

CUTTING TOOL ENGINEERING

January/February 2026 | Vol. 78 | Issue 1

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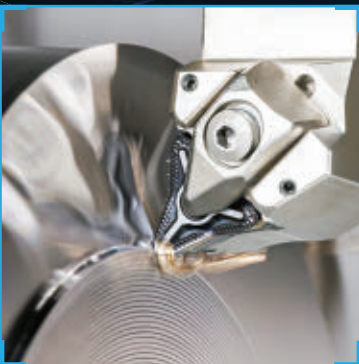
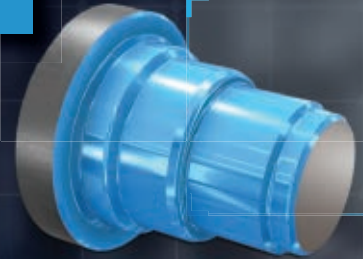
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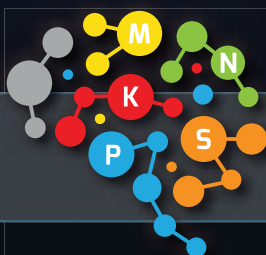
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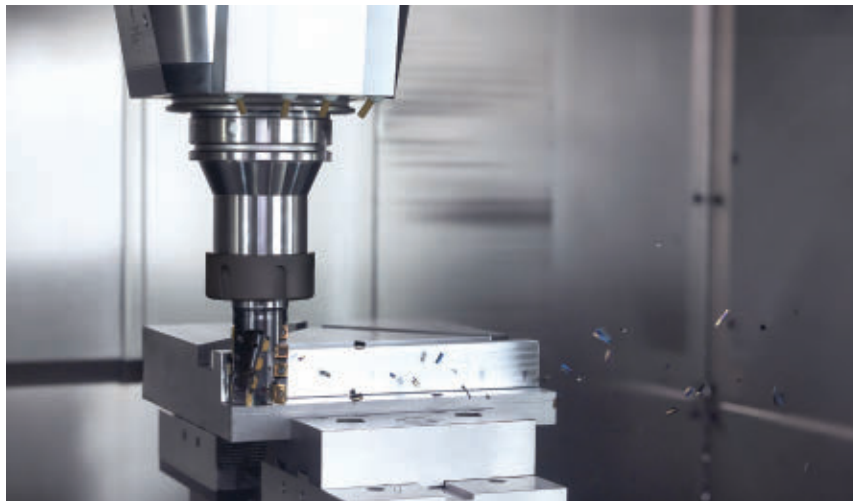
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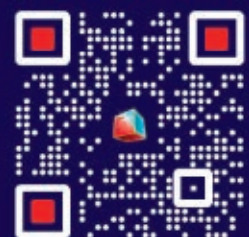
When the Long Way Leads to the Shortcut

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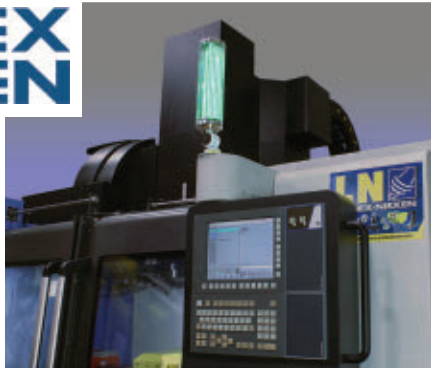
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Metalworking Product Review

**LYNDEX
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ROI ANALYSIS. Lyndex-Nikken's new EZ-SmartTower enables machine shops to seamlessly monitor and analyze production data for up to 30 machines – all from a single, centralized computer. The machine tracking solution logs machine cycle counts, records idle, cycle, and error times for spindle efficacy tracking, and captures operator, machine and part data for comprehensive analytics. The EZ-SmartTower is said to provide real-time machine analytics to help shops make data-driven decisions and maximize productivity.

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INSERTS WITH 25° CORNER ANGLE ENHANCE PROFILING. Tungaloy Corp. expanded its Y-Pro Series of inserts with the addition of precision-ground YCGT inserts featuring a 25° corner angle for enhanced profiling and undercutting performance. The expansion is Tungaloy's response to a growing demand for such high-precision inserts, especially for applications such as fitting components on automatic lathes, medical implants and shafts. Ideal for complex turning operations, the Y-Pro Series is also compatible with multitasking machines and automatic lathes.



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PILOT STEP DRILL IMPROVEMENTS TIMES THREE.

The Sphinx Drinox Pilot Step Drill at 3 x D from BIG DAISHOWA features a unique design that delivers up to three times longer tool life, three times higher coolant-through output and three times faster drilling, according to the company. Available in diameters from 0.70 mm to 3.00 mm, the Sphinx Drinox features coolant-through channels to maximize the coolant output. The newly developed TiSiN ultra-thin coating reportedly ensures high tool sharpness.



THREADING TOOLS FOR SAFETY CRITICAL APPLICATIONS.

The Self-Lock Threading Tools line from EMUGE-FRANKEN USA recently expanded with additional Threads-All/Aero Thread Mills, including new 2 x D sizes from #5-40 to 1"-12 and 3 x D sizes ranging from #2-56 to 1"-12. The thread mills feature helical flutes, multiple teeth and TiAlN-T46 coating, producing self-locking threads ideal in demanding industry applications such as aerospace where nickel alloys, titanium and stainless steel are the norm, according to the company.

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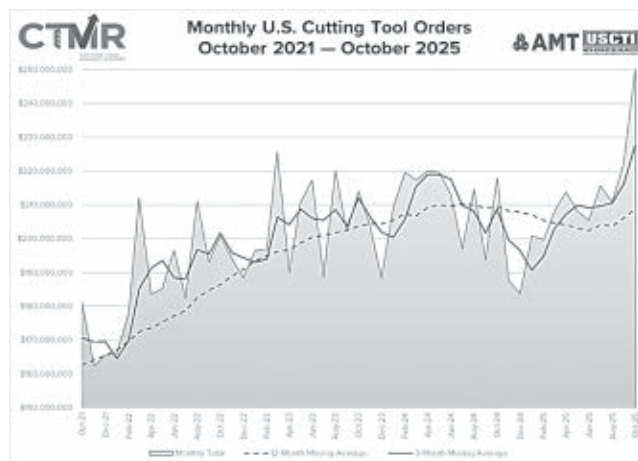
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OCTOBER 2025 CUTTING TOOL ORDERS JUMP 14.7% OVER OCTOBER 2024

Shipments of cutting tools, measured by the Cutting Tool Market Report (CTMR), a collaboration between AMT – The Association For Manufacturing Technology and the U.S. Cutting Tool Institute (USCTI), totaled \$250.1 million in October 2025. That represents a 12.7% increase over the previous month — September — and a 14.7% jump over the monthly cutting tool consumption reported in October 2024. Year-to-date shipments trended positively for the first time this year and totaled \$2.13 billion, up 0.6% from the same period in 2024.

"The latest three-month trend is looking more promising, but our industry is still flat to down over the past year," said Mike Stokey, president of USCTI. "I believe our industry is cautiously optimistic that 2026 will be slightly better than 2025. Obviously, that could change quickly based on any changes to economic policies."

Costikyan Jarvis, president of Jarvis Cutting Tools, said: "The very strong October 2025 results are likely the re-



sult of several one-time factors driving demand rather than a new baseline; however, the overall picture continues to show a slow rise in industrial output, with the promise of more growth in 2026. The year-to-date 2025 data versus 2024 data show a strengthening trend consistent with other economic indicators. This suggests that industrial manufacturing is looking at a much better 2026 than 2025."

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US METALWORKING MACHINERY ORDERS SURGE 40% YEAR-OVER-YEAR IN OCTOBER

New orders of metalworking machinery, measured by the U.S. Manufacturing Technology Orders Report (USMTO) published by AMT – The Association For Manufacturing Technology, totaled \$538.9 million in October 2025. This was a 9% increase from September 2025 and a 40.3% increase from October 2024.

Machinery orders tracked by USMTO through October 2025 totaled \$4.47 billion, a 19.7% increase over the first 10 months of 2024.

Both the value and the number of units ordered in October were the highest since March 2023. It was the third month in 2025 to surpass \$500 million in new machinery orders — the most since 2021, when six months saw investments above \$500 million. Despite widespread fears about the economy, manufacturers continue to invest in metalworking machinery due to renewed tax incentives and sustained demand for manufactured goods from both consumers and government entities.

October orders from contract machine shops, the largest customer of manufacturing technology, were the largest since March 2023. Despite the high dollar value, the number of units ordered was the same as in September 2024, but with a 13.2% lower order value. The trend of expanding average order values in this industry underscores the increased demand for automation at all levels of the supply chain.

October saw the highest order value from aerospace manufacturers since March 2025. This investment comes one month before the end of the government shutdown, which saw a significant number of Pentagon contract announcements, as well as the end of the Boeing defense workers' strike. These developments could foreshadow additional orders before the end of the year, given the sector's rising capacity constraints.

Manufacturers of engines, turbines, and other power transmission equipment also increased orders significantly in October, reaching their highest value since February 2023 and the highest number of units since March 2022. Continued demand for electricity from data centers is prompting additional investment in new generation capacity and extending the life of some coal-fired plants that were slated for decommission.

While numerous experts have predicted a mild industrial downturn in 2026, opportunities remain for manufacturing technology providers in sectors that have been outperforming the overall economy. **CTE**

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DEBURRING DEBUTS

By William Leventon

Machining firms in North America have a couple of new toolholder options designed to help users automate and improve edge-finishing operations.

The products are additions to the FM-DBR7 line of deburring holders developed by the Japanese firm Kato Manufacturing Co. Ltd. and sold in North America by Bel Air Finishing Supply Corp. in North Kingston, Rhode Island. Patented in Japan and suitable for CNC machining centers and robotic systems, FM-DBR7 holders feature special load mechanisms that enable front-, back- and dual-side deburring in a variety of production scenarios.

Traditionally, deburring has relied heavily on manual processes that require a good deal of time-consuming setup and maintenance and also produce inconsistent edge-finishing quality, noted Steve Alviti Jr., vice president of Bel Air Finishing. Alviti said the quality issues "were especially significant during high-volume production, where you get a lot of variance and rejected pieces." So Kato's goal was to create reliable toolholders that can adapt to some variety in part tolerance in order to allow stable deburring that can be maintained during long hours of continuous machining.

New to the North American market, Kato's FM-DBR7-1D series deburring toolholder is designed for automated top and bottom (tension and compression) deburring of machined holes in one pass, eliminating tool changes. By compensating for workpiece dimensional changes during production runs, its tele-

scopic compression/tension mechanism is meant to ensure consistent deburring volume and stable cutting performance even in high-mix, variable-batch operations. Originally developed for cast iron, the 1D series now includes three holder options that each provide a specific spring load — light, medium or aggressive — for the different cutting-pressure requirements of a variety of materials, including aluminum and stainless steel.

Bel Air's other new holder offering is a product recently introduced by Kato, the FM-DBR7-SC, which is designed specifically for front-side

deburring and chamfering. The SC features an adjustable spring-load mechanism that maintains consistent cutting pressure during machining of parts with minor height or dimensional variations. The unique four-stage mechanism can switch between pressures ranging from "soft" to "very hard."

