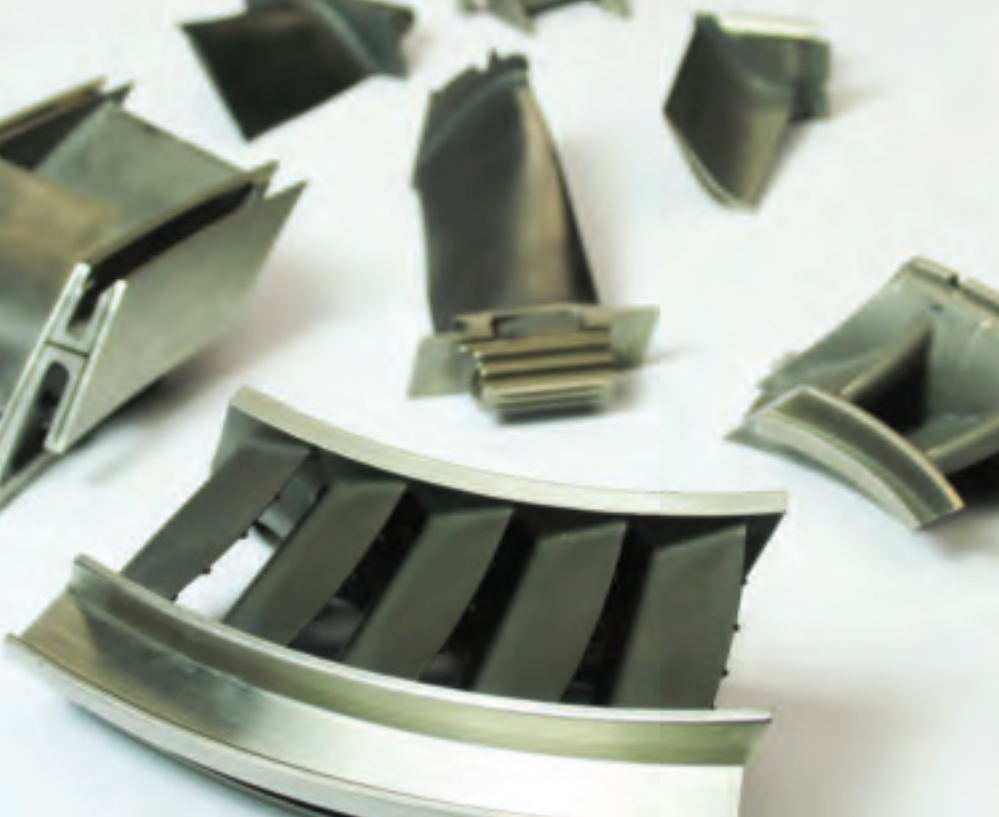
As the diamond wears, the contact area becomes wider, meaning the diamond hits the grits more times. This dulls the grinding wheel. So, a nearly new diamond might have a contact region of $0.008" \times 0.008"$, providing a sharper grinding wheel. At the end of its life, the diamond contact region might be $0.04" \times 0.04"$, giving a duller wheel and increasing the risk of grinding burn and chatter.

With a blade tool, there are several smaller rocks in a row, with more rocks beneath them. One rock might be only slightly worn, having a width of $0.008"$. However, the rock beneath might be $0.02"$ wide. As it wears, the wider rock might pop out, but there's a newer rock beneath it. The result is a series of rocks, with the largest rock at any one time having a fairly consistent width and therefore dressing more consistently.

CTE

About the Author: Dr. Jeffrey Badger is an independent grinding consultant. His Web site is www.TheGrindingDoc.com. He'll be giving his 3-day "High Intensity Grinding Course" May 23-25 in Chicago.

Most self-excited chatter occurs above 300 Hz and indicates your machine is not as stiff as it should be.



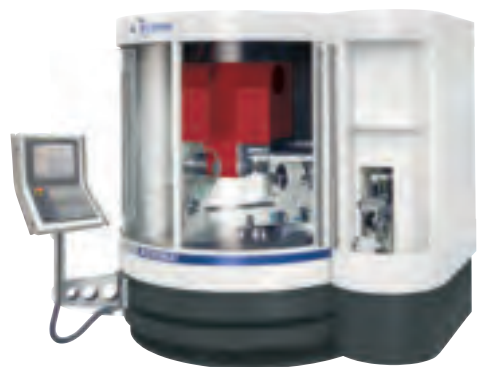
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Take Back Time

Cavalier Tool & Manufacturing's investment in new capabilities pays off with benefits in cost cutting and increased productivity.

By Tony Facione, Single Source Technologies

When times are tough, there's only one way for manufacturers to get ahead: be aggressive and forward thinking in their business planning and investments. Cavalier Tool & Manufacturing Ltd. took this approach and has reaped the rewards ever since.

cover story

Established in 1975, Cavalier Tool, Windsor, Ontario, is a global manufacturer of mid-sized to large plastic injection molds for the automotive, commercial, recreational, medical and aerospace industries. It specializes in tooling for injection molding applications that use materials with high glass filler content, including fans, shrouds, radiator intakes, lighting tools, door carrier plates and door panels. The high glass content enhances stiffness, noted Brian Bendig, company president. Because the molding material is abrasive, the tooling is typically made of H-13 and sometimes S-7 tool steels.

"It's important to know the capabilities you're strong at and those where you could use some improvement," Bendig said. "For the longest time, hardened material machining wasn't our strong suit, and as such we relied heavily on outsourcing. However, once the economy took a turn for the worse, we decided it was time to regain control by investing in hard milling capabilities."

Hard Milling, Easy Choice

Cavalier Tool was previously outsourcing machining of tool steel hardened to 48 to 52 HRC to a shop with a Makino A100 horizontal machining center, and Bendig was impressed with the machine's speed, accuracy and finishing capability. So when it came time to reevaluate the company's machining capabilities to recapture the hard milling work it was outsourcing, Bendig eyed Makino's selection of HMCs.



All images: Makino

The Makino a92's 10,000-rpm spindle, 1,969-ipm rapid feed rate and 0.4G acceleration/deceleration rate offer Cavalier Tool nearly three times the productivity compared to the moldmaker's previous technology.

Learn more about moldmaking



For more information on moldmaking at Cavalier Tool, view a slideshow presentation on www.ctemag.com by scanning the QR matrix bar code on your smart phone (app available at get.neoreader.com) or entering the following URL on your Web browser: ctepus.delivr.com/151or.



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"We had a lot of work coming through and had been researching machines for a couple of months," Bendig said. He noted that the company has been happy with the results of its Makino SNC 86 graphite electrode mill. "Another reason we wanted a Makino was longevity and reliability. We knew a Makino HMC would be able to support our business well into the future. Our SNC 86 has been on the floor for 17 years, and it's still very accurate and reliable."

In June 2010, Bendig purchased a Makino a92 HMC based on its similar characteristics to the A100. The a92's 10,000-rpm spindle, 1,969-ipm rapid feed rate and 0.4G acceleration/deceleration rate enhance productivity when producing large parts, according to Bendig. Its rigid construction provides positioning tolerances as tight as ± 0.00010 ", with ± 0.00006 " repeatability.

The machine has a 31"x39" pallet and X-, Y- and Z-axis travels of 59", 49" and 53", respectively, to handle workpieces up to 59" in diameter and height and



Brian Bendig, Cavalier Tool president, with his a92 horizontal machining center.

weighing up to 6,600 lbs. Its automatic pallet changer switches a pallet in 46 seconds, achieving spindle runtime of 92 to 96 percent on a 24/7 basis.

A Welcomed Addition

After the a92 arrived on the shop floor,

Cavalier Tool saw an immediate impact because the machine enables quick set-ups. "A lot of times, the orientation of the glass in the molding process is an unknown during tool production," Bendig said. "As a result, we have to be prepared

(continued on page 36)

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An advertisement for CJWINTER. In the foreground, several large, cylindrical metal parts with threaded sections are shown. In the background, a large, multi-story industrial building with a gabled roof is visible. The CJWINTER logo is in the bottom right corner.

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Moldmakers turning horizontal

MOLD SHOPS AND VERTICAL

machining centers commonly go hand in hand, but a new trend is beginning to reshape that tradition. Today's moldmakers are frequently finding horizontal machining centers to be a more efficient and profitable alternative.

An HMC offers many benefits not found in a VMC, including larger tool magazines, quicker tool changes, faster rapid traverse rates, reduced setup times, increased work zone real estate, improved part access and enhanced chip and coolant management. Compounded, these features can cut costs throughout the moldmaking process.

One of the biggest benefits offered by an HMC is increased tooling flexibility. While a typical VMC holds from 20 to 50 tools, horizontals offer capacities from 60 to 300 tools. This larger capacity enables manufacturers to store a wider variety of tools to cover the required operations. By combining this with faster average tool change times and rapid traverse rates of 30 and 65 percent, respectively, horizontals enable manufacturers to significantly increase productivity and reduce manual labor.

According to reported industry averages, about 40 percent of machine utilization is lost to setup. However, by using an HMC with an automatic pallet changer, moldmakers can set up outside of the machine without interrupting the machining process. This approach substantially reduces noncutting time compared to using a VMC.

Automation capabilities are another differentiating factor between the two platforms. Unlike verticals, horizontals are able to use high-capacity, rail-guided, robotic material-handling systems to automatically assign work and initiate operations based on machine and material availability. These systems increase machine utilization when workers aren't present.

Work zone real estate is another difference. The work zone of a VMC offers partial real estate in a single, square platform. By contrast, a horizontal has a cylindrical work zone that can be rotated using an indexing or contouring table. This design provides a work zone at least twice as large as a comparable VMC. By factoring in the second pallet, the HMC's work zone expands to approximately four times the

VMC's work envelope.

The improved part accessibility of an HMC with an indexing table enables various operations to be performed on three sides of a part in a single setup. Comparatively, a VMC would require individual setups to gain access to each side of the part, which can be detrimental to a manufacturer's productivity and part quality.

The configuration of an HMC benefits

from gravity, which enables chips to naturally fall out of the work zone and into the chip management system. On a VMC, operators are required to manually blow fluid and debris from the work zone to prevent recutting of chips, which can negatively impact surface finish and reduce tool life.

—Dave Ward, horizontal product line manager for Makino Inc., Mason, Ohio

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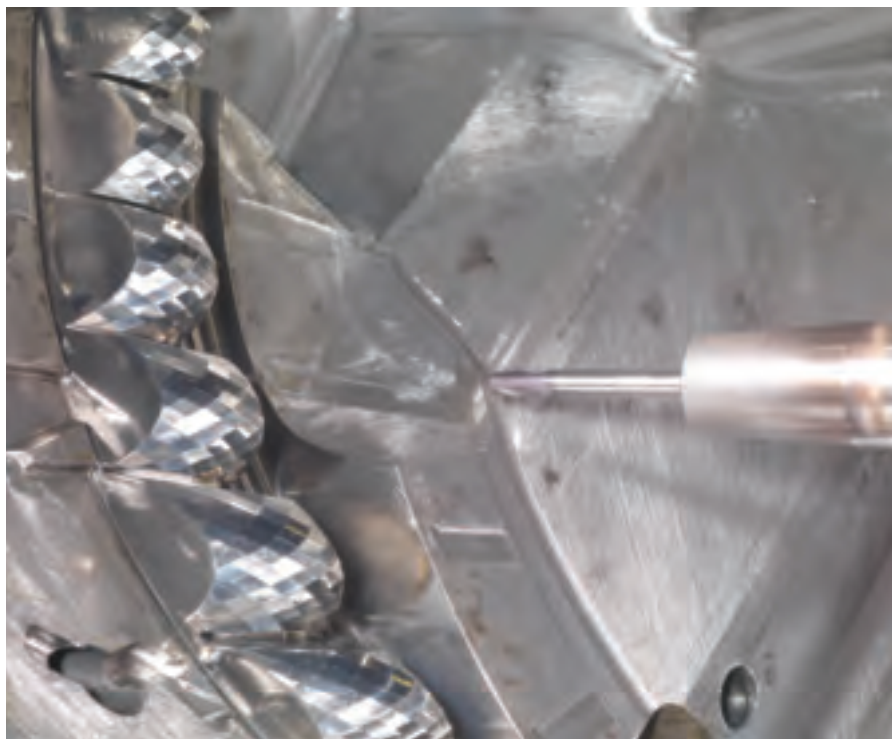
to handle any engineering changes from the OEM that occur during our production process. This makes it critical for us to be able to setup and tear down parts as quickly as possible without disrupting our overall workflow.”