Like the 1D series, the SC has a telescopic design meant to reduce chatter and over-cutting in order to ensure smooth surface finishes and repeatable results. The telescopic motion of the Kato holders produces less runout than other products with a similar telescopic feature available in the market, Alviti said. "We've tested our products versus the competitor's, and you can really see the difference at the tool point of the holder."

In addition, Alviti pointed out that the Kato holders are short and slim. "Ours are about 80% the size of the competitor's," he said. "So the risk



Bel Air Finishing

The FM-DBR7-1D series includes three holder options that each provide a specific spring load for different cutting-pressure requirements.



about the author

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W616 series 90° carbide rotary burs allow both top and bottom deburring of machined holes.

Bel Air Finishing

of interference is much lower, and the ability to get into the workpiece you're deburring is greater." He also noted that, the Kato units have a dust-proof cover that prevents chips and contaminants from getting into the holders, which helps to ensure high performance for longer periods of time.

Available accessories for both Kato holders include the company's W616 series 90° carbide rotary burs. Alviti explained that a 90° cutting-edge offset to the center al-

lows both top and bottom deburring of machined holes.

What impact can the Kato holders have on an actual deburring process? In one case reported by Bel Air, a machine tool manufacturer making FC200 cast iron parts with a vertical machining center switched from manual deburring to an automated process. According to Bel Air, the customer's manual deburring operation took approximately 20 minutes per workpiece, with variations in processing time and qual-

ity depending on the operator. But by changing to an automated process that includes FM-DBR7-1D holders, the shop achieved consistent, stable quality while dropping deburring time to 1.5 minutes. The customer also noted that W616 rotary burs provide significantly longer tool life than a brush-type tool from another manufacturer that had previously been tried.

Although deburring toolholders meant for automated operation are fairly common these days, the Kato holders are unique in their ability to handle variances in edge tolerance, Alviti said. "If you need that feature and you're doing high-volume or high-end/high-value products, these holders will be very successful for you." **CTE**



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A GRIPPING 5-AXIS MILLING TALE

By Brandt Taylor

The five-axis milling process continues to expand and evolve as machine tools and tooling become more capable. As an example, I recently learned about a new workholding system introduced to the market by EMUGE-FRANKEN USA in 2025 that features new vises for five-axis milling that are capable of considerably more clamping force than those offered by other companies. Before I fully explain the significance of this increased capability — to me, at least — it would help for you to know the technological advancements I have witnessed throughout my career.

When I went to engineering school in the 1960s, I learned Fortran programming using IBM punch cards to communicate with a computer that had a footprint of 300 square feet. When I started my shop, the first machines I bought were a manual milling machine and lathe. I soon learned about com-

puter numerical control and that CNC milling machines could do linear and circular interpolation of the different axes on a three-axis mill. That simplified my work and increased my income.

At that time five-axis milling was impractical. The computer power and memory were not up to the task. Then the PC revolution changed all that. Now I have a cell phone with orders of magnitude more processing power and data storage than my first computer — an IBM mainframe owned by the University of Massachusetts and housed on the second floor of the engineering lab building.

These days, five-axis milling has become not only practical but attractive.

To be clear, I'm talking about five-axis milling machines that have three linear axes of motion — X, Y and Z — and have a trunnion, rotary table assembly attached to the X and Y drive mechanisms in place of a rectangular T-slot table. The trunnion and rotary table provide

two axes of rotary motion, A and B. The A axis of the trunnion is parallel to the X axis, and the rotary table is mounted to the trunnion so that the face of the rotary table is parallel to the X-Y plane when the trunnion is at 0°. The trunnion may rotate 90° or alternately +/-90°. In either case, the face of the rotary table becomes parallel to the X-Z plane. With this degree of motion, a cube held against the face of the rotary table can have its top and four sides positioned by the rotary motion for machining. Then each of the five faces can be machined by the X, Y and Z motion of the mill. Various intermediate angular positions can be indexed — or different axes can be interpolated — so in one setup a part like the one shown in figure 1 can be made.

For the part in figure 1, the workpiece is mounted into the vises, then the start button is pushed. Now the operator is free to work on other tasks until the job is finished. The part is completed by removing

Figure 1



Figure 1 shows some of this tooling mounted on a rotary table and holding a strut made in one setup on a five-axis milling machine.

the two standoffs that were created in the five-axis machining process. That's productivity.

Another thing: spiral toolpaths can be generated when an axis of rotary motion is interpolated with an axis of linear motion. That is the correct geometry for mechanical devices that move fluids such as boat propellers, centrifugal pump impellers and turbine blades.

Back to Workholding

EMUGE's new workholding system, EvoGrip, is specifically designed for five-axis milling. It includes nine different vises, base plates with zero position indexing, riser blocks and a large variety of vise jaws. It is all designed to allow maximum accessibility of a cutting

tool to the workpiece.

With five-axis milling it is advantageous to grip the workpiece with a small clamping surface area. If the clamping area of a workpiece has indentations that mate with protrusions on the face of the jaws that clamp the part, more workholding force can be produced



about the author

Brandt Taylor is owner of Berlin, Massachusetts-based Taylor Engineering, a machine shop and manufacturer of lathe chuck jaws. He can be reached via email at gbrandt.taylor@gmail.com.



per unit of surface area than would be possible on a workpiece with smooth surfaces. For this reason, hydraulic presses are used to indent the surface of a workpiece for gripping before the part is mounted into a vise.

EMUGE's new vises can produce enough force so that the surface of a workpiece can be indented in the vise on the milling machine. That is a bit of evolution in workholding technology. Even though the part in figure 1 sticks out of the vises a considerable distance in the Z direction, two EvoGrip vises can be used so the part can be made safely, to spec and in a good cycle time.

In next month's column I'll get into the nuts and bolts of this new modular workholding system. **CTE**

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ID TAPER

By Jeffrey Badger, Ph.D.

Dear Doc: We constantly battle taper in ID (inner-diameter) grinding, especially when the hole is deep. It's as if the wheel is just riding over the workpiece. What can we do?

The Doc replies: ID grinding suffers from a major problem: a lack of stiffness in the spindle. When the wheel is inside the workpiece, the spindle deflects. Unfortunately,

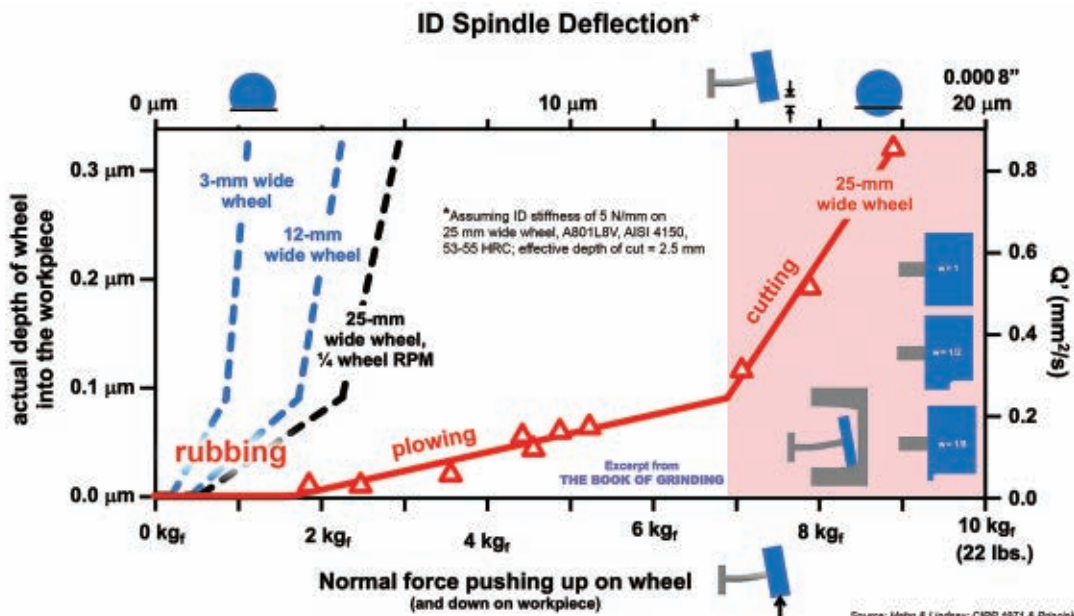
it doesn't deflect upward, it deflects at an angle. This creates taper. Some grinders call it "bell mouth."

Let's examine how to cope with that taper.

The accompanying ID Spindle Deflection chart shows work done by grinding greats Robert Hahn (1916-2021) and Richard Lindsay (1934-2018). When the wheel first contacts the workpiece, it doesn't grind. It just rubs. Material isn't removed. Then, when the force gets

to about 2 kg (4.4 lbs.), the wheel starts to plow the workpiece. Material is removed, but slowly, with a lot of rubbing and heat generation. Then, when the normal force gets to around 7 kg (15.4 lbs.), we finally start removing material.

Look at the spindle deflection at 7 kg of force. It's 14 μm (0.0006"). That's not insignificant; it's causing taper. And we have to plunge even deeper (with a bigger normal force) to start to get significant material removal.



about the author

Jeffrey Badger, Ph.D., is an independent grinding consultant. He'll be giving his popular High-Intensity Grinding Course in Columbia, South Carolina, from Nov. 18-20, 2025, and in Zurich, Switzerland, from Feb. 3-5, 2026. Visit www.TheGrindingDoc.com. England. For more information, visit www.TheGrindingDoc.com.



During sparkout, we're not plunging deeper. In fact, we're not plunging at all. So, the wheel just rides over the workpiece not removing much material. Or perhaps none. To complicate matters, we have coolant hydroplaning. This can create even more deflection than the grinding.

What can you do? Here are a few options to use during finish-grinding and sparkout:

Decrease your wheel speed — drastically. Perhaps to one-quarter of standard speed or even less. (Yes, this does violate the Grinder's Rule of "dress & grind at the same RPM." But we'll live with that.)

Reduce your wheel width. An easy way to do this is to dress off a bit of your wheel width. It doesn't need to be a lot, maybe 0.002" to 0.003" (50 to 75 μ m). This is enough to prevent contact. These first two steps will push the characteristic curve to the left, meaning we can move from rubbing to cutting without needing a huge normal force (and huge spindle deflection). Plus, decreasing your wheel speed and reducing your wheel width increases the Grit Penetration Depth, so the grits are taking a bite out of the workpiece — not just rubbing it.

Dress sharp. If you can't get the surface finish you want, use a smaller grit size. But at all costs, avoid a dull dress.

Reduce your cooling to a trickle. Yes, this reduces heat-sucking and lubrication. But we're doing sparkout. We can live with it. This will reduce or eliminate coolant hydroplaning, which is a big chunk of spindle deflection.

Finally, keep the wheel on the part. Don't exit. When you exit, the wheel contact width gets smaller and smaller, decreasing deflection to zero and creating even more taper.

Of course, the specific values for this characteristic curve change with different workpieces and different wheels. But the general trend applies to all grinding: rubbing, then plowing with low material removal, and finally cutting with significant material removal. We need cutting, and we want it at a small force.