The a92’s automatic pallet changer and a rear-clamping fixture coordinate system enable the moldmaker to set up several parts on a tombstone without interrupting the current machining processes or losing positioning accuracy. The rotary B-axis table increases flexibility much like that of a 5-axis machining center but without the inherent reduction in accuracy, according to Bendig.

He added that because it’s difficult to predict the “warp and windage” of molded parts, Cavalier Tool often needs to put the mold back on the a92 several times to recut it and having two pallets enables a mold to be prepared on one pallet while the other pallet is in the machine. When a mold is ready for recutting, which usually takes an hour or two, that pallet is positioned in the machine and, after recutting is completed, the pallet with the original workpiece is swung into place. “It’s difficult to predict what shape the final molded part will take,” Bendig said. “We can get it very close but often need to tweak the mold 1mm or 2mm—sometimes as little as 0.2mm. Sometimes we cut the tool ‘wrong’ to make the part right.”

Mike McNaughton, the shop’s machining supervisor, said: “The combination of programmable through-spindle coolant technology, 92-capacity automatic tool changer and B-axis rotary table enables us to perform several types of operations with fewer setups. This configuration allows us to do drilling, boring, thread milling, tapping, 2-D and 3-D machining without the operator ever touching the part. With jobs we’ve transferred to the a92, we’re typically seeing a 50 percent reduction in the number of setups and up to three times the productivity of previous processing techniques.”

The shop also tracks spindle utilization through “Pulse” machine monitoring software from Lemoine Multinational Technologies Inc. “All of our machines are monitored day in and day out through our Pulse monitor for performance track-



Every mold tool coming out of the a92 is pretapped, chamfered, engraved and with machined finishes that require little to no manual labor.



Cavalier specializes in applications with high glass filler content, including fans, shrouds, radiator intakes, door carrier plates, door panels and lighting tools, such as this one for an automotive head lamp.

ing,” Bendig said.

The software gathers idle times, feed rates, component name, operation type, operation length and other information and organizes the data in daily, weekly or monthly reports. These reports indicate that spindle uptime for the a92 is frequently in the 90 percent range.

Accuracy Is Key

Speed and uptime are nice, but they are insignificant if the machine isn’t accurate. Of course, the goal of any machine shop is to produce parts that don’t require

secondary machining or benching procedures.

“The rigidity of the a92’s Z-axis has allowed us to significantly reduce the time we spend performing secondary gundrilling operations,” Bendig said. “With the ability to drill up to 10” deep, we’re able to complete primary gundrilling on the a92, saving us from wasting costly time performing two setups on our gundrilling machine.” The machine’s horizontal configuration and coolant management

technologies avoid recutting chips and marring the surface finish, he added.

“Even the slightest inaccuracy in some of our applications can cause huge problems down the road,” McNaughton said. “If a single blade in one of our fan tools is off by even 0.001”, it could cause a slight imbalance in its use that would ultimately reduce the fan’s life span.” He added that Cavalier Tool achieves tolerances tighter than ± 0.0001 ” for enhanced seal-offs with little spotting and benching work.

“Every tool coming out of the a92 is

pretapped, chamfered, engraved and with machined finishes that require little to no manual labor," Bendig said. "Instead of starting at 80-grit benching procedures, we can move straight into 200 grit."

Growing in a Down Economy

Cavalier Tool has proven a shop doesn't have to be at the mercy of the economy. The company took steps to add capacity, acquire more business and regain business it was outsourcing, and those efforts are paying off.

"We've acquired a lot of new customers and continue to grow," Bendig said. "We've become successful because of how we machine. We leave the simple stuff to other shops. Everything we do is complex."

While other companies were cutting staff and closing their doors in 2009, Cavalier Tool had its best year ever. The company isn't satisfied, however. It recently opened a 20,000-sq.-ft. facility in El Paso, Texas, to serve the Mexican market.

"The new machine has added more versatility to our operation," McNaughton said, noting that the machine has reduced setup time, costs and handwork. "It's helped us increase production even though we removed seven machines from the shop floor."

Of course, adding new machinery isn't the only factor in Cavalier Tool's success. Bendig believes to be successful, a shop needs to focus on people, processes and existing equipment. That's the approach Cavalier Tool has taken for 36 years and will continue to take.

CTE

For more information about Cavalier Tool & Manufacturing Ltd., call (519) 944-2144 or visit www.cavaliertool.com.

About the Author: Tony Facione is sales engineer for Single Source Technologies, Auburn Hills, Mich., a supplier of machine tools, tooling, engineering services and application support. For more information about the company, call (877) 228-2884, visit www.singlesourcetech.com or enter #310 on the I.S. Form on page 3.

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Critical Mass

Mass finishing parts at the machining center offers economic advantages.



Rosler Metal Finishing USA

A six-load, centrifugal disc mass-finishing system from Rosler features automatic loading and auto screening.

By Dr. LaRoux K. Gillespie

There are major economic and scheduling advantages to having a part come off a machining center complete. Most machinists think parts are finished at this point because part dimensions are correct. However, they forget that most parts must be deburred, cleaned, weighed or counted and then packaged before shipping. In most shops, that involves moving the machined parts to another part of the shop, putting them on shelves and eventually having someone perform the final operations prior to shipment.

Done at the Machine

Deburring parts at the machine means that they are truly ready to ship. Joe Gasser, vice president of Osborn International, Cleveland, a manufacturer of industrial brushes and surface finishing tools, noted that manufacturers would obviously like to receive payment for their parts earlier than they do. His solution: "Finish your parts at the machine instead of having them sit for days or weeks waiting to be deburred."

There are other benefits to finishing parts at a machining center. Shops find and fix problems earlier, better understand the impact of keeping burrs small, prevent mistakes from using the wrong finishing process, do not lose parts, and possibly prevent oils from drying on parts, which makes the oils difficult to re-

About the Author: Dr. LaRoux K. Gillespie has a 40-year history with precision part production as an engineer and manager. He is the author of 12 books on deburring and over 220 technical reports and articles on precision machining. He can be e-mailed at laroux1@earthlink.com.



move. In addition, one person is responsible for the completed part.

There are three major ways of producing a burr-free part at the machine: preventing and minimizing burrs, brush deburring during the machine cycle, and cellular manufacturing that includes deburring.

Robotic deburring is the most recognized avenue of cellular deburring, but a lower-cost solution exists: placing small, portable mass-finishing machines at (but not on) the machine tool. These finishing machines have been available for at least 30 years, but have become more popular recently due to lean manufacturing initiatives and the availability of many smaller, lower-cost and faster finishing machines. Shops considering mass finishing must answer several key questions:

- How do I conveniently get machined parts into the finishing unit?

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What is mass finishing?

MASS FINISHING INCLUDES ALL PROCESSES that use a tumbling action of media over parts such that parts are inserted as a mass, or group, of parts. The most common processes are barrel tumbling, centrifugal barrel tumbling, centrifugal disc (also called roll flow) and vibratory finishing. Cryogenic vibratory finishing requires low-temperature control with consequent safety considerations and is less amenable to at-machine finishing.

Barrel tumblers normally require hours to finish parts and thus are not well suited for at-machine finishing. They require closed-unit operation and come in sizes as small as 1 pint. Centrifugal barrels use closed tops, which makes them less amenable to true continuous flow, but they can still be considered for some

work cells because they are much faster than vibratory units. For example, a 3-hour vibratory cycle is completed in 20 minutes in a centrifugal machine.

Centrifugal disc machines have open tops with programmed cycles for automatic dumping and offer low cycle times.

Bowl vibratory units are for true continuous flow operation. They also are well suited for compartmentalized finishing of parts that must not contact another part in the tumbling operation to prevent part-on-part damage. They are the lowest-cost mass finishing machine. Several tub-style vibratory units are available as portable units. They come in sizes as small as 1 pint, which makes them ideal for finishing small screw-machined parts.

—L. Gillespie

Critical Mass (continued)

- How much floor space is required?
- How much cleaning do I need? (Mass finishing also cleans.)
- How do I handle waste products?
- How much finishing capacity do I need at any one machine tool?
- How much does an appropriate finishing machine cost?

There are at least 40 suppliers of mass finishing machines operating in the U.S., as well as job shops that specialize in deburring, that can help answer these crucial questions.

Determining how many parts must be finished per hour at each machine is the next question. Knowing part size, edge and

finish requirements and production rates allows mass-finishing machine builders to calculate the required capacity and floor space. That information also helps determine the electrical power needed, water usage (if any) and drying requirements.

Next, determine the method for feeding parts into the mass finishing machine

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and handling them as they are removed. For many job shops, manual placement and removal of parts is adequate. For higher production and more continuous flow, a direct feed from the machining center or lathe into the finisher is needed. For complex and expensive parts, an overhead load/unload robot might be the answer. The last issue is to calculate equipment payback. Machine builders can help estimate that.

Some shops will choose roll-in finishing machines that can be moved from one machine to another. In most instances, users will want to use overhead power. Water is generally included in tanks under the machine, so a direct water hookup isn't required. One critical issue is how to treat and dispose of wastewater because it contains metal and fine abrasive particles from the deburring media or plastic particles if plastic media is used.



Rosler Metal Finishing USA

A Rosler automated centrifugal disc system finishes parts, separates them from the media and feeds the parts to final packaging.

Typical Machines

James Krier, sales and marketing manager for Burr King, Warsaw, Mo., noted that in the past 2 years he has seen more applications for deburring equipment at lathes and mills. While others provide roll-around units, Burr King offers a small, skid-mounted system that is moved with a floor pallet jack.

For the 1.3-cu.-ft. finishing machines typically found at machine tools, operators either chute the parts straight into the finishing machine, manually place

them one at a time or input a batch at a time, depending upon part size. Vibratory machines are available in many sizes. Smaller machines fit well next to a machining center, whereas larger ones, such as a 3-cu.-ft. machine that measures 3' to 4' in diameter, are better suited for placement at the end of a cell.

Burr King vibratory machines have a

filtration pack that removes fines from the unit's recirculating 8-gal. water tank. The 2-sq.-ft. footprint of its 1.3-cu.-ft. capacity machine is one of the smallest in the market, according to Krier. That system and the company's 4.5-cu.-ft. machine use 15-amp, 120v power, normally from an overhead drop. Not requiring 220v is a major advantage for many

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shops because it simplifies moving the deburring machine.

In addition, the machines do not normally use abrasives, eliminating the need to remove abrasive particles from parts. If necessary, users can mount a small ultrasonic cleaner on the machine to provide final parts cleaning. Burr King's small finishing system sells for around \$3,000.

Some of the workpiece material transfers onto the media and into the machine liner, which can then rub off on the next batch of parts, Krier noted. Cross contamination can present corrosion, color and plating problems when machining a variety of materials, such as aluminum, brass and steel. Dedicating small units to specific materials is the easiest solution.

Cellular Arrangements

For quickly finishing parts in a work cell, centrifugal disc machines are available. Steve Alviti, president of Bel-Air Finishing Supply Corp., North Kingston, R.I., noted that centrifugal discs used in cellular manufacturing have typical cycle

times of 5 to 30 minutes, with a load/unload time of 2 minutes. The 10G centrifugal force in an open-top centrifugal disc machine allows users to apply very small media, which reaches into small part features. However, this size of media is not effective in vibratory operations because

Cross contamination can present corrosion, color and plating problems when machining a variety of materials, such as aluminum, brass and steel.

vibratory forces cannot move the media with enough force to deburr.

One Bel-Air cellular system finishes bone screws. The traditional way of making bone screws involved machining, deburring, secondary operations, passivation, inspection and inventorying them in lots

of 2,000 parts. When QC at one part manufacturer found even a few rejects, it typically meant the entire lot of 2,000 had to be scrapped. It took 21 days, the process' cycle time, until the next lot could be produced. By reducing lot size to 200 parts and putting a deburring machine and an ultrasonic cleaner at the machine, the manufacturer's cycle time fell to 4 days, reject rates decreased dramatically and inventory shrank by 400 to 500 percent.

In another application, Bel-Air provided a firearms maker with a finishing machine that had to fit into a cell that performed boring, assembly, deburring and surface finishing, as well as other operations on multiple parts. Every operation had to be finished within a 4-minute *takt*, or cycle, time. The machined forging required 24 minutes to finish, but the required time was met by ganging six small bowl units for finishing to make a larger deburring machine. The first six parts each went into a

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Bel-Air Finishing Supply

Centrifugal disc systems from Bel-Air are suitable for finishing an array of parts, including small ones.

different bowl unit. When the seventh part came to the deburring machine after 24 minutes, the first one was finished and from that time onward a 4-minute time was achieved.

Large vibratory deburring machines are used for cellular operation in which several machining centers feed parts into a single finishing machine or for finishing large parts. The larger machines provide automated or semiautomated handling, complete mass finishing, washing, rinsing and even drying.

Bill Sherman, technical sales administrator for Almco Inc., Albert Lea, Minn., a manufacturer of large vibratory machines, noted that Almco has sold several systems with its 2.5-cu.-ft. tub machines for cellular applications in a batch mode without automated handling.

Larry Bevins, vice president of sales and marketing for Almco, indicated that once a system is in place and the production rate increases, users tend to purchase a larger machine to meet the increased production rate. Large machines, such as 3- to 10-cu.-ft. ones, typically use ceramic media and abrasive or polishing compounds and include filters or sediment settling tanks to capture media fines. However, some applications use only smooth metal balls to finish surfaces. While large machines last 15 to 30 years and longer, bearings need lubrication roughly every week, which can be done automatically or manually.

More cellular finishing, including automated and semiautomated, is performed in Europe than in the U.S., noted Harold Wagenknecht, president of Rosler Metal Finishing USA LLC, Battle Creek, Mich. Rosler makes cellular sys-

tems for finishing small to large parts. For example, Rosler manufactures machines as small as ½ cu. ft. with bowls from 1.5 cu. ft. to 64 cu. ft. for finishing a host of parts, such as orthopedic implants, as well as machines for parts up to almost 2 sq. ft.

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Burr King

A pallet-mounted vibratory system from Burr King is positioned at a machining center to finish parts after they're machined.

Critical Mass *(continued)*

While most cellular systems have relatively standard layouts, sometimes Rosler designs vertical systems rather than horizontal ones because the cost of floor space is so high in some plants.

Rosler's philosophy is that rather than just having a machine in a cell, users need a system that provides appropriate equipment life and repeatable results using acceptable media and compound usage—something that will not usually be achieved with machines that offer a low up-front cost, according to Wagenknecht. Instead, the system approach requires a machine that produces the desired results at the lowest cost per piece based on media cutting ability, media wear rate and machine life.

If integration with other machines is required, users also need to consider who will interface the software of existing systems to the finishing portion of the cell. (Electrical control integration is not essential for many small applications.)

Wagenknecht added that centrifugal disc machines, which finish parts 10

times faster than vibratory machines, are experiencing higher demand—especially in automated applications. Rosler has installed many single- and double-cell systems. The unique design of its centrifugal disc gap allows for constant adjustment. This extends the life of the tub and spinner and allows users to fine-tune the machine according to the media and part size so they can handle a range of part sizes. Recalibrating the equipment for finishing different parts simply requires changing screens for separating different size media and parts.

Multiple methods with varying equipment costs are available for finishing parts at the machine tool or work cell they were produced on, but they all enable manufacturers to more efficiently complete and ship parts.

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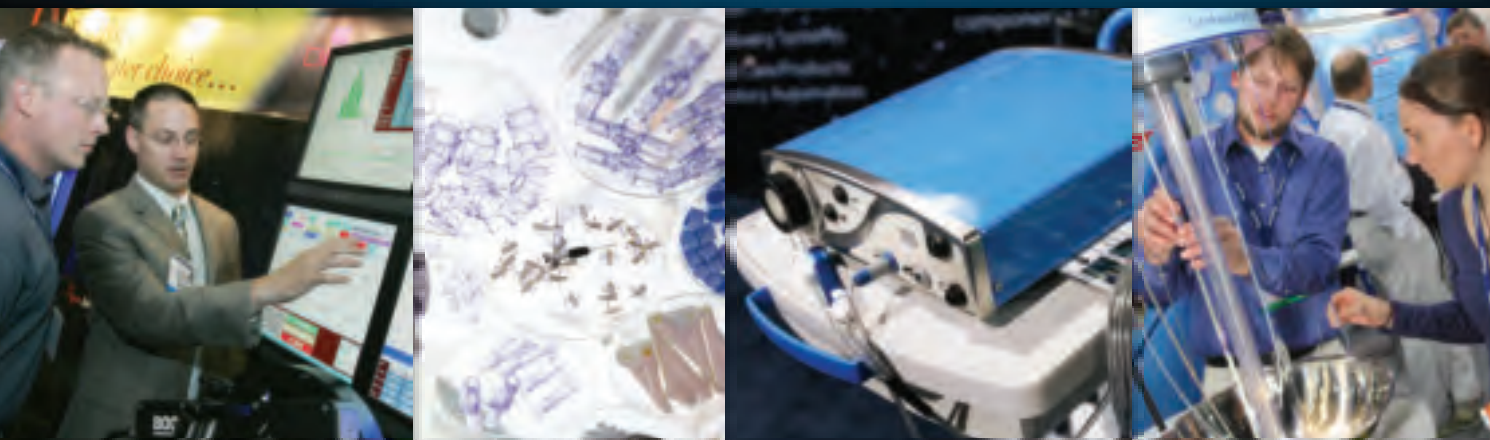
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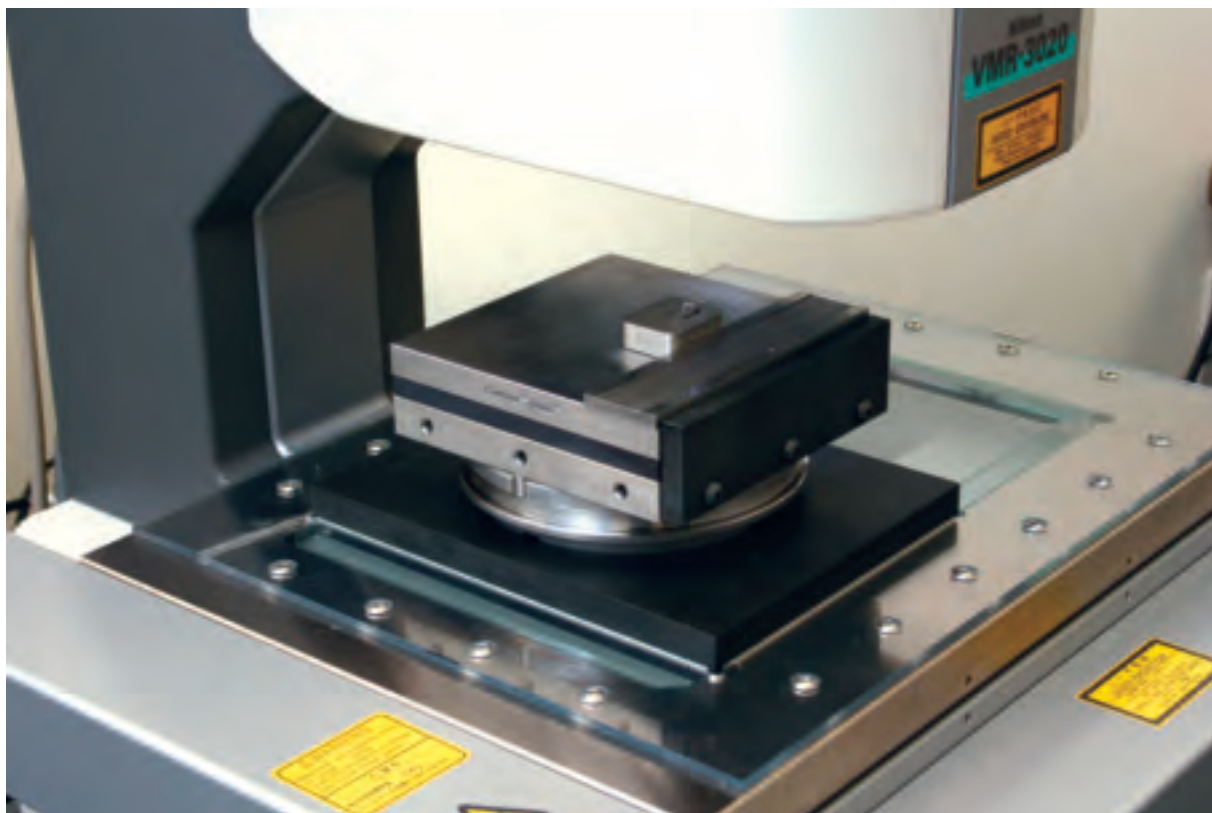
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Plastic Design

A micromold machined at Plastic Design is positioned on a Hermann Schmidt magnetic chuck mounted on a unit of System 3R's Nano reference system.

All Systems Go

Shop takes 'systems' approach to holding microparts.

By Bill Kennedy, Contributing Editor

Accurately machining and measuring a part requires it to be located and clamped with precision that matches or exceeds specified final tolerances. Generally, a shop can combine good machine tools, vises and tooling to get a good result. But when working with micron-level tolerances, good is not good enough. Beyond assembling high-accuracy workholding components, it is crucial to control how they relate to each other as an integrated system, and assure they are applied in a repeatable, systematic manner.

Zero-point palletizing, or referencing systems, can maximize precision in machining operations. In these systems, workholding pallets feature a centrally located drawbar or stud drawn into a machine-mounted chuck to provide con-

sistent and reliable positioning.

"In the case of developing or validating a process with small tools or small features, at some stage you have to remove the part and take it to a dedicated metrology device to inspect your results," said John Bradford, micromachining R&D team leader for Makino Inc., Mason, Ohio. "You then put it back in the machine, make adjustments to your process and continue machining. You must be able to remove, check and replace the part without repeating the whole setup process."

Microcavity Challenges

Plastic Design Corp. (PDC), Scottsdale, Ariz., deals with those challenges every day. The company manufactures

molds and uses them to produce small medical devices, microfluidic circuits and in vitro lab ware.

"We are cutting true microcavities," said PDC President Mark Kinder. "Typically, we are doing one- and two-cavity tools; a luxury for us is a four-cavity mold. In the case of microfluidic devices, he said, "the X-Y of the cavity may be pretty big—3"×5"—but we are cutting features in the 30µm to 50µm range."

Machining features as small as 10µm, he said, "is no big deal." However, there are many variables that affect the shop's ability to consistently generate those tolerances. For example, all rotary chip-removal systems feature some degree of spindle whip. "When you bring the machine up to speed, the centerline shifts subtly," Kinder said. "It's a centripetal phenomenon. The better the spindle, the less there is, but it occurs. We've mapped all of our machines. We can predict it,

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All Systems Go (continued)

but it is never an exact thing. It's subtle—tenths (10-thousandths of an inch) or microns."

In consideration of that and other variables, Kinder regularly checks part dimensions while machining. The parts are taken from a vertical machining center or EDM to a Nikon NEXIV VMR-3020 optical/laser 3-D coordinate measuring machine, inspected and returned for re-machining, if necessary. The actual steps followed are dictated by a shop's familiarity with, and confidence in, a specific operation, as well as the tolerances of the part being machined.

"If we have a high level of confidence, we will make the cut and check the part just for verification," Kinder said. If the part is out of specification, it's either scrapped or, if possible, refixed for further machining.

On the other hand, if tolerances are especially tight, Kinder said he takes a different approach. The initial CAM program is written to cut the part to slightly larger-than-final dimensions. Then the part is inspected, the program is adjusted and the part is refixed for machining to final dimensions.

For that reprogramming and remachining to be accurate, the part must be positioned identically for measurement and machining. About 2 years ago, PDC was having trouble repositioning work after removing it for inspection. "When you get down to splitting tenths, measuring the part is difficult enough," Kinder said.

"But getting it back into a location where we could take a 0.00004" (1µm) cut is where we were really struggling. We were spending 2 hours on a good day, and 4 to 5 hours, on average, getting the block trammed back into the machine."

A palletizing system might eliminate much of the time spent repositioning the molds, Kinder observed, but standard systems didn't provide accuracy high enough for his needs. Then he saw a demonstration of the Nano referencing chuck system from System 3R USA Inc., Elk Grove Village, Ill. "Repeatability was basically unmeasurable," Kinder said.

Tweaked and Finessed

Jack Sebzda Jr., System 3R Northeast regional manager, said the Nano system is a "tweaked and finessed version" of System 3R's standard Macro chuck system. "We take standard chucks out of the production line and basically balance and blueprint them, sort of like they do to an automobile engine to improve its performance," Sebzda said. "The chuck is hand-lapped and hand-measured; everything is done with the goal of making it as accurate as possible."

For example, he said, instead of being simply rough milled and tumbled, the locking surfaces of the pallet drawbar are ground so those dimensions are consistent drawbar to drawbar. "It's overkill for what you might normally expect, but we want the same exact pull force to be exerted on the pallets every time," Sebzda explained. The result is repeatability better than 1µm, he said.