Play around with all of these steps and see what happens. And don't be timid about it. We're doing sparkout, not rough grinding. Don't reduce things by 10%. Reduce them by 75%. Or more. We can live with a super low wheel speed. We can live with a thinner wheel. We can live with poor cooling. Our primary goal is to get that wheel to bite into the workpiece. **CTE**

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BRIDGING THE AWARENESS GAP

By Terry M. Iverson

Communities throughout the U.S. have a renewed — if not new-found — appreciation for the U.S. manufacturing industry. A year of tariff-induced uncertainty along with the painful lessons learned from supply chain disruptions caused by the Covid pandemic have triggered an epiphany — people now better understand why our country needs a stronger manufacturing sector.

To nurture this epiphany, however, we in the industry need to take action. Striking now with a focused campaign of inspiration, education and action is what is needed

in order to capitalize on this moment in history. We did this back in WWII when our country needed war supplies, but there was a shortage of labor. So the government called on women to join the workforce to help in factories supporting the war effort. Not only did the appeal work, it inspired a symbol of female empowerment known as “Rosie the Riveter” that remains a powerful icon today. Keep in mind, the government’s effort succeeded at a time when mass communication consisted mostly of radio, newspapers, posters and movie-house newsreels.

Today we have a plethora of media options at our fingertips that

make it infinitely easier to reach a wide audience with the news that U.S. manufacturing offers lucrative and rewarding career opportunities that do not require a four-year college degree. That said, the general public’s awareness of manufacturing career opportunities remains low.

I have always said that if young people do not want to go into manufacturing for a career, that’s fine. But let’s make sure they get a chance to consider a manufacturing career. That’s not likely if they’re not even aware manufacturing careers exist.

Most Americans remain unaware of manufacturing careers and the importance, relevance and opportunities that exist within our indus-

Middle school students attend a Camp CHAMP at the College of DuPage in Glen Ellyn, Illinois.



try. If we as an industry can increase that awareness among Americans, we should be able to increase the applicant pool for unfilled manufacturing jobs.

Unfortunately, the solution is not that simple. The awareness problem is not one-dimensional. The problem isn't just that manufacturing careers are no longer on the American radar; it's that parents who are aware of manufacturing careers often are holding onto antiquated ideas about what various manufacturing jobs entail.

This is not your grandfather's manufacturing industry anymore. Technology leads the way with the word "advanced" usually preceding the word manufacturing as a descriptive connotation. The dark, dingy and dead-end descriptors have been replaced with words like bright, challenging and lucrative.

Teachers and guidance counselors are still getting up to speed with regard to today's manufacturing career opportunities.

Another problem facing the industry is the idea that automation will eliminate the need for employees. So, the dead-end thinking goes, why go down a career path with no future.

We know Americans generally think automation means replacing workers. Meanwhile, those of us in-

involved in the industry understand how automation guarantees a future by improving global competitiveness. Automation also necessitates a higher level of critical thinking skills for programming, trouble-shooting, installing and monitoring machine cells with automation.

Our political leaders (on both sides of the aisle) and media often minimize the importance of manufacturing related issues. Because of a general lack of understanding, or just ignorance, these issues are viewed as not newsworthy without the flash and or shock value breaking news seems to require.

Eliminating the Awareness Gap

Manufacturers need to look in different sectors to build out the workforce. The female gender, people of color and special needs applicants need to be an area of focus. We can no longer afford to overlook any potential talent in our communities. Our owners and HR departments should experience a reboot on hiring and advocacy for their job openings.

Additionally, we as a manufacturing community need to speak of our careers and job offerings with pride. We need to actively educate our friends, family and peers as to the excitement, challenge and intrigue manufacturing careers offer. Manufacturing associations, state MEPs

and manufacturing alliances need to join together like never before.

If we all work together, we have a chance to speak with a singular, focused message about manufacturing career opportunities. With so many media options available making it possible to reach a wide audience, it's more imperative than ever for the industry to speak with a singular coherent voice. I'm not saying stand-alone efforts by various manufacturing organizations is the problem, mind you. I'm saying all those efforts become much stronger and more effective when they become part of a coordinated, consistent messaging effort.

Vision for this Column

My vision is that we should have a national view. There are so many parts of our country that are home to vital manufacturing companies, but they are invisible to the general public. People drive by our biggest and best manufacturing plants with no knowledge about what takes place inside the four walls of these facilities. By participating in Manufacturing Day events, we can invite the public inside and open up a whole new world of understanding and appreciation.

In future columns, I plan to highlight a variety of workforce development efforts that have been suc-



about the author

Terry M. Iverson is an industry veteran and the founder of CHAMPION Now!, a nonprofit organization on a mission to change the way American manufacturing is perceived in the United States. CHAMPION Now! supports the mobile Camp CHAMP educational campaign that brings hands-on machining experience to middle school students with the help of high school student mentors. Iverson is also the author of two books — "Finding America's Greatest Champion" and "Inspiring Champions in Advanced Manufacturing" — to help inform parents and students about careers in manufacturing. He can be reached via email at terry@championnow.org or by phone at 904-312-0731.



Workforce Development

cessful and may help guide your own efforts down the road. I will highlight stories and examples of either people or communities having success and swinging the pendulum in the direction of acceptance and appreciation of what has been misunderstood for far too long.

Getting in Ship Shape

Some of the key ships for our success going forward must include internships, apprenticeships and mentorships. These models are key to get back to the old school models that have been successful in the past, and can be successful again. We may have to tweak some things, but it is very possible, very doable and very necessary. Maybe internships need to precede apprenticeships. Maybe reverse mentoring needs to be a part of every mentorship model.

Public-Private Partnerships

In my second book, *Inspiring Champions in Advanced Manufacturing*, I featured two front covers. One was for parents, the other for students. I'm planning a third book that will address education and industry. This is where the disconnects lie and have existed for way too long. If we can have industry talk in the same language as educators and have educators walk in the same shoes as industry leaders, we would have much to gain.

Call to Action

Changing our culture will not be easy! Parents need to get involved in learning more about options for their children. Manufacturers need to lead the way in inspiring parents and children alike to learn about manufacturing careers. Our political leaders will need to help our educational system retool a bit to acknowledge the viable and lucrative career opportu-

nities that manufacturing offers. We can not afford to have our youth get degrees from universities that cost way too much in money and time, and don't lead to careers that have anything to do with their degrees. Our media needs to rediscover manufacturing, rather than overlooking its urgency and promise.

We need an awareness campaign. CHAMPION Now was born in 2012 to be exactly that. Support for such

ties that otherwise would not have a chance to learn about manufacturing careers. This pop-up portable camp inspires middle schoolers to pursue a technical education path. A mentorship element allows high schoolers to not only appreciate the fine art of mentorship, but gives them an opportunity to gain teaching experience while inspiring and leading students to manufacturing success and excellence.



Camp CHAMP brings hands-on machining experience to middle school students with the help of high school student mentors.

a noble effort has been missing from all parts of the community. A precious few have joined in and have been noble in their volunteered and financial contributions. We need a volume exponentially larger. Our communities all over the country are large, but our informed fraternities and sororities are very small. We need more to join the financial ledger for change to happen, for the betterment of all. Write a check, buy a Camp CHAMP, sign up to volunteer in some fashion, recruit for the organization.

Our youth are our future CHAMPIONS. Camp CHAMP is looking to inspire our future manufacturers, leaders and CTE teachers. We need to get the word out in the communi-

Passing the Torch

I am a Baby Boomer. As such, I am painfully aware that we are leaving the work force in droves. We are old, and we have done our time. But we are more than willing to pass the torch and, in the process, pass on our tribal knowledge. However, that torch might have to be re-ignited with a multicolored digital flame and a 3D-printed base with a humanoid robot carrying it. Who knows what future machining processes will look like, what they will cost and how they will be perceived. AI has not yet defined its place in manufacturing, but rest assured it will — and soon! Together we can pass the torch, but everyone has to play their part! **CTE**



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PROTECTING CASH FLOW

By Tom Stamborski

Precision manufacturing companies operate in a capital-intensive environment where long payment cycles, material volatility and rising labor and equipment costs can put continuous strain on liquidity. While operational efficiency and quality improvement receive significant attention, one factor ultimately determines a company's ability to grow, invest and withstand volatility: a stable, well-structured approach to financing.

Cash flow interruptions — whether caused by extended customer terms, project delays or uneven order patterns — can ripple through the business quickly. Maintaining reliable access to working capital is essential for protecting production schedules, supporting vendors, securing materials and keeping the organization financially resilient.

The Cash Flow Challenge

Precision manufacturing companies often work with OEMs and industrial customers that operate on 45-, 60- or 90-day terms. During that waiting period, manufacturers must still fund material purchases, tooling, coatings, labor, transportation and equipment maintenance.

Traditional credit from banks can help, but that doesn't always scale with the pace of production or the timing of customer payment cycles. Companies with concentrated customer bases, rapid growth or project-driven revenue often find their borrowing availability fluctuates exactly when stability is most needed.

For these manufacturers, a financing strategy built on flexibility — rather than rigid traditional lending limits — provides a significant operational advantage.

Factoring: Immediate Liquidity Based on Completed Work

Factoring has become an increasingly practical cash-flow tool for precision manufacturers with strong B2B

- automatically as sales increase, no requirement for additional hard collateral beyond invoiced A/R,
- predictable funding even when customer terms extend or project timing shifts, and
- support for vendor payments, payroll and material purchasing without disruption.

For companies operating on thin



receivables. By advancing funds on open invoices, factoring eliminates the lag between shipment and payment, converting receivables into same-day working capital.

Key advantages of factoring:

- immediate access to cash tied directly to production output,
- financing that scales auto-

margins or managing multiple jobs simultaneously, factoring acts as a stabilizer, ensuring essential expenses are covered regardless of how long customers take to pay.

Beyond providing liquidity, factoring also creates operational clarity. Manufacturers gain more predictable cash-flow timing, which simplifies planning for material purchases, subcontracting and machine utilization. It also reduces the financial strain created by large, long-running projects where costs accumulate for weeks or months before invoices are eligible for payment. Factoring helps convert complex production schedules into a consistent financial rhythm, allowing companies to manage growth without tying up cash in outstanding receivables. In many



about the author

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cases, it becomes the foundation that supports reliable production flow during both peak demand and seasonal slowdowns.

Strengthening Cash Flow with Layered Financing Tools

While factoring is a strong foundation, precision manufacturers often benefit from blending multiple financing methods to create a more resilient working-capital structure.

Equipment Financing — CNC machines, grinders, automation tools, inspection systems and robotics represent significant capital investments. Financing equipment purchases — rather than paying cash — keeps liquidity available for day-to-day operations. Longer amortization schedules also align payments with

the useful life of the asset.

Purchase Order Financing — For large or material-intensive jobs, purchase order (PO) financing covers upfront raw-material costs before production begins. This is especially valuable when customers require extended terms or when suppliers demand deposits.

Inventory Financing — Manufacturers carrying high-value alloys, specialty materials or pre-machined blanks can convert that inventory into a borrowing base. This unlocks capital tied up in stock without sacrificing production readiness.

A More Stable, Predictable Financial Foundation

Precision manufacturing companies that adopt a strategic, multi-lay-

ered financing approach reduce their dependence on customer payment timing and smooth out the natural volatility of project-driven work. By strengthening liquidity, companies protect production capacity, avoid unnecessary borrowing stress and maintain the flexibility to invest in equipment, people and technology when opportunities arise.