Conquering constraints

PLASTIC DESIGN CORP. OPERATES

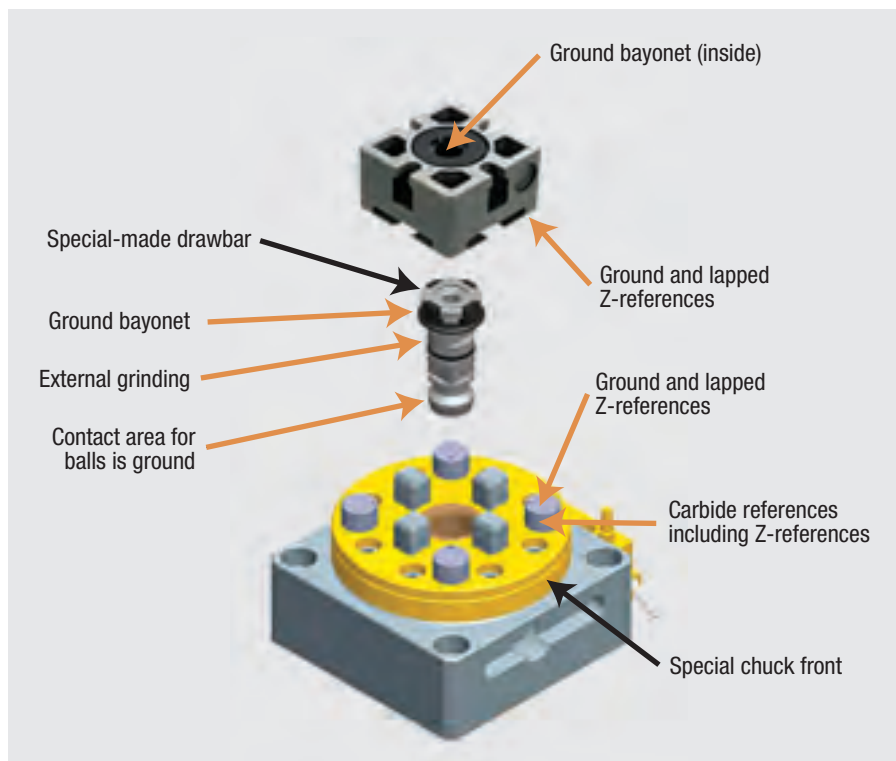
under the theory of constraints, also known as constraint management and "debottlenecking," according to company President Mark Kinder.

"We look at the aggregate efficiency of the shop, not the efficiency of a given machine tool," he said. "We will yank a setup if there is another job that we need to get through that piece of equipment to keep the overall workload in the shop moving."

Most shops focus on reducing downtime for individual machines. Kinder counters that "if you throw away micro profit centers

and efficiencies based on single operations and look at overall plant efficiencies, you can really achieve a lot more with limited resources."

High-precision, palletized workholding helps PDC make decisions on shopwide workflow. Kinder described a situation where the shop followed a run of EDM electrodes on its V-22 Makino VMC with a hard-milling job. A programming error on the sinker EDM produced features that were too shallow. "We didn't scrap the block, but all the electrodes were consumed," he said. "We looked at the shop schedule and decided that the block being



System 3R

The Nano reference system's chuck components are ground and lapped to maximize accuracy and produce repeatability better than $1\mu\text{m}$, according to the company.

Kinder enlisted his workholding supplier, Hermann Schmidt Co., South Windsor, Conn., to integrate Schmidt's workpiece-holding chucks with the System 3R palletizing system.

PDC required precision vises and different styles of magnetic chucks for its machining center and EDM, said Peter Schmidt, president of Hermann Schmidt. The company provided 6"×6" magnetic chucks ground to better than 0.00005" square. When mounting the

magnetic chucks to the System 3R pallet chucks, Schmidt said, "We indicated the rail around the outside of the magnetic chuck (against which the part rests) from the centerline of the System 3R reference chuck, so that in multiple chucks the work offset is within 0.00003" square and parallel from the center location."

A Step Higher

Palletizing is a long-established technology and most suppliers will guarantee

burned was more critical than a job we were hard milling."

The decision was made to take the hard-mill job off the VMC, switch the machine back to mill electrodes, remake the electrodes and finish EDMing the part that day. Prior to implementing an integrated System 3R/Hermann Schmidt palletization system, such a change would require hours, Kinder said.

Kinder authorized the change back to electrode machining and went to lunch. Upon his return he found operators working on the hard-milling job. When he asked why the electrodes weren't

being remade, he was told they were already done. "With the pallet system, the operators could interrupt the hard-mill program, pop that pallet off and drop in the electrode pallet. The electrode program was stored in the machine and, fortunately, we hadn't pulled the endmills we were using for the EDM work."

The electrode pallet had a vacuum box for dust removal, and the VMC was configured to handle either flood and mist coolant or vacuum dust collection. "They were set up and running electrodes in about 10 minutes," Kinder recalled.

—B. Kennedy

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their products to repeat within 2µm. However, while 2µm repeatability is good enough for most applications, "Mark Kinder's world is a whole other step higher," Schmidt said. "Mark wanted to take a pallet out of one machine, put it in another machine and repeat to 1µm or better. We are talking about going from 0.00008" repeatability in one machine down to 0.00004" repeatability machine to machine.

Hermann Schmidt takes the prefinished chuck and bolts it to the referencing system. When two objects are bolted, they are stressed, so at some point in the process one of the surfaces is lightly machined to qualify it. For example, the flat plate on the back of a magnetic chuck will be requalified via grinding and lapping.

PDC just had to mount the chucks and tram them in. "It has become our standard workholding system," Kinder said. The pallets are installed on PDC's VMC, sinker EDM and CMM. Some hold magnetic chucks, some grinding vises and some System 3R electrode hold-



Plastic Design

Pallets in the System 3R Nano referencing system can be removed and replaced with repeatability at levels less than 0.5µm (500nm), according to the company.

ers. After initial machine setup, no further setup is required.

Such precision is not inexpensive, Kinder noted. "We put as much money into that system as we would a machine tool," he said. "Originally, when we priced the system out, I had an ROI of 3 years on it, based on the shortened setup time after measurement." However, because of the system's positive effect on constraint management at PDC (see sidebar on page 50), the payback was

9 months.

Peter Schmidt stressed that this kind of precision workholding system is not a set-and-forget proposition. "It requires a systematic approach not only in how we build it, but in how they use it," he said. "If they don't use it the same way every time, if they change that procedure, they are not going to hold tolerance."

Jack Sebzda agreed. "That last 10-millionths is an expensive and difficult thing to get at," he said. "Maintenance, cleanliness and consistency are critical. You can put the best chuck in the world in a shop and you'll fail miserably if the machines are not maintained properly, or the operators don't handle things with care."

Some variables, inconsequential in macro applications, become significant in micromanufacturing. For example, System 3R specifies that even the air pressure used to actuate the chucks be tightly controlled. "If we want the reaction

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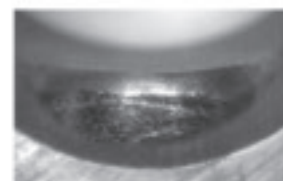
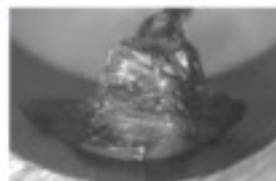
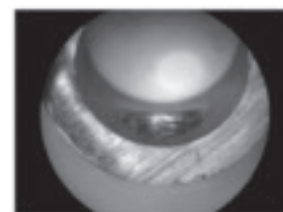
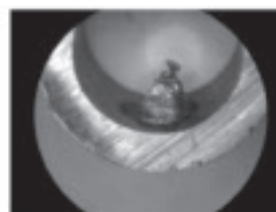
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of this chuck to be identical every time, the procedure for opening and closing the chuck must be as accurate as everything else," Sebzda said. While System 3R recommends air pressure of 5 to 7 bar (about 70 to 100 psi) to operate its standard chucks, air pressure for the Nano should always be 6 bar.

One challenge is that advances in machine tool accuracy may limit the usefulness of some palletizing systems, according to Makino's Bradford. He cited machines such as Makino's Hyper 2J VMC that features 0.000000020" (0.5nm) scale feedback with guaranteed positioning accuracy of $\pm 0.3\mu\text{m}$ (± 0.000012 ") and repeatability accuracy of $\pm 0.2\mu\text{m}$ (± 0.000008 ").

In actual applications, he noted, the machine has provided positioning accuracy and reliability on the level of $\pm 30\text{nm}$ ($0.030\mu\text{m}$). When machining parts or features that take advantage of those machine capabilities, removing the part from the machine for measurement may not be an option since part tolerance might only be a few microns.

As the machines are introduced with repeatability in the 70nm to 80nm range, more accurate workholding systems are a must, he added. "If your tooling only gives you repeatability of 700nm to 800nm, you are losing the benefit of the machine's accuracy and stability." In those cases, he said, machine tools will offer increasingly sophisticated on-board measuring systems that permit inspection

without removing the part.

However, according to Sebzda, advanced palletizing systems are already in the same tiny ballpark as the machines Bradford described. System 3R's Nano referencing system can repeat at levels under $0.5\mu\text{m}$ (500nm), but the problem has been how to prove it, he said. "By placing optical sensors on both the pallet and reference surface of the chuck, we are able to monitor and confirm system performance." Testing of the system has taken place when optical grinding, he said, including work with the Fraunhofer USA Applied Research Institute.

The Whole Package

To remain competitive, shops must continually seek and apply new technology. Regarding workholding, Schmidt said there are manufacturers who struggle because they are unaware of new equipment and integration services that enable high precision. To those who struggle, Schmidt said, "There are people who understand what you are talking about and your problems."

Sebzda said all machining elements must be included in the upgrade. "I can put the most expensive tires possible on a Yugo, and it's still a Yugo," he said. "The whole package has to be there. Sometimes that package has to be chosen from a variety of suppliers. It all has to be researched and constantly reviewed because there is always a better way to do it.

"What is coming down the pike must be understood, accepted and embraced," Sebzda continued. "Unless you move with the changes, you are going to be behind the times. We are coming to the point where our industry is doing the elite work; the no-brainer mold work, the blow molds, cheap toys and things like that are all gone. What's left are the upper-level, tip-of-the-pyramid processes that only a few can truly achieve." **CTE**

About the Author:

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B. Kennedy

On a Marubeni Citizen-Cincom K16 Swiss-style CNC lathe, a 0.047"-dia. drill working from a slide servicing the subspindle creates a hole in a brass workpiece used to verify the setup for machining a dental abutment screw.

Swiss Made

Tactics and tools for Swiss-style machining.

By Glen Crews, Marubeni Citizen-Cincom Inc.,
and Bill Kennedy, Contributing Editor

Swiss-style CNC lathes provide outstanding precision and flexibility while also posing special process control challenges and considerations. They offer machining capabilities and process control advantages apart from those of conventional CNC machines.

However, effectively operating a Swiss-style machine requires a different approach than machining on a conventional lathe. This article covers several key areas of Swiss operations, including segmentation, workpiece options, bushing maintenance, tooling, machine size and burr avoidance.

A Swiss-style machine differs from a standard lathe by virtue of a sliding headstock that feeds a rotating bar-fed work-

piece through a guide bushing. Static and rotating side- and end-mounted tools cut within millimeters of the guide bushing, effectively eliminating workpiece overhang and part deflection. Multiple axes and driven tools perform nonturning operations, including milling, drilling and deburring. CNC technology enables standard tool geometries to produce complex and nonround shapes, and twin-spindle configurations facilitate finishing both ends of a part.

Swiss-style machines are categorized by their maximum bar capacity, typically from 2mm (0.08") to 38mm (1.50"). Most smaller-capacity machines 16mm (0.63") in diameter and smaller can handle 1/16"-dia. bars with minimal difficulty.

In operation, Swiss-style machines can produce long runs of consistently precise, complex parts complete in one chucking. The machines routinely turn diameters down to 0.003" or smaller, and can machine features as small as 0.0003". Tight tolerances are the norm. A ± 0.001 " tolerance is considered wide open on a Swiss-style machine; shops running the machines typically work in four decimal places, and some shops consistently maintain tolerances of ± 0.0002 ".

Part Segmentation

A Swiss-style machine's sliding headstock and guide bushing provide superior workholding rigidity. To take full advantage of this inherent rigidity, the

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Swiss Made (continued)

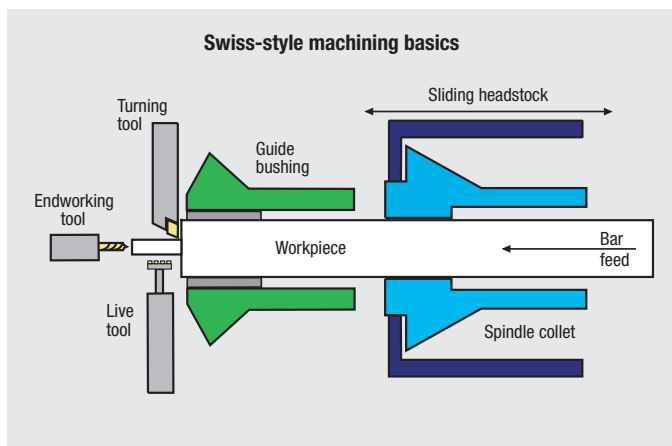
workpiece material must always remain in contact with the guide bushing. This requires the workpiece to be segmented—machined to completion one section at a time.

For example, all ID work is performed first. The material is fed through the guide bushing where a tool turns the part's first diameter. Then the next feature, such as a groove or cross-hole, is machined. When the material advances through the guide bushing, the next feature, such as a diameter, is turned. This sequence continues through completion.

Segmentation assures that the workpiece is always supported by the guide bushing. As a result, rough and finish turning usually are not performed separately but in one pass. A rigid Swiss-style screw machine permits much heavier DOCs than a conventional lathe.

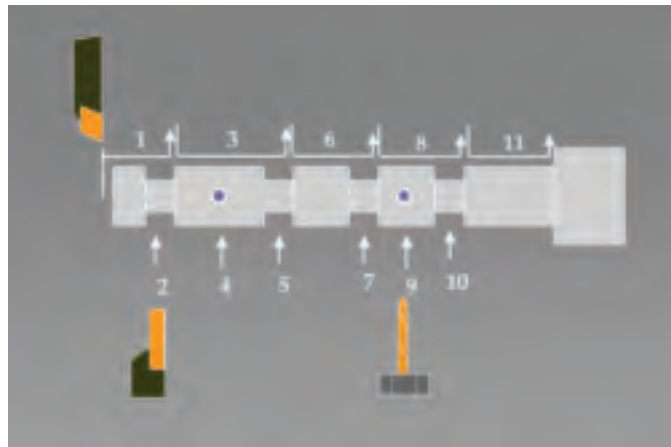
Material Significance

Workpiece material condition has a strong influence on the precision of parts produced on a Swiss-style machine. Most of all, the bar stock diameter must be consistent and typically is centerless-ground to a diametric tolerance of ± 0.0002 ", particularly for exotic alloys. For example, titanium stock must be



B. Kennedy

In a Swiss-style lathe, a sliding headstock feeds rotating stock through a guide bushing, eliminating overhang and deflection.



G. Crews

A key Swiss-style machining tactic is segmentation, in which the workpiece is closely supported by the guide bushing and machined to completion one section at a time.

ground because it tends to be inconsistent and somewhat out of round.

But there is no requirement for more precision than necessary. Many material suppliers provide screw-machine-quality material that will handle perhaps 98 percent of a typical shop's work without any difficulty. These higher-quality drawn materials generally have a tolerance of ± 0.0005 ".

More important than absolute tolerances, however, is maintaining a consistent diameter along the entire length of the bar. A bar may be 0.0005" undersize, but as long as the entire bar is undersize by the same amount, adjustments can be made to produce the required part dimensions. In general, a Swiss-style machine can hold 60 percent of bar stock tolerance; that is, if bar stock varies by 0.001", the part can vary by as much as 0.0006".

Bar stock should be straight, exhibiting a bow of less than 0.001" per 12" of length. It also must be round. If the material is out of round, the machined part will be out of round, too.

That fact highlights a significant difference between Swiss-style and standard turning. On a conventional lathe, an out-of-round bar can be chucked between centers and turned until round. Conversely, in a Swiss-style machine, an out-of-round bar will be rotating in the guide bushing, and the machined part will be out-of-round as well.

Bushing Guidance

The configuration, adjustment and quality of the guide bushing are major factors in successful Swiss-style machining. An inaccurate or worn guide bushing often causes problems with dimensional control or tolerances.

The two most common styles of guide bushings are synchronous rotary and fixed. For parts with tolerances looser than ± 0.0005 ", a rotary guide bushing is preferred. The rotary bushing and head-stock rotate in sync with the workpiece material.

Tighter-toleranced or smaller-diameter parts may require a fixed guide bushing, which remains static while the bar stock spins within it. A fixed guide bushing is adjustable and must be sized so the bar stock fully contacts the bushing but can still spin freely without seizing. The operator's "feel" for the relationship



Marubeni Citizen-Cincom

This three-part bell was produced using three different Marubeni Citizen-Cincom Swiss-style machines. The handle was machined from 1"-dia. stainless steel, the clapper turned from $\frac{1}{2}$ "-dia. stainless, and the bell body was machined from $\frac{1}{4}$ "-dia. brass.



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between the bar and bushing helps determine a fixed guide bushing's effectiveness. A good Swiss-style machine provides consistent repeatability, but if the bar stock, workholding or toolholding components are inconsistent, it doesn't matter how accurately the machine can repeat.

Tooling Requirements

In Swiss-style machining it is essential to apply cutting tools engineered specifically for producing small parts, but until recently, these tools were difficult to find. Fortunately, a growing number of cutting tool manufacturers provide Swiss-style tools.

In general, turning tools for Swiss-style machines should have sharp edges, small nose radii and large clearance angles behind the cutting edge. Sharp tools minimize cutting forces. The greater the radius of the cutting edge, the more cutting force it generates, and the greater the possibility of workpiece deflection. Chipbreakers should be ground—not molded—into the cutting edge to ensure



B. Kenedy

A carbide insert turns a brass workpiece, part of a 3½-minute process on a Marubeni Citizen-Cincom Swiss-style CNC lathe that involved 16 tools.

they cut and bend the chip effectively.

Clearance angles are an issue because Swiss-style tools operate in close proximity to the workpiece; sufficient clearance behind the cutting edge prevents it from rubbing on the workpiece. As part

features shrink in size, tools with smaller nose radii are required.

Some tooling issues become less important as parts and machines grow in size. Clearance angles are not quite as critical. Tool settings need not be as

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precise—there is more margin for error, for example, in adjusting tool center height. Larger machines also offer more room to work.

Challenges in acquiring and caring for small tools also decrease when machining the contours of larger parts. Machining characteristics and toolholding requirements are dramatically different for a 0.025"-dia. endmill compared to a 1/4"-dia. tool. You can push a 1/4"-dia. tool much harder than a 0.025"-dia endmill.

Although toolmakers are expanding their offerings of Swiss-style tools, specials may still be needed for certain applications. For example, appropriate reamers were unavailable for a job requiring holes with a ± 0.0003 " finished tolerance. The solution was custom, tight-tolerance drills that achieved the finished hole tolerance without reaming.

A Machine that Fits

Larger Swiss-style machines can handle occasional runs of smaller-diameter bar stock and produce smaller parts, but efficiency issues arise during long runs. A shop that regularly runs 1/4"-dia.

Swiss-style programming for challenging parts

EVEN MODERATELY COMPLEX SWISS-STYLE MACHINED parts often can be manually programmed. For more challenging jobs, however, Swiss-specific automated CAM systems are available. A shop should weigh the cost of such a system and decide if the level of sophistication it provides is required for the parts the shop produces.

Key to effective use of a Swiss-style CAM software package is learning to exploit its full capabilities. The programmers should already be familiar with manual programming of Swiss-style machines, which will allow them to recognize the codes being generated and have a sense of their appropriateness for the parts at hand. A CAM system may generate codes that are not precisely suited for what a shop wants to do, but a skilled programmer can change the automatically generated codes to most efficiently fit a specific application.

For very small parts, the speeds and feeds recommended by toolmakers may not be realistic. In turning, for example, reaching the recommended surface speed may require a spindle speed of 25,000 to 30,000 rpm, a speed generally not available on standard machines. To some degree, however, a machine can be upgraded via modifications such as spindle liners and reduction sleeves for the pickoff spindle to achieve an increased spindle speed.

Compromises are often necessary, and, in many cases, effective. Tool geometries play an important role in finessing machining parameters. For example, sharper geometries work better at slower surface speeds because they cut with lower force. Dialing in the most productive program will come down to testing and experience; when a part is machined, the results can be documented and a root cause analysis performed to find what is causing the result and make any needed adjustments.

—G. Crews

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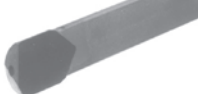
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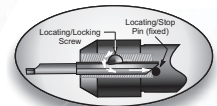
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Swiss Made (continued)

and larger stock on a 32mm (1.26") machine can easily machine a few thousand parts from 1/8"-dia. material. But if 100,000 of those parts are needed, a machine engineered for a smaller maximum bar diameter will be more efficient. Tool movements will be shorter, and the machine will be better suited to handle smaller parts.

For some parts, smaller, less complex machines actually run faster than larger machines. In some cases, simple and compact Swiss-style machines can rival the speed of cam-controlled screw machines, which are well known for high-speed production of less-complex parts.

Larger Swiss-style machines have larger work envelopes, more axes and can mount more tools than smaller machines. Those features are beneficial when dealing with complex work, and can also enable a Swiss-style machine to be set up to handle different parts without retooling. The machine turret and/or gang plate can be tooled for two or three different jobs, and the machine tool programmed to minimize changeover time. This arrangement enables shops to run small lots and achieve cost savings by slashing the time

spent setting up between jobs.

There are many other ways to expedite setups on a Swiss-style machine. Tooling manufacturers offer a variety of quick-change systems, and in some cases the same tools can be used for a variety of operations and parts. For example, the same center drill, turning tool and cutoff tool can be applied to different workpieces. Then, when it's time to change over to a new part, a tool change is not required.

A programming technique to speed setups involves the use of macros. The operator only has to enter a variable to adjust a macro for a certain part length, for example, and the rest of the program remains the same. Using techniques like these, changeovers can be done in literally 30 seconds by just plugging in a different part number.

Burr Avoidance

Other techniques can also improve Swiss-style machining. For example, operations that prevent and/or remove burrs while a part is still on the machine can eliminate the time and expense of secondary deburring operations.

In some cases, running a drill through a hole more than once limits burr formation. Or, after a cross-hole is drilled,

The automation option

OFTEN DESCRIBED AS "SWISS AUTOMATICS," Swiss-style machines are designed to run unattended. Theoretically, a Swiss-style machine can run overnight and hold the same tolerances as when it is attended.

Running lights-out is a common practice, but it involves risk. If a tool breaks or the material seizes up in a fixed guide bushing, the machine can crash or start a fire.

The machining characteristics of the workpiece material help guide the decision to run lights-out. Some materials are good candidates for unattended machining; brass, for example, is free-cutting and can usually run for days unattended. Other materials must be monitored. Certain materials tend to cause rapid tool wear or breakage, and, typically, the more exotic the material, the greater the risk.

Titanium, for example, usually is not a good candidate for running lights-out. If a tool breaks or dulls in titanium, it can heat the material to the point that the machine's cutting oil will flash and catch fire. Gummy materials can also be a problem. If chips ball up, they can interfere with the tool and break it.

Lights-out machining comes down to process control. Shops usually don't decide to run unattended until their processes are controlled. And lights-out doesn't have to mean an entire shift. If a shop determines it can complete 100 parts trouble-free, it can set a parts counter to shut the machine off after 100 parts run unattended.

After a process is under control, the repeatability of a Swiss-style machine will allow it to be run with inspection intervals much longer than those seen when making parts on other machines. I've run flat X-bar charts (graphs that measures variation above and below a certain nominal point) for Swiss operations with no measureable variation for an entire day.

—G. Crews

a pass with a turning tool across the hole mouth removes a burr. Another alternative is to drill the hole in two steps, first performing a predrill close to finish size, then finish-drilling the hole to the final diameter. The second pass removes minimal material and leaves no burr.

Cross-holes and other features can be deburred with nylon wheels or brushes for use with hand-held tools or in the ma-



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In some cases, Swiss-style machines can perform operations other than machining. In a demonstration, a slide whistle was machined and also assembled on a Swiss-style machine.

chine. Applied in a live spindle, the brush knocks the burr off without scratching the part. Some shops adapt tiny dental burs to remove heavier burrs or make their own deburring tools.