In an industry where financial stability is just as important as machining accuracy, protecting cash flow is not simply an accounting concern, it is a competitive advantage. The companies best positioned for long-term success will be those that build a financing strategy capable of supporting both today's production demands and tomorrow's growth. **CTE**

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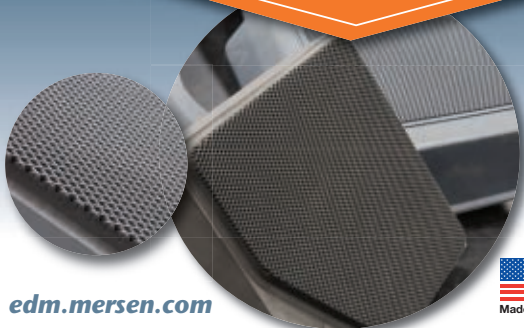
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HIGH-FLYING GRADES

Machining aerospace-grade aluminum alloys is manageable when using the proper tools and techniques.

By Alan Richter

All aluminum alloys are not created equal. One of the most commonly machined aluminum alloys is 6061 because it is cost-effective and has the physical properties required for many applications.

"It's really a baseline, go-to aluminum alloy," said Troy Marusich, R&D engineer for Maple Plain, Minnesota-headquartered Protolabs Inc.

However, when a lightweight metal is needed to provide a higher level of tensile strength while offering outstanding fatigue resistance and enhanced corrosion resistance, such as for aerospace components, part manufacturers frequently turn to 2000 and 7000 series aluminum, such as 2024 and 7075. "They were designed for that," Marusich said. "You will see those in a lot of airframe applications — so components that need to be lightweight and high strength. It could be drones or anything that leaves the ground."

In addition to providing CNC machining services for a variety of industries using a host of workpiece



Protolabs worked with the National Aeronautics and Space Administration Goddard Space Flight Center, where NASA generatively designed a hypothetical collection apparatus for the Artemis space mission. Protolabs machined and delivered the 6061 aluminum part in 36 hours.



Protolabs

Protolabs' CNC machining facility in Brooklyn Park, Minnesota.

materials, Protolabs provides injection molding, 3D printing and sheet metal fabrication services. "Today, we're about \$500 million in revenue," he noted. "In a year, we might see 50,000 unique customers that have ordered parts from us."

In addition, the manufacturer developed Protolabs Network, with offices in Chicago and Amsterdam. The network of independent manufacturing partners is hand-picked by Protolabs, Marusich said, to outsource work that Protolabs does not have the capabilities to perform at its facility. "We work very closely with them on making certain that they are high quality, and they are able to deliver on time. It's all available on an e-commerce platform, so our customers come in and it's fairly transparent to them."

The aerospace alloys, which are also used in other industries, are stronger while consuming more power to machine them than other aluminum alloys, but the objective is still to remove material quickly while imparting a fine surface finish, Marusich explained.

"A poor surface finish can lead to degradation in strength and toughness," he said. "We're avoiding chatter and vibration in our systems, and because

we're doing high-speed machining on these, we want to go in and dynamically tune the processes to avoid these chatter regimens."

Depending on the application, Protolabs also offers:

- post-processing options for machined metal parts, such as anodizing to improve part durability and add color,
- bead blasting to provide a uniform finish and light texture, and
- electroless nickel plating to deliver a wear-, abrasion- and corrosion-resistant finish.

When machining aerospace aluminum, Marusich said the manufacturer removes both material (internal bulk) stress that can cause part distortion and induced stress from the machining process. Part bending is usually driven by internal bulk stress, and part twisting is typically driven by machining stress.

Aerospace aluminum is used to produce a large array of components, but the high-performance parts often have long, slender features, deep pockets and/or thin walls, he noted. Producing those features can require a high buy-to-fly ratio — the weight of the initial workpiece material compared

High-Flying Grades

to the weight of the final product. The ratio might be 10-1 or even 20-1. "That would be about 95% of the parent material that you're removing to get that final part."

Tools of the Trade

With a high buy-to-fly ratio and high-velocity machining at spindle speeds up to 30,000 rpm or more for aluminum aerospace parts, a large quantity of chips is created quickly that must be controlled and managed at that rate, said Steve Oszust, product development manager/lead tool design engineer for Fullerton Tool Co. Inc. in Saginaw, Michigan. "You start with a 1,200- or 1,800-lb. billet, and you finish with a 70- or 100-lb. part. There's a ton of swarf that has to come out."

To create those chips, the tool-maker produces a variety of cutting tools, with the 3833 AlumaMill G3 being the lead tool in its repertoire, Oszust said. The three-flute endmill is highly polished, has a specialty helix and an engineered rake core, and is suitable for roughing, finishing, plunging and ramping. Fullerton also offers the two-flute 3825 AlumaMill and the three-flute 3835 AlumaMill with a higher rake angle. "The G3, for the most part, is going to be our workhorse unless you're looking at big structural components. Then it's the 3802/3803 AlumaMillHV series."

For ferrous applications, the rake angle is from 6° to 10°, whereas the rake angle for nonferrous applica-

tions starts at 10° or 12°, excluding high-silicon aluminum, and goes to 20°, he explained.

To drill aerospace aluminum, Oszust said Fullerton makes the 1565 AlumaDrill, which is also suitable for drilling titanium, composites, graphite, plastics, brass and copper. The three-flute "go-to" drill for nonferrous applications has a hybrid spur point where the tool's center comes to a 90° point and backs off to about 130° to enhance penetration. "It's easily self-centering in round or unparallel surfaces, so it's very forgiving. Feed rates on

it are very fast. It pulls chips that look like tin foil."

What distinguishes aerospace aluminum, such as 2024 and 7075, from other aluminum alloys and can make them more challenging to machine is their percentages of alloying elements. Alloying elements such as copper, magnesium and zinc are relatively gummy, or sticky, Oszust explained, and can cause workpiece smearing. "If you don't have a good, polished edge, you can definitely impart some of the parent materials, or alloying elements, into the cutting edge and



Fullerton Tool

The 3833 AlumaMill G3 is a high-performance endmill with three flutes for roughing, finishing, plunging and ramping aluminum and other nonferrous metals.



Fullerton Tool

Fullerton Tool's 3802/3803 AlumaMillHV series is for machining large structural nonferrous components.



about the author

Alan Richter, a 40-year veteran journalist, has spent the last 25 years covering the metalworking industry for Cutting Tool Engineering and currently serves as its editor-at-large. Contact him at alanr@ctemedia.com.



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For more information from Fullerton Tool about its AlumaMill G3 cutting tool, view a video presentation at www.ctemag.com by scanning the QR code with your smartphone or entering this URL on your web browser: <https://qr.ctemag.com/25xzi>.



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that just leads to all kinds of issues when it comes to removing the material."

According to technical data sheets from Kaiser Aluminum, 2024 has 3.8% to 4.9% copper, 1.2% to 1.8% magnesium and 0.25% zinc,

while 7075 has from 1.2% to 2.0% copper, 2.1% to 2.9% magnesium and 5.1% to 6.1% zinc.

"Sometimes that magnesium or zinc can make them even stickier," Oszust said. Because 7075 has a higher percentage of those elements, he recommends slightly reduced cutting speeds and feeds at a higher torque when machining

7075 compared to 2024. The flipside is that cutting 7075 consumes more power. "If you're not right on top of your game with 7075, maintaining sharp tools and a proper feed rate, you can workharden it during the cut. Once you start doing that, it's just a downward spiral from there."

To help overcome a problem with gumminess, Fullerton makes its tools for machining aluminum using lower cobalt carbide. The material, however, is quite brittle when the cobalt content is below 5%, Oszust added. "Our feeling is that aluminum and its alloys essentially love the cobalt. Your standard 10% grade is just not where you want to be in terms of longevity."

In addition, Oszust said the tool-maker uses nanosized-grain carbide to help with edge retention.

Many end users apply highly polished uncoated cutters when machining aerospace aluminums, he continued, with ZrN and TiCN being two effective coating options. ZrN is a bit porous and requires post-polishing to smoothen

A selection of aluminum parts with various surface finishes.



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'A poor surface finish can lead to degradation in strength and toughness.'

it out, and Fullerton deposits TiCN as a monolayer coating. "TiCN maintains a very good edge structure and sharpness because its monolayer is super predictable."

He added that chip formation is more predictable when cutting 2024 than 7075 because 2024 chips tend to be uniform in size and shape while 7075 chips tend to have non-standard shapes and stick together. Also, tools experience more wear when machining 7075 than 2024, which is more forgiving.

A Balanced Approach

Regardless of the tool and what's holding it in the spindle, a balanced tooling assembly with minimal runout is critical to effectively machining aerospace aluminum. Oszust said Fullerton offers tools that are designed and built to be completely balanced. "We send the tool to the end user, and they put it in their already balanced holder, very little adjustment — if any — is needed to maintain that. We've actually gotten a lot of attention in the aero-

space world because you send your tool balanced and the setup guy just doesn't believe that that can be done. Software allows us to do that."

Marusich of Protolabs concurred. Because aerospace aluminum al-

loys are often cut at a high rpm, he said that it's important to minimize runout by having a balanced tooling assembly and spindle system, which Protolabs ensures. In addition, an end user should make

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High-Altitude Platforms:

The Stratospheric Advantage Between Drones and Satellites

By Hamed Khalkhali

There's a new story unfolding in the sky. High-altitude platforms (HAPS) are emerging in the thin air between drones and satellites, creating a new class of aircraft that's gaining attention for its cost, reach and persistence – meaning its ability to stay on-station and maintain continuous coverage.

High in the stratosphere, beyond commercial airspace but below orbit, these aircraft can stay aloft for weeks or even months. Their endurance enables missions that previously depended on satellites or numerous shorter-range drones.

By combining the persistence of satellites with the flexibility of unmanned aircraft, HAPS are opening a new layer of aerospace utility. For defense and commercial operators, the question is no longer whether they'll reshape surveillance, communications and research, but how soon?

Satellites have long been the go-to for global connectivity and Earth observation, but they come with steep costs and slow deployment cycles. A single communications satellite can cost hundreds of millions of dollars to design, launch and maintain. In contrast, a high-altitude platform can be deployed at a fraction of that cost and serviced without leaving the atmosphere.

Once airborne, HAPS can loiter over a specific region, continuously monitoring or providing communications coverage without the latency or handoff challenges associated with orbiting constellations. For industries that rely on precision, such as defense intelligence, agriculture or infrastructure monitoring, the long endurance time translates to lower costs and higher reliability.

In short, where satellites are expensive to replace and drones are limited by endurance, HAPS offer an economical middle ground that scales with mission needs.

Historically, high-altitude systems were viewed through a military lens, focused primarily on intelligence, surveillance

and reconnaissance. While that remains a core capability, advancements in payload modularity are rapidly expanding their utility.

A single airframe can be equipped with sensors for environmental data collection one week and a telecommunications relay the next. Payload swaps can occur in hours rather than months, creating a platform that shifts between defense, scientific and commercial missions with minimal downtime.

For example, telecom providers are exploring HAPS as a cost-effective way to extend broadband coverage to remote areas without the infrastructure investment of ground towers or satellite networks. In addition, disaster response agencies see value in platforms that can be deployed quickly after hurricanes or wildfires, restoring emergency communications when ground systems are down, while climate and atmospheric researchers are turning to HAPS for persistent, high-resolution monitoring of weather patterns, greenhouse gas concentrations and storm formation.