Swiss-Driven Innovation

The multiple axes and tooling options available on a Swiss-style machine provide the capability to perform processes and produce parts not possible on other equipment. In one case, a part required support on both ends during a series of aggressive milling operations. A live center was loaded into a drill station in the Swiss-style machine. The machine's sub-spindle was programmed to pick up the center and move it to support the free end of the part during milling. When milling was completed, the subspindle replaced the center in the drill station for use on subsequent parts.

With a little creative thinking, a Swiss-style machine can perform operations other than machining. In a demonstration, a slide whistle was machined and assembled on a Swiss machine (see photo above).

For the whistle body, bar stock was center drilled, drilled, bored, profile

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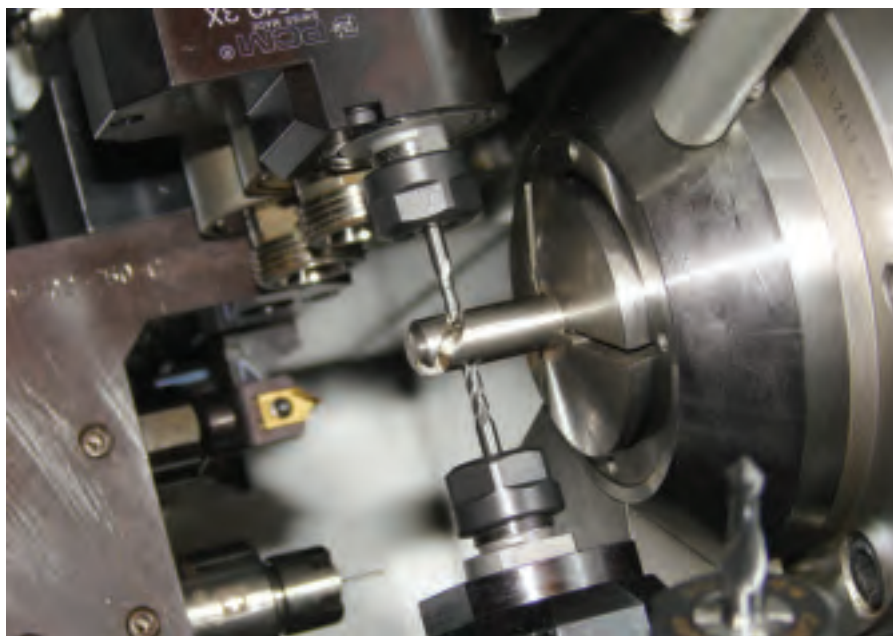
IS #35

Swiss Made (continued)

turned and milled, then cut off and picked up by the machine's subspindle. The subspindle moved the body down to endworking tools below the guide bushing for work on the part's back end. During those operations, the whistle plunger was milled and turned in the guide bushing.

When the plunger was completed, the subspindle brought the machined body back up to the guide bushing and slid the body over the plunger, which then was cut off. Finally, a small plug was machined in the guide bushing and pressed, via headstock motion, into the end of the plunger. The three-piece, fully assembled whistle dropped out of the subspindle complete. A video of this 3-minute, 37-second operation, performed on a Citizen K16-VII Swiss CNC lathe, can be viewed at www.youtube.com/watch?v=Ep0crJUFEIc.

The full range of capabilities provided by Swiss-style machines is not widely recognized. One shop owner at a trade show saw a demonstration part and said, "I



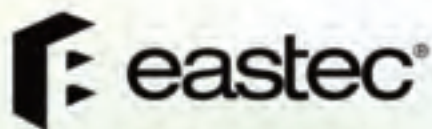
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Simultaneous high-speed pinch milling, shown here in a Marubeni Citizen-Cincom M32-Y machine, is one of the capabilities of Swiss-style lathes.

never would have thought to make that on that machine." As a rule of thumb, a Swiss-style screw machine should be considered for processing any part that can be machined from bar stock 1¼" in di-

ameter or smaller.

Swiss-style machines are growing more sophisticated, with some machines adding tooling capability to permit even complex parts to be machined complete



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in a single fixturing. Compared to running a part through a series of operations on different machines, such arrangements speed throughput and maximize part quality because all features are machined in one fixturing.

No Mystery

Despite its reputation among some shops as an arcane art, there is no unsolvable mystery to Swiss-style machining. Perhaps the two main contributors to success in working with Swiss-style automatic lathes are patience and a desire to produce precision parts.

Patience is required to monitor and control every facet of the process, from the workpiece material, workholding and toolholding components to the cutting parameters. For truly challenging parts, processes don't always work the first time around, and patience again plays a role in developing a solution.

Swiss-style machining does involve factors that aren't common in conventional CNC machining. Builders of Swiss-style machines and tooling representatives can supply a great deal of practical informa-



Marubeni Citizen-Cincom

tion. It's their job to demystify the process and help shops facilitate the production of consistent, high-quality parts. **CTE**

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IS #11

Tough Enough

Advancements enable ceramic inserts to tackle difficult machining applications.

By Ed Woksa, Ingersoll Cutting Tools

If you still think ceramics are “too delicate” for anything but continuous cuts and finish passes, think anew. Advanced ceramic inserts—even grades that are not reinforced with microscopic fibers, called “whiskers”—are now capable of rough turning as well as finishing. Milling and boring are also suitable applications.

And unreinforced ceramic grades are also applicable in difficult-to-cut materials such as Inconel, outproducing reinforced styles by a factor of two or more in some applications. This is achieved because the silicon-nitride-based material is similar in density but tougher than reinforced grades. These characteristics provide more consistent results because cutting edges wear rather than fracture. Many of the tougher grades of unreinforced ceramic inserts can handle feeds of 0.024 ipr and higher when roughing.

For example, a valve manufacturer in Texas turns Inconel 718 valve balls four times faster with new unreinforced Si_3N_4 ceramic inserts from Ingersoll Cutting Tools than with carbide inserts and twice as fast as with any other ceramic insert the valve manufacturer tried. (Ingersoll also offers a new whisker-reinforced ceramic grade.) The valve manufacturer also improved the material-removal rate fivefold when rough milling compared to carbide and doubled the mrr vs. other ceramic grades. Moreover, the manufacturer is successfully boring Inconel—an application usually considered off limits for ceramics because of the high risk of recutting chips.

The inserts have a special edge preparation, including a 0.2mm land width and a 25° lead angle, which helps them run cooler by putting the heat into the chip and not into the insert or workpiece.



Advanced ceramic inserts have also boosted productivity when cutting cast iron. A recently developed unreinforced silicon-aluminum-oxynitride (Sialon) ceramic insert increased the cutting speed by 40 percent and extended edge life when rough and finish turning gray cast iron brake shoes with interrupted cuts vs. an existing Si_3N_4 -based insert.

For gray cast iron, optimal machining parameters are cutting speed of 2,400 sfm and 0.024-ipr feed rate for roughing, and speeds up to 3,000 sfm and 0.08-ipr feed for finishing. For nodular cast iron, the

Materials	Grade	AW20	AB2010	AB20	AB30	TC430	AS500	SC10	AS10	AS20
Cutting speed: V (m/min.), Feed: f (mm/rev.)										
Gray cast iron (180-230 HB)	V	400-1,000	—	—	300-800	—	400-1,000	400-1,000	400-800	—
	f	0.1-0.5	—	—	0.1-0.5	—	0.2-0.6	0.2-0.6	0.2-0.8	—
Ductile cast iron (200-240 HB)	V	300-600	—	—	250-500	—	200-600	200-600	200-500	—
	f	0.1-0.2	—	—	0.1-0.3	—	0.1-0.5	0.1-0.5	0.2-0.6	—
Chilled cast iron (> 400 HB)	V	—	50-200	50-200	—	—	—	—	—	—
	f	—	0.05-2.0	0.05-0.2	—	—	—	—	—	—
Hardened steel (40-50 HRC)	V	—	100-400	100-400	100-300	—	—	—	—	—
	f	—	0.1-0.2	0.1-0.2	0.1-0.2	—	—	—	—	—
Hardened steel (> 50 HRC)	V	—	50-250	50-250	—	—	—	—	—	—
	f	—	0.05-0.2	0.05-0.2	—	—	—	—	—	—
ADI or HSS roll	V	—	—	50-100	50-80	50-100	—	—	—	—
	f	—	—	0.2-0.5	0.2-0.5	0.2-0.7	—	—	—	—
Nickel-base superalloys	V	—	—	—	—	150-400	—	—	—	100-300
	f	—	—	—	—	0.1-0.3	—	—	—	0.1-0.3

Table 1. Recommended cutting conditions for a range of newer ceramic insert grades. Source: TaeguTec



Ingersoll Cutting Tools

A grade-AS20 Si_3N_4 ceramic insert handles interrupted cuts when rough milling a pocket in an Inconel 718 valve ball.

parameters are 1,200 sfm and 0.020 ipr for roughing, and 1,700 sfm and 0.008 ipr for finishing.

Achieving these parameters stems from advances not only in substrate composition but also from coating, insert geometry, edge preparation and clamping system enhancements.

Substrate Choice Continuum

The range of available ceramic substrate materials has broadened significantly to cover a wide application range. Where once there was only hard, brittle alumina good for only fine finish turning (and requiring a very rigid machine), today there are more than 10 grades built around three basic ceramic chemistries: Al_2O_3 , Si_3N_4 and, more recently, SiC. Some are still whisker-reinforced, but many of the newer grades are not, and productivity isn't sacrificed. The performance of the unreinforced grades matches or exceeds whisker-reinforced ceramics because their blended substrates are more impact resistant than the alumina used in reinforced grades.

For example, zirconium-dioxide and Ti(C,N) "alloying agents" add toughness to some of the harder grades. Grade AW20 is a blend of Al_2O_3 and ZrO_2 ; AB2010 is Al_2O_3 , TiC and TiN; AB20 is Al_2O_3 and TiN; AB30 is Al_2O_3 and TiC; TC430 is whiskered SiC; AS500 is Sialon; SC10 is Si_3N_4 and TiC-coated;

AS10 is Si_3N_4 ; and AS20 is Si_3N_4 and TiN (Table 1).

Eliminating reinforcing whiskers dramatically reduces the cost to produce inserts. There will, however, always be a place for whiskered ceramics, particularly for high-speed milling and turning of Rene, Waspaloy and other nickel-base superalloys.

As a result, end users can find an effective ceramic grade for high-feed and medium- to high-speed rough turning and mild milling, as well as high-speed and low-feed finish turning. The inserts' improved reliability qualifies them—even unreinforced grades—for more lights-out machining applications.

Increasingly, ceramic inserts are available with the same PVD and CVD coatings that improve the cutting performance and tool life of carbide grades. For example, a CVD TiN coating helps alumina inserts run longer and cooler, and PVD TiN coatings improve the performance of ceramic inserts when cutting gray cast iron, which is used to make brake parts.

Stronger, Thicker Inserts

Newer insert shapes also help users get more mileage out of each insert. In the past, choices were limited to zero-lead triangles, squares, rhombi and rounds. The sharp-cornered triangle and rhombus geometries offered multiple cutting edges per insert at the expense of strength, while round inserts were stronger and reduced potential stress-raising sites but offered an uncertain number of edges. Although users can safely index a round to get six edges per side, most settle for two or three because they lose track of orientation on a featureless round. This is unnecessarily wasteful.

As a solution, thick, hexagonal ceramic inserts are being developed to enhance strength and provide clear references for indexing. The idea is simple: be closer to an inherently strong round shape than a square or triangle. Because the hex shape provides discrete orientations in the clamp, users don't throw away an insert that still has plenty of life left in it. In addition, the insert's thicker cross section provides greater process security, and the 45° OD and facing lead angle facilitates high-feed machining.

Newer ceramic inserts are also available with edge preparations that assist

when interrupted cutting and reduce cutting forces during roughing. Special edge preps can improve performance in specific applications. For example, a sharper edge reduces heat when cutting nickel-base superalloys, and a honed edge enhances toughness in interrupted cuts.

Dimple Clamping

Improved clamping systems have also reduced the risk of insert fracture, qualifying ceramics for more roughing and interrupted-cut milling. Dimple-type clamping systems eliminate the center hole through the insert, leaving a stronger tool with reduced stress-raising geometry. Instead of a hole, a precise bump in the clamp engages a matching dimple in the insert top face.

A recent refinement is the round dimple, rather than a square or elongated dimple. A round dimple ensures more uniform distribution of clamping stresses and full tangential contact regardless of indexing position.

These improvements are solving problems when machining difficult-to-cut materials during lights-out production.

Ceramic is orders of magnitude harder and more temperature-resistant than carbide, and the developments outlined in this article allow users to take full advantage of those attributes while minimizing the risk of fracture or catastrophic failure. As long as users follow manufacturer's recommendations, they can count on gradual, predictable wear to determine edge life and not a sudden tool wreck.

Today's ceramics perform well in difficult as well as ideal conditions. There's no need to baby them anymore or limit their applications. And once they overcome a particular bottleneck, payback is quick.

CTE

About the Author: Ed Woksa is marketing manager for turning and holmaking products for Ingersoll Cutting Tools, Rockford, Ill. For more information about the toolmaker's product line, call (866) 690-1859, visit www.ingersoll-imc.com or enter #350 on the I.S. Form.

www.ctemag.com

For more information, visit "Resources," click on "Article Archive" and select the "Materials" category.

iProductivity

Founded in the Netherlands, Holmatro is a global company with three manufacturing operations, one in the U.S. and two in Europe. Holmatro supplies hydraulic tools and systems for rescue, industrial and marine applications. The tools range from spreading and cutting equipment used in vehicle rescues to massive leveling cylinders employed when constructing offshore wind power projects to sophisticated winches for racing yachts.

At the company's Glen Burnie, Md., facility, manufacturing engineer Chuck Cain said products are manufactured from start to finish, excluding injection molding, welding, painting and plating operations. Typical parts include check valves, valve bodies and cylinders. Materials machined include nickel-chromoly steel, low-carbon steels and aluminum alloys. "We are about 60/40 in ferrous and nonferrous," Cain said.

Hydraulic components demand tight tolerances. "We are required to hold 1µm for true position," Cain said about some parts.

Cain estimates the facility machines about 5,400 different part numbers, with typical production runs of only 50 or so units. Inventory of completed parts is kept to a minimum. "Every tool and pump being produced in our facility has a customer attached to it," he said.

One key to maximizing efficiency is having most of the shop's 12 machine

tools in production 21 hours a day, with the remaining 3 hours used for setup, Cain noted. Seven machine tools can run unattended.

As part of a continual effort to improve productivity, Cain visits Iscar Metals Inc., Arlington, Texas, yearly to attend turning and milling seminars and learn about new products. At an event he attended last summer, Iscar introduced the Iscar Tool Advisor (ITA), a Web-based tool selection software program. The software enables users to search the toolmaker's electronic catalog for inserts and tooling components by entering a variety of criteria. By analyzing user-entered data, software algorithms recommend cutting parameters and provide other application information. The ITA can be accessed online or via an application uploaded to an Apple iPhone, iPod Touch or iPad.

When Cain heard about ITA, "I went right to the Apple app store, and before I got on the plane to come home I already had it on my iPhone. I also use the ITA on my desktop PC, but when I'm on the shop floor I can use it at any piece of equipment, mill or lathe."

Jeff Giambalvo, Iscar sales and applications representative, said Cain's immediate adoption of mobile ITA is no surprise. "Chuck is always out there searching for a better mousetrap," Giambalvo said. "He's always looking for ways to work smarter."

Cain handles a variety of tasks via ITA, including, for example, ordering a miss-

END USER: **Holmatro USA**
(410) 768-9662
www.holmatro-usa.com

CHALLENGE: Maximize productivity by facilitating tool acquisition and application.

SOLUTION: Electronic tool catalog and application recommendation software.

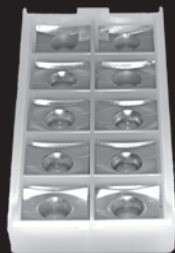
SOLUTION PROVIDERS:
Iscar Metals Inc.
(888) ISCAR88
www.iscar.com/ita or
www.iscarmetals.com
IS #300

ing screw for a toolholder. "I can hop on the ITA, put in an insert description and start going backwards," he said. "I point to the picture of what I have, pick the toolholder and get the part number for the screw." The ITA enables Cain to order parts directly from the iPhone after finding them in the catalog. "I can e-mail the distributor for a quote," he added. If more research is required, Cain prints the appropriate screen for further review.

The ITA also recommends cutting parameters. "A lot of things you know, but when Iscar comes up with a new grade or a new chipformer, you don't necessarily know what it's capable of," Cain said. He enters criteria, such as the feature being machined, workpiece material, tool in use and machine power, and receives



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recommended starting speeds and feeds.

To solve metalcutting problems, Cain said he has used both sides of the ITA application. When an insert was chipping, for example, he identified the tool through the catalog, switched to the software's speed and feed section, plugged in the tool and indicated the workpiece material. By changing the feed rate, Cain solved the chipping problem and also reduced cycle time.

The ITA also expedites direct Iscar customer support. "If Chuck goes into ITA and finds something that he hasn't tried before, he and I might have a conversation about testing those tools," Giambalvo said.

"We are in business to solve problems," added Steve Bauers, Iscar regional technical specialist. "ITA is a nice service for those who use our e-catalog."

Cain said adoption of advanced technology such as the ITA can also produce opportunities for new work. Previously, Holmatro USA made parts exclusively for



Chuck Cain

Hydraulic equipment maker Holmatro employs Iscar Tool Advisor (ITA) Web-based tool selection software to handle tool ordering and other tasks. The user enters a tool description, finds a part number and then orders parts through Iscar's electronic catalog directly from an iPhone or other Web-enabled device.

the U.S. market. Last year, Holmatro's manufacturing operation in the Netherlands asked the U.S. operation to bid on work that was being subcontracted to European job shops. Holmatro USA's

high productivity enabled it to win contracts for the work. As a result, the shop has produced about 35 new products, "with probably another 70 plus to go," Cain said.

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Editor's Note: For information about EMAG LLC's new VLC 250 P turning machine and the company's upcoming 2011 Technology Days, scheduled for May 10-11 at EMAG's U.S. headquarters in Farmington Hills, Mich., see the invitation opposite page 18 of this issue, scan the QR matrix bar code on your smart phone (app available at get.neoreader.com) or enter this URL on your Web browser: <http://cteplus.delivr.com/151o5>.) The VLC 250 P will be one of several new EMAG machines featured at the 2011 Technology Days event. Cutting Tool Engineering is the exclusive media partner of the event.



Established less than a decade ago, Axle Alliance Co. LLC is part of Daimler Truck North America LLC and supports many Daimler brands by machining rear-axle ring gears and pinions, as well as supplying multiple finished assemblies.

Based on its German sister company's success with the builder's machines, Axle Alliance uses six machine tools from EMAG LLC, Farmington Hills, Mich. Mike Bagdasarian, senior manufacturing engineer for Axle Alliance, Redford, Mich., noted that the machines—VTC 315 Duo, VTC 315 single spindle, two VLC630s, VSC 400 R single spindle and VSC 400 Duo—were purchased simultaneously and each one is dedicated to a part line.

The dual-spindle VSC 400 Duo vertical turning machine, for example, hard turns ring gears prior to grinding the gear teeth. The 390mm-dia., medium-carbon steel ring gear has a hardness of 59 to 62 HRC.

Although Axle Alliance considered purchasing machines from other builders, some builders "no quoted," Bagdasarian said. He attributes that to the parts' large sizes, heavy weights and tight tolerances. "When we told them we needed to meet a target cycle time in addition to our tolerance requirements from the



Axle Alliance

Axle Alliance's VSC 400 Duo vertical turning machine from EMAG hard turns ring gear prior to gear teeth grinding.

END USER: Axle Alliance Co. LLC
(313) 592-7438
www.daimler-trucksnorthamerica.com

CHALLENGE: Overcome workpiece variations while effectively hard turning large ring gears.

SOLUTION: A workpiece measuring process for a vertical turning machine.

SOLUTION PROVIDER:
EMAG LLC
(248) 477-7440
www.emag.com
IS #301

first operation to the second operation, I think some suppliers had no choice but to no quote," he added.

When the VSC 400 Duo was run-off in EMAG's German factory where it was built, the machine achieved the tolerance requirements, according to Bagdasarian. However, Axle Alliance experienced problems when it conducted on-site runoffs, which also included a subsequent grinding operation. The grinding machine came from a different builder that didn't participate in the off-site turning runoffs.

Because of distortion during heat treatment, a stack-up of in-process tolerances or both, there are slight size variations from part to part. The machine was initially set up to remove a specific amount

of material in both the first and second turning operations, but a lack of controls to monitor the tooth height variance from part to part led, in some cases, to too little or too much stock remaining for grinding. "We had to have 100 percent control over how much stock was removed in the first turning operation," Bagdasarian said. "It was an oversight on our part. Not having full control of stock removal in the first operation relative to the tooth height dimension had a huge impact on the success of the subsequent operation."

To achieve that control, programmers from Axle Alliance and EMAG worked together to develop an algorithm that enables the machine's in-process touch probe to premeasure part height similar to how a pitch line chuck might be used, Bagdasarian explained. "We measure the part across a set number of teeth and compare those values to a nominal value," he said.

With the measuring subprogram in place, the machine measures a part, determines how far it is from the nominal value and adjusts the Z-axis direction to achieve the required amount of stock removal. "Every part that we machine in the first turning operation is treated as an independent entity," Bagdasarian said. "The second turning operation is only taking off the resultant amount of stock that's left over from the first operation."

He noted that a capability study of 35 workpieces that measured the stock removal on the gear teeth using a coordinate measuring machine for gears showed a variation of less than 15µm. "It's as repeatable and consistent as you can ever

imagine," Bagdasarian said.

He noted that Axle Alliance's EMAG machines continue to produce large quantities of high-quality ring gears and pinions without any need to upgrade or replace equipment. "When the need arises for additional equipment," Bagdasarian said, "I would, without fail, put EMAG at the top of my list."

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Automated surface finishing is a 'game changer'

Some manual surface finishing operations can cause operator discomfort, fatigue and injury that shrink productivity and compromise product quality.

In the case of RCBS, Oroville, Calif., concerns about just such a scenario resulted in a goal to eliminate a manual finishing operation. It also led to an estimated 60 to 70 percent increase in productivity and a substantial quality improvement.

RCBS has been a leading producer of ammunition reloading equipment for more 60 years. Among its products are

steel and carbide reloading dies for rifle and handgun ammunition, which are produced in high volumes, according to engineer Tim Taylor.

The die production process involved extensive manual labor to finish bores. Workers wrapped emery cloth on rods and polished the internal die surfaces, which imparted inconsistent surface finishes, according to Taylor. "That resulted mainly from ergonomic factors," he said. "So achieving a consistent, high-quality surface finish and avoiding worker discomfort in the finishing operation



Depending on the die, RCBS uses multiple hone sizes as well as varying abrasive materials to impart the required surface finish.

- END USER:** **RCBS**
(800) 533-5000
www.rcbs.com
- CHALLENGE:** Automate ID finishing of ammunition reloading dies.
- SOLUTION:** Flexible brush hones on CNC equipment that improved quality and throughput while eliminating operator injury and fatigue.

SOLUTION PROVIDER:
Brush Research Manufacturing Co. Inc.
(323) 261-2193
www.brushresearch.com
IS #302

became high priorities.”

RCBS explored process improvements including CNC equipment and various finishing tools. A possible solution surfaced at a trade show in the form of flexible ball-style hones that could be tailored to meet the die bore surface finish requirements and worked with RCBS’s recently acquired CNC equipment.

Supplied by Brush Research Manufacturing Co. Inc., Los Angeles, the Flex-Hone tools consist of a shaft from which nylon filaments with abrasive grit extend. The tools are available in many diameters, abrasive materials and grit sizes, and are suitable for various surface finishing and deburring applications.

“We decided to test the Flex-Hone on steel dies,” Taylor said. “Brush Research gave us some recommendations and basic guidelines. Using a spare CNC mill, we tried different speeds and feeds until we were able to consistently achieve the desired results.”

The toolmaker helped by developing a series of brushes that enabled RCBS to apply progressively finer silicon-carbide abrasives to meet its stringent surface finish requirements. According to Taylor, the steel dies come off turning machines with a suboptimal finish, which the brush honing operation improves by a factor of eight to a submicron finish. “Depending on the die, we use multiple hone sizes as well as varying grit sizes and number of strokes,” he said.

With steel die finishing automated, RCBS successfully migrated the brush honing process to its carbide dies using tools with a diamond abrasive. Then Taylor set about optimizing both processes by writing a CNC program that selects the correct brush and process parameters based on operator input about bore length, ID and other elements.