This adaptability gives operators across sectors the ability to collect, transmit and act on real-time data. This is a capability that will only grow as onboard power, payload weight and endurance continue to improve.

Unlike satellites, HAPS can be assembled, launched and operational within days. This responsiveness makes them



about the author

Hamed Khalkhali, president of Swift Engineering Inc. in San Clemente, California, is an aerospace engineer with more than two decades of experience in unmanned systems, autonomy and advanced aerospace platforms. For more information, call 949-492-6608 or visit www.swiftengineering.com.



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certain that tools from a supplier conform to published specifications and maintain toolholders over their life because they get damaged during machining from normal wear and tear. "And make certain that they are free of chips. We don't want any cutting chips get-

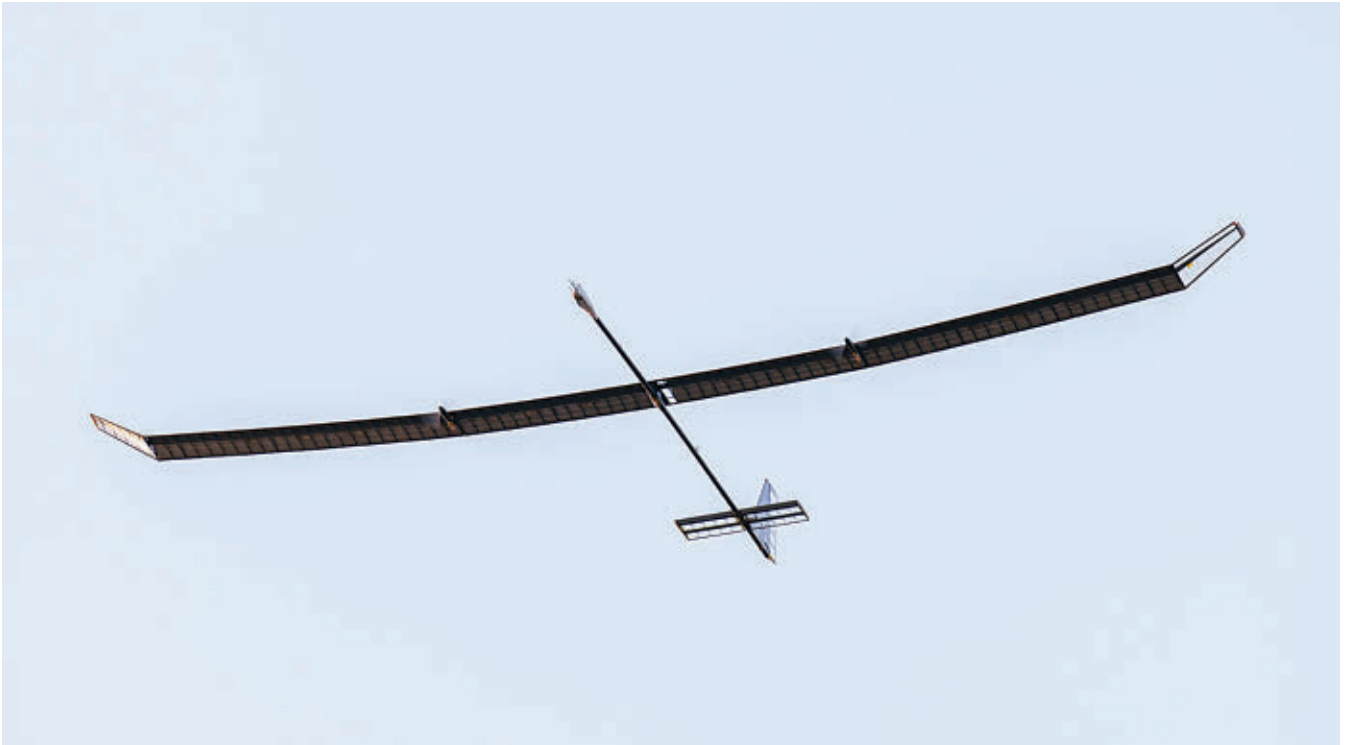
ting inside the holder and disrupting the balance of the holder."

Properly evacuating chips from the tool/workpiece interface is also beneficial to avoid recutting them and damaging the tool, Marusich added. "Once you machine a chip like that, you've strained it to a high degree. That's really a different material."

Both Protolabs and Fullerton Tool

agree that it is helpful for end users to develop solid partnerships with cutting tool manufacturers, especially beyond the OEM level.

"The learning curve has to be really short," Fullerton Tool's Oszust said. "That's why having the relationship with a quality tooling supplier, no matter who it is, is imperative to the success of these smaller Tier 2 and Tier 3 shops."



Swift Engineering

High in the stratosphere, beyond commercial airspace but below orbit, high-altitude platforms can stay aloft for weeks or even months.

uniquely suited for time-sensitive missions, from military reconnaissance to humanitarian operations.

Equally important is geographic agility. HAPS can reposition as missions evolve, offering regional persistent coverage without being locked into an orbital path. In practice, that means a single system could cover multiple operations within a single deployment window – a level of versatility unmatched by other aerospace assets.

At Swift Engineering, we see high-altitude platforms as the missing link between Earth and orbit: the connective layer

tying together drones, satellites and everything in between. Operating in the stratosphere, HAPS offer a new level of persistence and adaptability that traditional systems can't match.

This is the dawn of a new operational domain. As governments, researchers and private industries seek faster, cleaner and more resilient ways to move data and insight across the planet, HAPS are poised to become an essential part of that network and a stratospheric backbone for the next generation of aerospace utility.

Marusich emphasized the importance of having Protolabs' manufacturing engineers work with cutting tool manufacturers' engineering teams to be able to set up machining processes, tune them and receive ongoing feedback.

Whether an aerospace-grade aluminum alloy is machined to produce a meter shaft, gear, frame, fitting, shaft key, drone component



contributors

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Protolabs Inc.
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or whatever, Marusich said more objects are in flight than ever be-

fore, and high-performance alloys are needed to achieve high-performance part designs. And these designs are more generative than in the past, with more organic shapes that are a departure from traditional ones.

"The aluminum alloys are good candidates to achieve that," he concluded, "because it's a lightweight, strong material." **CTE**

DON'T LET MILLING MAKE

An in-depth look into some slots and pockets.

By Robert Layng

Deep milling, whether it is in pockets or slots, can be a task that quickly ages even some of the most skilled machinists. This is regardless of the material being cut — although the tougher the material, the sooner trouble could rear its ugly head — because deep mill work has the compounding hazards of longer

tools sticking out of the spindle, less coolant penetration, higher potential of recutting chips, increased heat, and the list goes on. These factors alone are enough to spell trouble for your tools and parts.

Recently, when finishing a set of bell cranks for a student's design project (see figure 1), we needed to sink a clearance slot for a rod end to nest inside. Not having a slitting

saw that was thick enough or of a large enough diameter to hob the slot while laying the part flat, I decided to stand the part up in tall vice jaws backed up by a couple of C-clamps (see figure 2), and use a long-reach endmill to do the job (see figure 3).

As you all know, tools sticking way out of a mill's spindle tend to make an awful racket, even when all the cutting parameters are cor-

Figure 1



Robert Layng

Figure 2



Robert Layng

YOU CRANKY

rect, at least on paper, that is. A screaming cutter is a product of large amounts of localized vibrations, which lead to chatter which feeds back into the harmonic imbalance faced by the cutting tool. If left unchecked, you end up with only a shank locked into your toolholder and the cutting end either lodged into your part or free to explore the inside of your machine at a high rate of speed. Neither of which is an acceptable result.

In the spirit of full transparency, I

share my experiences through the lens of a prototype shop that does not directly make money on the parts we machine. (Frankly, very few even leave our building, let alone campus.). So, getting parts off the machines and out the door only serves us to help in the completion of Engineering's various projects. All this to say time is not nearly as much of a factor for us as it is for shops trying to make a profit. The advice I give may or may not serve your company, yet I share it freely in

the hopes it does help you.

When we have deep milling to do, and a limited amount of endmills with which to do it, we partake in a healthy diet of Cheaties, and rough out as much as we can with either a stubbier endmill (as in the case of these bell cranks) or we drill out as much as we can (as in the case of deep slots or pockets with side walls). The caveat being that stubbier endmills and drills are, by comparison, much cheaper to replace than specialty tools like

Figure 3



Robert Layng

Figure 4



Robert Layng

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"Deep milling can age even the most skilled machinists, thanks to long tools, poor coolant penetration, recutting chips, and heat."



Don't Let Milling Make You Cranky

longer reach endmills.

In the case of these parts, we needed a 0.501"/0.502" wide slot at 2.250" deep across the top of the part. This would allow the crank to crush down onto the rod end when the cross bolt was tightened (see figure 4).

The way we were able to complete this part was by taking an endmill with a cutting length half that of the finish depth. We hogged out as much as we could with the full reach of that cutter, leaving about 0.0625" per side for the finishing cutter to clean up. We then switched to the long reach endmill and ran that cutter along both sides of the desired slot, leaving about 0.010" per side until we reached finish depth. We then ran the cutter along both walls at finish width. Thankfully no chatter and no screaming cutter, just a nice finish and a completed slot in two parts.

I hope these tips and tricks help you stave off any crankiness when milling.

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Be sure to catch me live on CTE's newest podcast, "The Daily Grind™," where we talk about machining topics just like this — and

so much more — with a new topic each week. The show is live on Mondays at 8 a.m. Eastern time,

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about the author

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DAYS OF MILLING PAST

Commodity machine tools not up to the market's need for process capability.

By Christopher Tate

It is interesting to see how the machine tool market has evolved in the last few decades. When I started buying CNC mills in the mid 1990s there were more builders in the market and the price disparity between commodity machines and high-end machines was much smaller. There were more mid-range machines available that offered a good balance of price, performance and tech features.

Small shops were being forced to adopt CNC milling to remain competitive. Adopting CNC milling technology allowed small shops to automate the milling process in the same way and for the same reasons that large manufacturers had adopted it. Not surprisingly, many small shops gravitated toward the commodity milling machines because they provided an economical way to automate their machining and stay competitive.

At that time the goal was to have a machine that could perform repetitive motions, create multiple pieces of geometry in one hold and allow the skilled machinist to monitor and adjust rather than turn handles. Commodity machines provided the vehicles for this transformation.

A new day

The landscape is different today. In the past, I was a proponent of small shops purchasing commodity machines, and I even wrote articles discussing how a small shop could be efficient with them. Unfortunately, it is difficult to see how most small shops can continue to be successful with commodity mills.

Process capability, or more accurately, the need for process capability

is going to drive shops to move away from commodity machines.

Six sigma is the name given to the science and mathematics of process capability that everyone has heard about. While the tools can be complex, the goal is simple: Create machining processes that are accurate, precise and reliable so that the finished product is made to the desired specifications with as little intervention as possible.

Small shops were never under the same pressures that necessitated process capability for large manufacturers and, therefore, it was of little concern. Again, things are different today. While small shops will not need to employ the complex statistical tools associated with six sigma, they will need to adopt the concepts to be successful in the future.

Those entering the workforce today rely unconditionally on digital technology, in every part of life. Although it seems there is a robust DIY community out there, few DIYers are familiar with the tactile nature of making things. Skilled machinists in the past were accustomed to the feel of a machine's handles, and relied on their senses to understand what was happening with their machines and cutting

tools. Digital technology is quickly eliminating the tactile experience from machining so younger machinists are not as adept at interpreting machine performance by sight, sound and smell.

Sight, sound and feel

In the past, when a new machining process was introduced, it was expected that the machinist and engineers would fine-tune it by speeding it up, slowing it down or changing to a different tool. Newer machinists may not have the opportunity to learn by sight, sound and feel like their predecessors, so machining centers and machining processes must be more stable and accurate out-of-the-box.

Not only are younger machinists going to enter the workforce with a different set of experiences, there will be fewer of them. More and more, the expectation will be that one person monitors multiple machines. Their responsibilities will shift from piloting the process with constant inputs to monitoring machines and process conditions. Measuring parts, changing tools, loading stock and making setups on multiple machines is quickly becoming the standard for machinists. Machining centers must be capable of producing parts to the specifications repeatedly without intervention to maintain profitable productivity levels.

Go to any trade show these days and you will see a plethora of automation like robots, gantry loaders and bar loaders. Machine tool builders have recognized that shops of all sizes are turning to automation to resolve labor issues. Automation is costly, and the only way to get an acceptable return on the investment is to have it work



about the author

Christopher Tate is the owner of Tate Engineering in Natchez, Mississippi. Tate, who holds a master's degree in industrial technology from Mississippi State University, has 32 years of experience in the metalworking industry. Contact him at chris23tate@gmail.com.



flawlessly. To do this, the machine tools must be highly repeatable. If machinists are required to continually interact with the machining processes, then the true value of automation will not be realized. Accurate and repeatable machines are a necessary foundation for successful automation projects.

Machine tool market

So how does the need for process capability impact the machine tool market? Commodity machines are not able to perform at the same level as the “high-end” machines.

First, the commodity machining centers are constructed differently. Manufacturers utilize lower cost construction techniques like fabricated steel weldments. While these techniques deliver good serviceable machine tools, the machines are less stable than those constructed using more traditional methods like casting.

Commodity machines typically rely on lower cost linear and roller guideway systems. Though some of these are made with roller type guideways, when combined with less robust construction methods the resulting machining center becomes more susceptible to the various forces acting on it, making machining processes less stable.

The more robust and advanced machines also come with features like thermal compensation, which measures the position of critical components that change when the machine heats up and cools down. As the machine moves from thermal forces the control compensates for the movement and works to eliminate the need for tool and work offset adjustments — all of which makes the machining processes more stable.

Changes in the workforce will continue to drive shops toward automation. Shops are expecting their machinists to manage multiple machining processes. Newer machinists and programmers are children of

the digital age and expect little deviation between a simulated process and an actual process. For these reasons machining centers must be extremely stable and accurate.

What to expect

It is becoming increasingly difficult for shops to make money with commodity machines. In the future,

small shops are going to move away from commodity machining centers in the same way we moved away from manual machines just a few decades ago. Shops will be driven to purchase machining centers that provide the necessary build quality and features that allow the creation of stable machining processes to address the changing workforce. **CTE**



The advertisement for Star Cutter Company features a large, detailed image of a grinding wheel on the right side. The background shows various industrial grinding machines in a factory setting. The Star Cutter logo, which includes a stylized 'S' and the text 'Since 1927 Star STAR CUTTER COMPANY', is positioned in the top left corner. A red banner across the middle contains the text 'GRINDING SYSTEMS ACROSS PRECISION APPLICATIONS.' Below this, a list of machine types is provided with checkmarks. At the bottom, a paragraph describes the company's grinding technologies portfolio, and a tagline is followed by the website address. A 'MADE IN USA' seal is located in the bottom right corner.

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REAMING BASICS

Achieving Precision Holes in Machining Operations

By Erez Speiser

Rreaming is a sizing and finishing operation performed on a pre-existing hole using a rotating cutting tool called a reamer that is fed into the hole to slightly enlarge and improve its geometric accuracy and surface finish. The goal is to produce holes with extreme precision in size, roundness, straightness and surface finish.

Unlike drilling, which creates the initial hole, reaming removes only a small amount of material (typically 2-5% of the hole diameter) to bring the hole to exact specifications. This process is essential when applications demand tight tolerances, such as dowel pin holes, bearing seats or precision shaft fittings.

The 3 Main Hole Making Operations

Three primary methods for creating precision holes in machining: drilling, boring and reaming. Each serves a distinct purpose in the hole-making process.

Drilling creates the initial hole by removing material with a rotating drill bit. It's the fastest method but produces relatively rough surfaces with limited accuracy. Drills typically have two or three cutting edges and are designed for material removal rather than precision sizing. However, modern carbide drills produce decent quality holes, which are good enough in most cases. When a hole demands higher quality, boring and reaming come into play.

Boring uses single-point cutters to enlarge existing holes and improve geometric accuracy. This method offers superior control over hole geometry and can correct lo-

cation errors from previous operations. Boring excels when position accuracy is critical. Boring tools can also be adjusted; thus a single tool can serve a wide range of diameters.

Reaming provides the highest precision for hole diameter, roundness and surface finish by removing minimal material from a drilled hole. However, reamers follow the existing hole path and cannot fix positional errors. They will "copy the mistake" if the pre-drilled hole is misaligned.

not correct location errors.

Basic Reamer Structure and Cutting Action

Understanding how a reamer cuts is fundamental to using it effectively. Unlike endmills that cut with multiple edges along their length, reamers primarily rely on small chamfers at the tool's tip to perform cutting. These chamfered cutting edges do all the work.

The face of a reamer cannot cut, and the outer edges (flutes) are not cutting either. Their critical

Process	Diameter Tolerance	Roundness	SSurface Finish (Ra)
Drilling	±0.002–0.004"	0.0012–0.003"	125–250 µin
Boring	±0.0002–0.0008"	0.00008–0.0004"	30–60 µin
Reaming	±0.00008–0.0004"	0.00004–0.0002"	15–30 µin

Drilling is primarily a hole-making operation, not a sizing operation. Boring offers the best control over geometry and true position, with the ability to correct location errors. Reaming delivers the tightest size and surface finish but can-

task is to guide the tool through the hole, using the already reamed section as a drill bushing to aid alignment. As the reamer advances, the chamfered edges remove material while the body follows the path established by the previously cut portion.

This design makes the pre-drilled hole critical. Since reamers follow the existing hole, starting with a quality drill and proper hole size is essential. The 3% rule of thumb recommends leaving 2-5% diameter stock allowance after drilling for the reamer to remove. Too much allowance overworks the cutting chamfers, degrading surface finish. Too little causes the tool to rub instead of cutting cleanly, generating heat and accelerating wear.

Types of Reamers and Their Applications

Reamers fall into two main categories: hand reamers and chucking reamers.



about the author

Erez Speiser is the founder and developer of the Machining Doctor website, which reflects his 30 years of experience serving in management, engineering, production and marketing roles within the machining industry. Combining his extensive knowledge of the industry and web development skills, Erez founded the Machining Doctor website, a platform where he shares a wealth of expertise and insights to industry professionals. Contact Erez on LinkedIn.



Hand reamers are designed to be held by hand or with a wrench. They feature extended cutting edges along their flutes and often have a square interface on the shank end. These tools are suitable for fabrication work, but will chatter and fail if used in CNC machines.

Chucking reamers are designed to be held precisely in machine tool chucks and fed axially into the workpiece. This article focuses on chucking reamers.

Main Chucking Reamer Types

- **Straight-flute** reamers are the most common type. They are typically made from carbide and work on both blind and through holes. This is the first choice for most applications.
- **Spiral-fluted reamers** spread the load around the entire hole diameter, making them a better choice for interrupted cuts. For example, a bore intersected by side bores.
 - **Left-hand spiral reamers** (still right-hand cutting) force chips forward, making them suitable only for through holes.
 - **Right-hand spiral reamers** pull chips out, working better for blind holes.
- **Carbide-tipped or high-speed steel reamers** offer cost advantages for larger diameter holes where solid carbide becomes expensive.

Best Practices for Reaming Operations

Cutting fluids are essential. They lubricate cutting edges, cool the tool and workpiece, flush away chips, prevent built-up edge, and reduce friction and wear. Use flood coolant when possible, applying from both sides for through holes. For blind holes, oil-based fluids work best because they remain in the hole better.

Secure workpiece clamping

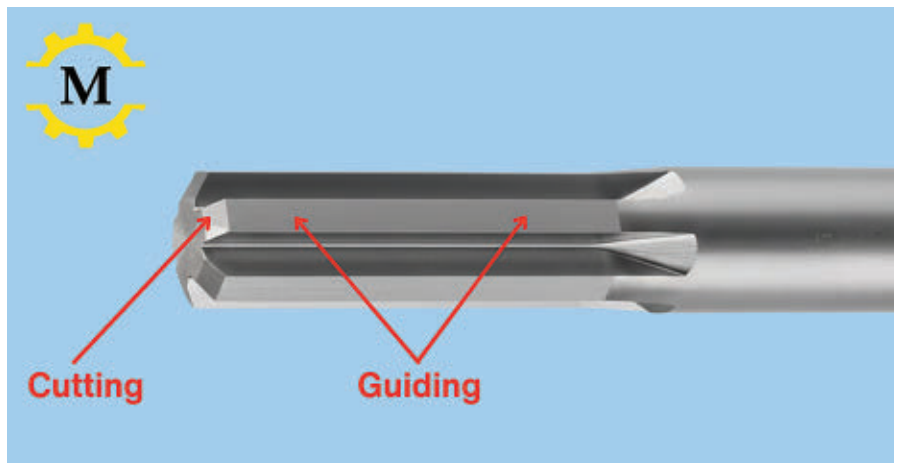
prevents problems. Even minor looseness causes chatter, poor finish or an inaccurate hole size.

Spindle speeds and feed rates require balance. Slower speeds between 100–500 rpm work best for most reaming, depending on material and hole size. This prevents chatter while allowing effective cutting. Feed rates should match spindle speeds based on material hardness, typically ranging from 0.002–0.012 ipr. Harder materials require slower, more controlled feeds.

- Never run a reamer backwards. Always maintain a clockwise rotation with an M3 command.
- Check reamer runout with an indicator or tool presetter. Runout causes oversized holes and poor finishes. The reamer must be held precisely centered in the chuck.

Summary

Reaming transforms pre-drilled



Machining Doctor

The cutting and guiding elements of a reamer.

Apply smooth, continuous pressure. Excessive pressure breaks the reamer or causes chatter; insufficient pressure leads to poor cutting.

Clear chips periodically in deep holes. Back the tool out regularly to clear chips and apply fresh cutting fluid. Allowing chips to pack into flutes increases friction and can cause tool breakage, especially with straight flutes.

CNC Programming Tips

- For optimal results, use a G85 canned cycle that feeds in and feeds out. This produces better surface finishes. While a G81 cycle (feed in, rapid out) saves cycle time, it often leaves marks inside holes, which compromises surface finish.

holes into precision features with tight tolerances and superior surface finishes. The key to success lies in understanding that reamers work differently from drills. They follow existing holes and remove minimal material through small chamfered cutting edges.