“The new automated process is a real game changer,” Taylor said. “It is probably 60 to 70 percent more efficient than the manual process, and it resulted in a substantial increase in quality. But the ergonomic improvement alone—eliminating the potential for operator discomfort and injury—would have been enough to justify the new process.” **CTE**



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IS #26

PEOPLE

- Superabrasive tool manufacturer **Abrasive Technology Inc.**, Lewis Center, Ohio, announced that Daryl L. Peterman became a shareholder. Peterman joined the company in 2005 and currently is process engineer for sales, marketing and customer service.
- **Doosan Infracore Co. Ltd.**, Pine Brook, N.J., appointed John Crean national sales manager for its machine tool division. Crean will coordinate sales activities of the division's more than 40 distributors throughout the Americas. In other company news, Doosan Infracore completed its move to larger headquarters in Pine Brook.
- The **International High Speed Steel Research Forum (HSS Forum)** elected Carlos Pujana president. Pujana is the managing director of **Izar Cutting Tools SAL**, Bilbao, Spain. The HSS Forum is a nonprofit association for toolmakers, HSS producers and coating companies.
- **Sapient Automation**, Doylestown, Pa., which provides automated storage and retrieval systems, appointed Ed Romaine chief marketing officer.
- **Steiner Technologies Inc.**, Fairport, N.Y., named Will Zenaty worldwide sales and marketing consultant. Steiner makes back spotfacing and back counterboring tools.
- Grinding machine tool builder **United Grinding Technologies Inc.**, Miamisburg, Ohio, promoted Larry Marchand to general manager of the company's profile technology division. Marchand will have overall sales, administrative and financial management responsibilities.



John Crean



Carlos Pujana



Will Zenaty



Larry Marchand

- Davenport, Iowa. Jancy produces HSS annular cutters and magnetic drills.
- Software developer **Celeritive Technologies Inc.**, Cave Creek, Ariz., appointed two manufacturer's reps for its VoluMill toolpath engine. **Gaudian Industrial Sales**, Romeoville, Ill., represents Illinois, Minnesota, Wisconsin, North Dakota, South Dakota and the Upper Peninsula of Michigan. **Innovative Products & Services**, Franklin, Ohio, represents Ohio, Kentucky and Indiana.
- Software developer **CGTech**, Irvine, Calif., announced 22 North American Vericut Users' Exchange (VUE) events for 2011. Attendees will learn about new software features and tips for improving manufacturing efficiency. For more information about the free events, call (949) 753-1050 or visit cgtech.com/usa/cgtech/vue.
- **Eriez**, Erie, Pa., introduces Orange University, a mobile training and education center for hands-on demonstrations and workshops. Eric Confer is the Orange University team leader. The center includes product and video demonstrations and educational materials. Eriez provides technology for magnetic, vibratory and inspection applications.
- Metrology solutions provider **Hexagon Metrology**, Cobham, U.K., entered into a commercial cooperation pact with **GE Measurement & Control Solutions**, Wunstorf, Germany, for the first computed tomography system to be introduced into Hexagon Metrology's key industry segments.
- **Houghton International Inc.**, Valley Forge, Pa., completed its acquisition of **Shell's Metalworking and Metal Rolling Oils** business, a specialty fluids manufacturer. Houghton International produces specialty chemicals, oils and lubricants.
- Workholding products provider **ITW Workholding**, Traverse City, Mich., is now marketing its products under the Forkardt brand name. Also, the

company appointed Bill Seganik group general manager of Forkardt.

- **Joining Technologies**, East Granby, Conn., launched a laser additive manufacturing division. The company also entered into an agreement with laser development and contract research institute **Fraunhofer Institute for Laser Technology (ILT)**, Aachen, Germany, whereby Fraunhofer ILT will provide laser additive manufacturing R&D services.
- Toolmaker **Kennametal Inc.**'s Beyond Blast metalcutting technology was honored with a 2011 Carnegie Science Center Award in the Advanced Manufacturing category. The awards recognize and promote outstanding science and technology achievements in western Pennsylvania. Beyond Blast technology directly channels coolant through the insert to the tool/workpiece interface.
- **Okuma America Corp.**, Charlotte, N.C., announced three new companies have joined its Partners in THINC: **Blum-Novotest GmbH**, a measurement and testing technology developer, Ravensburg, Germany; tooling provider **Command Tooling Systems LLC**, Ramsey, Minn.; and cutting fluids manufacturer **QualiChem Inc.**, Salem, Va. Okuma America provides CNC and machining technology. Partners in THINC offers integrated solutions to streamline manufacturing processes.
- Toolmaker **Sandvik Coromant Co.**, Fair Lawn, N.J., and the **Joe Gibbs Racing Team**, Huntsville, N.C., announced a 2-year extension to their partnership. Sandvik has supplied the NASCAR franchise with cutting tools for more than 8 years.
- Toolmaker **Widia Products Group**, Latrobe, Pa., will make its NASCAR Sprint Cup Series debut at the Martinsville Speedway in Virginia on April 3. The No. 1 **Bass Pro Shops/McDonald's** Chevrolet will become the No. 1 Widia Chevrolet.

CTE

COMPANIES

- Aluminum maker **Alcoa Inc.** acquired the aerospace fastener division of Cleveland-based **TransDigm Group Inc.** The division will be part of **Alcoa Fastening Systems**, Torrance, Calif., which manufactures fasteners, components and installation tools. The acquisition includes 400 employees and three plants.
- Power tool manufacturer **C.&E. Fein GmbH**, Schwäbisch Gmünd, Germany, is acquiring **Jancy Engineering Inc.**,

Look-Ahead (continued from page 76)

identification systems. The RFID technology collects real-time data from machines and other shop equipment. The information, such as quality-related data, is measured by external devices, such as a laser scanner, or integrated sensor elements on an RFID transponder, such as a strain gage or temperature sensor, Reinhart explained. "Therefore, RFID provides the basis for a precise image of the real world," he said. "By combining workpieces with RFID transponders, they become smart products that are enabled to share information with the planning level and other resources on the shop floor through a respective communication infrastructure. Smart products are therefore able to actively influence their way throughout the shop floor."

For example, a workpiece "asks" machine tool No. 2, "Can you drill a 50mm-dia. hole in the required amount of time or shall I take myself to another machine?" If the machine says "yes," then the workpiece uses the information



CoTeSys/Kurt Fuchs

Within the CoTeSys framework, virtual cooperation enables a robot and human to simultaneously work on the same workpiece.

on the transponder to book a "factory taxi" and says to the transport system, "Please take me to machine No. 2."

For more information, contact

the Institute for Machine Tools and Industrial Management, Munich, Germany, at +49-89-289-15500 or www.iwb.tum.de.

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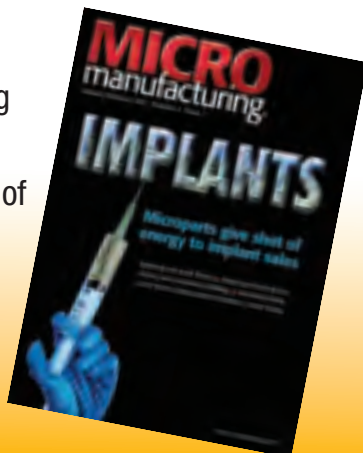
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By Alan Richter, Editor

THIS MONTH

Cutting Tool Engineering covers:

- A unique insert clamping mechanism and seating configuration; and
- A cognitive factory that "thinks" for itself.

GOLD IS THE METAL

Increasing the material-removal rate to reduce cycle time using lower horsepower while imparting the specified surface finish is the goal when turning. To achieve that, Ingersoll Cutting Tools introduced the Gold-Duty family of CNMX and SNMX double-sided turning inserts.

The aggressive HB chipbreaker on the inserts lowers cutting forces and therefore lowers a machine's horsepower requirement, the company reports. The chipbreaker also provides finer finishes when medium to rough turning compared to equivalent CNMG and SNMG inserts. The toolmaker says the new inserts offer performance comparable to single-sided CNMM and SNMM inserts, but with the double-sided economy advantage.

For example, when test cutting a 4.0" length of 25"-long, 0.45 percent carbon steel at 500 sfm, 0.040 ipr and a 0.200" DOC, Ingersoll's CNMX 553 HB insert imparted a 8.8 μ m R_a finish compared to 9.0 μ m R_a for a competitor's double-sided CNMG 543 insert and 9.7 μ m R_a for a competitor's single-sided CNMM 543 insert.

Instead of having a flat bottom to maximize seating rigidity, Gold-Duty inserts have four resting pads on their concave sides that enable even a used side to be raised above the convex mating seat yet stably contact it, explained Ed Woksa, marketing manager for turning and holmaking products. That further lowers cutting forces and enhances chip flow at the recommended DOC from 0.060" to 0.315".

Woksa added that a hook lever clamping system enhances seating rigidity



Ingersoll Cutting Tools

Ingersoll's new Gold-Duty double-sided insert for medium to rough turning is securely clamped with the toolmaker's hook lever (bottom).

in the insert's new H-type holder by exerting a double-clamping force. In contrast, a conventional lever design on a P-type holder pushes the insert in one direction back into the two seating walls. "We're getting multidirectional clamping force," he said. "That's going to be 30 percent stronger than the typical lever lock."

According to the company, the hook lever clamping system eliminates the need for top clamps, which often wear out because of chip wash.

For more information, contact Ingersoll Cutting Tools, Rockford, Ill., by calling (815) 387-6600 or visiting www.ingersoll-imc.com.

THE THINKING FACTORY

With the integration of cognition sensor networks and computer algorithms, machine tools are entering the virtual world. Within that world, Munich Technical University's Institute for Machine Tools and Industrial Management is conducting research within the framework of CoTeSys (Cognition for Technical Systems), which is funded by the German Research Foundation. "We aim to use the tripartite requirement of 'detect, deduce, deliver' to make machines more proactively autonomous than they used to be," said professor Gunther Reinhart, director of the institute.

He noted that Cognitive Technical Systems differ from other technical systems in that they perform cognitive control, which includes reflexive and habitual behavior in accordance with long-term intentions. "Cognitive capabilities such as perception, reasoning, learning and planning turn technical systems into ones that 'know what they are doing,'" Reinhart said.

To move the research from the "ivory tower" down to earth, the university developed the Cognitive Factory demonstration platform—a factory that thinks for itself. Researchers from multiple disciplines, including mechanical and electrical engineering, informatics and psychology, are working on the project, located at the university.

"The related project CogMaSh (Cognitive Machine Shop) aims at using cognitive capabilities to achieve a balance between flexibility, performance and cost-effectiveness by transforming machines and processes into cognitive ones," Reinhart said. "As a basis for validation, a flexible manufacturing system is used as a demonstration platform."

The FMS includes machine tools, assembly robots, a quality assurance area, a storage facility, a pallet transportation system, depth and infrared cameras and sensor networks with radio frequency

(continued on page 73)



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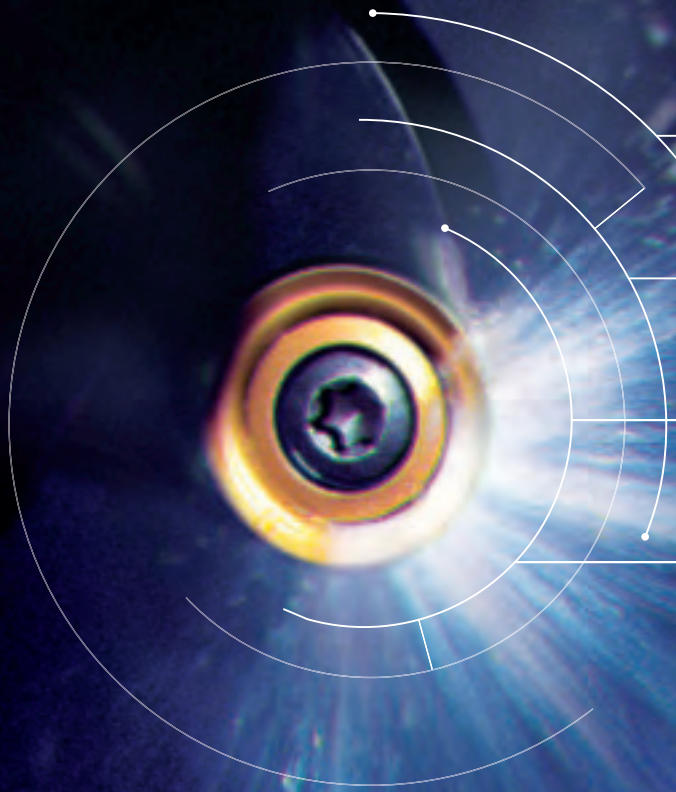
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