Start with a quality drill and leave 2-5% stock allowance. Use proper cutting fluids, secure clamping, and appropriate speeds and feeds. Choose straight-flute carbide reamers for general work, and spiral-flute designs for interrupted cuts or specific chip evacuation needs.

When applications demand holes with tolerances down to ± 0.0002 " and surface finishes of 15–30 μ in, reaming is the go-to solution. It's an indispensable process that takes hole quality well beyond what drilling alone can achieve. **CTE**

LIVING LARGE

A run-of-the-mill toolholder won't cut it when aggressively machining with a large diameter tool.

By Alan Richter

Aggressively machining a part with a large diameter cutting tool requires a toolholder that's up to the task of handling the high metal removal rates as well as the elevated side loads and engagement. One option is the powRgrip (PG) 48 press-fit toolholder from Rego-Fix Tool Corp. in Whitestown, Indiana, which is for cutters up to 40 mm (1.57"), the toolmaker reports.

Achieving that capability did not happen overnight, said Rego-Fix Senior Engineering Manager David McHenry, who also manages the company's Center for Machining Excellence. The company started with two smaller sizes when it launched PG about two decades ago and later added PG 32 for tools up to 25.4 mm (1"). "But there was that segment that wanted to hold inch and a quarter and inch and a half tooling for large castings, large aerospace, large defense type of projects."

The limiting factor in quickly offering PG for that segment, he explained, was the system's PGS tool setting press, or clamping machine, that capped out at 9 tons of clamping pressure. For PG 48 toolholders, he added, 15 tons of clamping pressure were required. "The development of that machine took years. It wasn't something that we could just take our existing 9-ton machine and sprinkle some water on it and balloon the size up. We literally had to do lots of reengineering, lots of testing."



ARCH Cutting Tools

An ARCH employee assembles one of the toolmaker's large diameter facemills.

McHenry added that securing a 40 mm-dia. tool requires more than 2,000 Nm (2,950 ft.-lb.) of clamping force. "That's a lot of clamping force."

The PG system handles a variety of tapers, including CAT, HSK, BT, Capto, Big-Plus, TC and ISO, and is reportedly quick and safe for assembling tooling. To operate, a cutting tool is placed in a collet, then the collet is inserted into a toolholder, and the toolholder is then placed into the machine and a button is pushed on the machine.

Assembling large toolholders was a safety concern for an aerospace manufacturer that approached Rego-Fix while it was still conducting internal research for PG 48, McHenry said, adding that tightening an external nut required considerable force. "One of their

operators had slipped during the assembly of one of the tools they were using and broke his shoulder blade because he fell backwards into a file cabinet. Having something that's manually loaded and tightened down to generate those forces is not the easiest."

The smallest tool Rego-Fix designed the PG 48 to accept is 19.05 mm (3/4") in diameter, "which is a pretty big tool to start with," McHenry said. To provide 100% pullout protection when performing heavy material removal applications, the holders incorporate cap nuts from the secuRgrip tool locking system for powRgrip.

Although the smaller PG systems provide a TIR of less than 3 μ m (0.0001"), he noted that the TIR for PG 48 is 5 μ m (0.0002"). "It's still re-

ally good for what we're doing."

Dual Contact

The specific runout limit for a large toolholder used in aggressive machining is important but is not as significant a concern as a TIR increase occurring over time, explained Alan Miller, senior manager, engineering, for BIG Daishowa-Americas in Hoffman Estates, Illinois. "If it continues to trend in the wrong direction, then something needs to be addressed. The harder you push the machine, catching these things early will save a lot more trouble down the road."

The toolmaker offers a variety of toolholders for large diameter cutters, including collet, milling and hydraulic chucks, as well as shrink-fit holders. The latter, however, is not the first choice for heavy-duty applications, Miller said, adding that a milling chuck, in general, provides

twice the gripping strength of a shrink-fit holder.

One heavy-duty milling chuck in the company's line is the Hi-Power milling chuck, which has a thick-walled body and provides stable performance and a high level of gripping force and rigidity, BIG Daishowa



The PGS tool setting press for the powRgrip 48 system requires 15 tons of clamping pressure.

reported. Narrow slits in the body make the clamping part deform properly to ensure an even, strong gripping force and stable runout.

"In that type we can hold a 2"-dia. round cutting tool shank," Miller said.

Miller added that a variant of that milling chuck is the Mega Double Power Chuck that features a smooth OD pre-balanced for high-speed operations and a rigid design for heavy cutting. The expanded contact diameter of the chuck's nut to the flange reportedly provides a level of rigidity similar to the chuck and nut being one solid piece, enabling aggressive machining without chatter.

"And then we take that chuck and make a Mega Perfect Grip version, which uses the Weldon flat to trap a cutting tool shank inside the milling chuck so it cannot rotate, and it cannot pull out," he said. "It's the



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Living Large

ease of assembly of a milling chuck will all the anti-pullout properties."

Whether it is CAT, HSK or Capto, all the company's large-diameter holders feature the Big-Plus dual-contact spindle system, Miller noted. The system enables the shank to contact the spindle taper and spindle face simultaneously, increasing tool rigidity to improve surface finishes and dimensional accuracy, extend tool life, eliminate Z-axial movement at high speed and prevent fretting corrosion caused by heavy cutting. "Big-Plus uses some elastic deformation of the spindle itself to lock that face against the face of the spindle to give the base of support all the way out to the edge of the flange rather than just at the cone."

Because heavy-duty cutting exerts a high level of stress on a machine tool, he recommends conducting more preventive maintenance checks than a machine for less-aggressive applications, including checking runout and pull stud retention force more regularly. "Make sure that everything is tip top if you are going to push the machine as hard as you can."

Miller added that U.S. part manufacturers tend to use some of the larger tools in the world. "Our aerospace industries are one of the biggest drivers of using these larger tools. We'll continue to see that demand for some time."

Complete Cutter

When it comes to large diameter tooling for heavy machining, Bloomfield Hills, Michigan-based

ARCH Cutting Tools pushes boundaries. "For large diameter facemills, our Flushing location currently manufactures up to 30" cutters," said John Carstensen, shop floor manager for the toolmaker.

"ARCH Cutting Tools in Flushing, Michigan, provides a comprehensive selection of toolholders," Carstensen noted, "including CAT 40, CAT 50, CAT 60, as well as HSK models ranging from 40A to 125A, along with collets and



BIG Daishowa—Americas

Mega Perfect Grip combines the cutting performance of a heavy-duty milling chuck with security against the pullout of a solid side lock toolholder.

shrink-fit holders. Our offering begins with BT 30 (CAT style) and extends through CAT 60."

ARCH also supplies integral shank holders, which enhance repeatability by eliminating the need to mount the cutting tool and holder together, he added. In setups using indexable inserts, this configuration lets operators rapidly index or swap inserts without removing the entire cutter. "They don't have to send the whole cutter out, recheck it, and get it reground. Many shops standardize inserts so

they can order them off the shelf."

To optimize both durability in the taper and machinability at the cutting end, the toolholders are heat treated with a proprietary process to establish hardness zones, Carstensen explained. "Our process strengthens our tools while the insert end performance withstands wear allowing precision machinability. This process also allows for our tools to endure the rigors of machining during the customers application process."

ARCH tapers are ground precisely to an AT3 tolerance, Carstensen said. "If a holder goes out of spec, our RECON360 service restores it to like-new condition, even for other brands. Simply send the part or a photo for a quick quote, and if it's reusable, we'll refurbish it. RECON360 gives you the performance of a new tool at a fraction of the cost."

Conversely, McHenry said it's not possible to refurbish Rego-Fix's powRgrip toolholders, which are produced using a special surface treatment process to provide an exceptionally long life.

"It's not something that you're going to wear out the outside of the collet or the inside of the ID in any relatively short period of time," he added. "It needs to be oiled and cleaned and put away properly so that it's not going to rust, and that's any tool. Just like any high-performance system, cleanliness is key."

Keeping Clean

Refurbishing a BIG Daishowa holder is possible, but Miller said the company does not do a lot of it. Instead, he recommends always



about the author

Alan Richter, a 40-year veteran journalist, has spent the last 25 years covering the metalworking industry for Cutting Tool Engineering and currently serves as its editor-at-large. Contact him at alanr@ctemedia.com.



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For more information from ARCH Cutting Tools, BIG Daishowa and Rego-Fix Tool about toolholders for large diameter tools, view video presentations at www.ctemag.com by scanning the QR code with your smartphone or entering this URL on your web browser: <https://qr.ctemag.com/25y9q>.



cleaning the bores and the cutters before clamping. "The one advantage we have over a lot of other milling chucks is they're sealed in both the front and the back, so there is no real maintenance involved with them. As long as you keep the bore clean and it doesn't get damaged, they'll run pretty much indefinitely."

One element of a tooling assembly that has a finite life and should be replaced regularly is the pull stud, or retention knob, he added. "Generally, we say a pull stud that's in a production environment should be changed every three years."

ARCH Cutting Tools manufactures retention knobs as part of its standard product line, each heat-treated for maximum durability. For unique machine tool requirements, ARCH also produces specialty knobs on request. As Carstensen noted, ARCH's business is dedicated to highly engineered custom

solutions, backed up by U.S. manufacturing of solid round, indexable and PCD cutting tools, within 17 U.S. locations — from more than 25,000 off-the-shelf standard tools in the "Collection" catalog, to quick turn-around custom or modified tooling.

To achieve the desired level of performance from any type of steep taper toolholder, McHenry said maintaining the proper torque on a pull stud is required. "Make sure that when it's assembled by

the toolroom, they put the pull stud on correctly, they torque it down to proper specification with some sort of locking agent like Loctite Blue and they don't deform the taper."

The proper torque value for a 40-taper holder was up to 90 ft.-lb., but times have changed, McHenry said. "Anything more than 36 ft.-lb., I'm deforming the taper."

When a large diameter cutter for aggressive machining is properly assembled into the toolholder, running it at the correct speed and feed is essential in order to avoid, for example, chatter when a tool rotates too fast and rapidly across a part, Carstensen said. Following the recommended machining parameters, however, may not do the trick. "Sometimes you have to play it by ear. Watch the cutter and watch the chips. A lot of people think everything is in a book, and it's not always that way." **CTE**

contributors

ARCH Cutting Tools

866-935-5771

www.archcuttingtools.com

BIG Daishowa—Americas

224-770-2999

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Rego-Fix Tool Corp.

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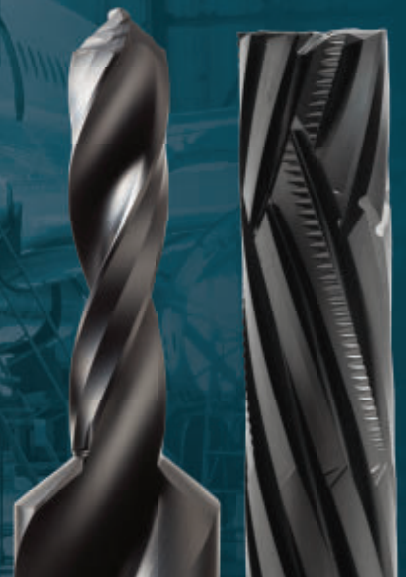
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ZERO-POINT CLAMPING SPEEDS SETUP

Sometimes the idea for a workholding solution takes some time to implement. That was the scenario at A to Z Machine Co., said Marc Manteufel, manufacturing engineer and IT manager. The 29-year-old, employee-owned CNC machine shop has 11,150 sq. m. (120,000 sq. ft.) spread over three buildings in Appleton, Wisconsin, where about 135 employees work during two shifts.

For a long-term job machining a part made from austempered ductile iron for the defense industry, the shop was using a pin-based system for clamping fixtures for about six years, Manteufel noted. With that system, a 20 mm (0.787") pin went through a receiver alignment bushing in the fixture plate into a receiver bushing in the base plate. "Then you have a thumb screw that you have to crank down."

He added that there were eight clamps, or pins, on the fixture plate, and the operators had to unclamp the pins, clean them, change the fixture plate and line up the bushing holes so they could insert the pins every cycle. Not only did each changeover consume about 10 minutes, but the process was also physically awkward. "They were reaching up and over the fixture to get at the back pins, so ergonomically it was not very pleasant for them."

Manteufel said he had known about zero-point clamping for years and decided he wanted to implement it with the fixture the company makes. He did an extensive amount of online research to learn more and then contacted a couple of distributors he has worked with who connected him to tooling representatives. After considering various systems, A to Z Machine turned to Lyndex-Nikken Inc. in Mundelein, Illinois, for a zero-point clamping system manufactured in Germany by Zero Clamp GmbH.

"The features of the product stood out from the competition," he said. "Mechanically, it seemed a lot more sound and simpler. I wanted something that I felt was going to last trouble-free."

Manteufel noted that the system from Lyndex-Nikken has a full contact collet like a drawbar on a machine tool. A low amount of air pressure pumps up an internal diaphragm and expands the die spring plates, which pulls the collet back. The collet clamps when the air pressure is removed.

"There's just a lot more contact, so there are no concentrated points for wear," he said. "Nobody else had anything like that at all."

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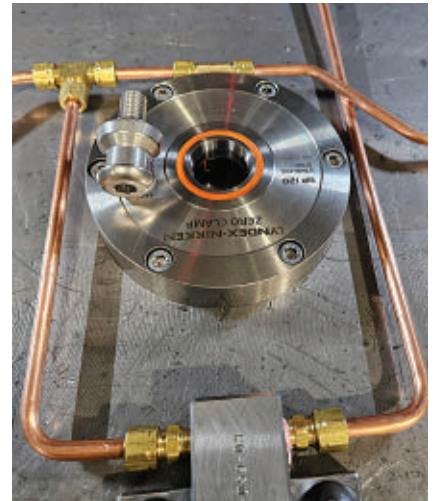
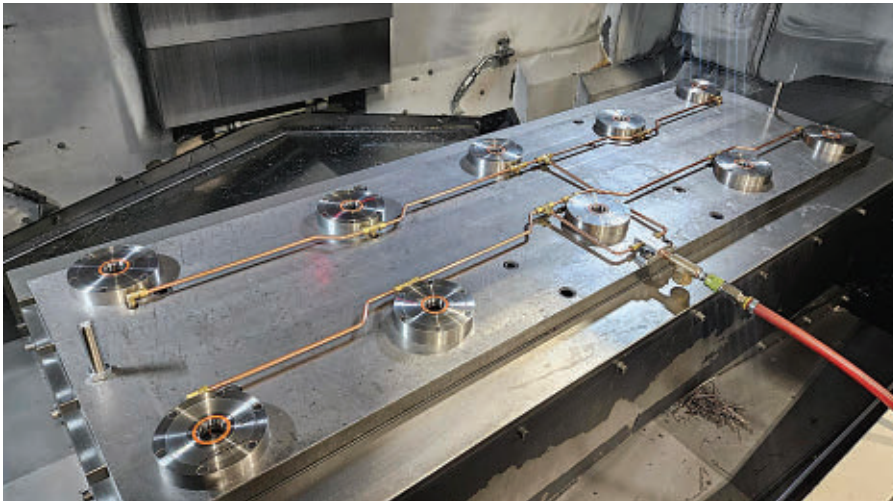
In addition, rubber seals between the clamping segments prevent dirt, coolant, moisture and other debris from entering, Manteufel added.

Because only one type of clamping stud, or retention knob, is required, the Lyndex-Nikken system beat the competition when it came to simplicity of operation, according to Manteufel. "Because their tapered ring on top that locates is able to expand slightly and then radial float ever so slightly, it takes up any difference in length measurements between the pots. You do not have different style knobs to worry about."

Another attractive difference between the Lyndex-Nikken zero-point clamping system and those from the competition was cost. "For a superior product, it was actually considerably less money than the nearest competition. I was really happy about that. Some of the competition was almost double the cost."

Prior to making the purchase, Manteufel said A to Z Machine received some zero-point clamping hardware to do bench testing and see how the system functions with the shop-produced base plate for holding the zero points and fixture plate positioned above. The shop also collaborated with counterparts from U.S. and German companies to determine if there would be any issues. "They gave me a thumbs up and said it's a good design that should work well."

The shop implemented Lyndex-Nikken zero-point clamping into a work cell with two machines, with 10 clamping pots in the 120 mm (4.72") size for each machine, he explained. The pots are plumbed into one air line. An operator opens the machine door and plugs the air line into the fixture plate to unclamp the top plate. A crane is used to lift the large top plate out and load the next plate that's ready to go using pull studs



A to Z Machine Co.

Ten 120 mm clamping pots are utilized in each of the machines in a work cell at A to Z Machine. Each pot has a clamping force from 12.5 to 60 kN (2,810 to 13,488 lbs.).

that stick out to guide the plate into the zero points. Then the operator unplugs the air line — enabling the system to clamp the part — and closes the door.

The setup for A to Z Machine's new zero-point clamping system is "foolproof," Manteufel added. "They can't run the machine unless the air line is unplugged and the operator door is closed." With the previous pin-based workholding, an operator might forget to put some pins in or not tighten them enough and a part would come loose and start rattling around.

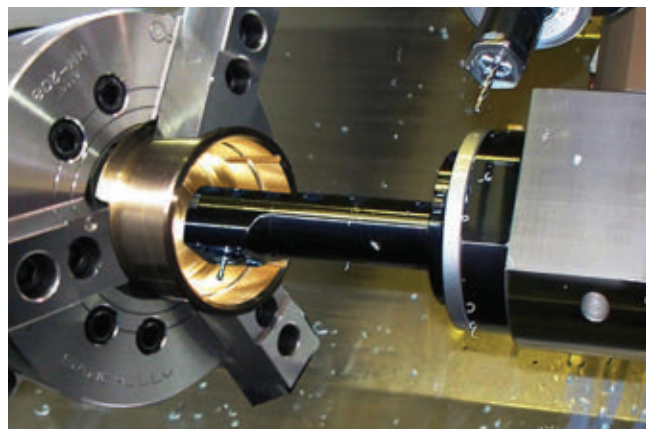
Before implementing the new clamping system, Manteufel said the setup time was 10 minutes. With the Lyndex-Nikken zero-point clamping system, the setup was reduced to three minutes. The time savings adds up when machining 140 parts a week, he noted, adding that the shop expects the project to continue for at least a decade. "That's saving us \$1,000 a week conservatively, so this ROI is going to be half a year."

The payback for operators was immediate. Manteufel said they let him know that the new process eliminated back soreness and the risk of slipping caused by reaching up and over a large part to access the back pins. "To me, the safety and ergonomics of the employees were just as important as the setup savings."

Because of the enhanced rigidity of the zero point setup, Manteufel estimates that the shop has seen a 5% increase in tool life and fewer fiascos. "We're having a fraction of the tool failures."

Although Lyndex-Nikken describes the zero-point clamping system as a predecessor to automation, Manteufel said the complexity of the cast part requires a lot of operator intervention when loading to get the part

lined up properly on the fixture. "The castings experience a whole lot of inconsistencies and warp. It takes automation out of the picture for us." **CTE**



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Precision is everything at Watchtower Firearms LLC, a Spring, Texas-based manufacturer of rifles and handguns for military, law enforcement and U.S. consumers. The reported mission of the veteran-owned company is to ship products with precise tolerances and flawless surface finishes that are ready to use out of the box. Each component undergoes machining, such as milling gun frames, polishing and hand-fitting at Watchtower's facility near Houston. Director of Operations Curtis Hearon said he closely monitors every aspect of the manufacturing process looking for improvement opportunities.

He noticed persistent problems that seemed related to the metalworking fluid in the CNC machines, problems such as less-than-optimal surface finishes on stainless steel and wrought aluminum parts. In addition, operators complained about the rancid smell of the coolant and the skin irritation it caused. Both poor finishes and odors can be symptoms of a failed coolant emulsion. When a coolant emulsion becomes unstable, the oil droplets clump together and are no longer uniformly dispersed throughout the water. The result is less effective cooling and lubrication, oil settling to the bottom of the sump or floating on the surface, and unpleasant odors.

Concerned about the impact on productivity and operator satisfaction, Hearon turned to Greg White, area sales manager at Blaser Swisslube Inc. in Goshen, New York, for a full situation analysis.

"Since no two machine shops are the same, we use a four-step process to evaluate the shop environment and application before recommend-

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The B-Cool MC 660 semi-synthetic metalworking fluid from Blaser Swisslube being used at Watchtower Firearms.

ing any metalworking fluid," White said. The analysis includes testing the local water quality, understanding the types of materials to be machined and the cutting processes, and knowing about specific equipment capabilities. At Watchtower, the CNC machines process a mix of stainless steel and military-grade 7000-series aluminum workpieces.

After the analysis, White recommended Blaser's B-Cool MC 660 based on the material mix, machining processes and the improvement goals outlined by Hearon. "B-Cool MC 660

is a semi-synthetic, water-miscible metalworking fluid that can be used for large or small series production. It performs equally well when machining steel alloys, cast iron or aluminum alloys, or a mix of those materials."

The formula is low foaming in high-pressure systems, and its effective rinsing behavior keeps workpieces and machines clean, according to Blaser. It can be mixed with all water types and does not contain critical substances such as boron, chlorine, formaldehyde or sulfur.

Watchtower, which asked two other coolant manufacturers to vie for the company's business, ultimately selected Blaser Swisslube.

"I was able to defeat one of my competitors simply because their coolant turned into slime in the sump and messed everything up," said White, noting damage to the filters and high-pressure unit. "I still have the photos on my phone."

The other competitor's representative dropped off samples at the back door with a business card and instructed Watchtower to let him know the results, White recalled.

On the other hand, White cleaned the machine to be tested with Blaser's coolant, mixed the coolant with his own mixer and made sure everything was in order. "I gained the trust and loyalty of the shop once the ma-

chinists saw I was there not only as a Blaser rep but as a trusted friend and adviser on how to use our product. They said they'll go with Blaser because this guy put on work clothes and helped clean the machine."

The transition yielded immediate improvements to the shop environment, he said. B-Cool MC 660 maintained a stable emulsion, reducing bacterial contamination risks and minimizing maintenance time. The new coolant eliminated powerful odors and proved to be gentle on the skin, improving working conditions. Plus, with no residue on the parts, cleanup is easier and part handling after machining is reduced.

In comparison, the previous coolant's emulsion degraded quickly, required frequent maintenance, in-

creased disposal and top-off costs and contributed to unplanned downtime, Watchtower reported.

The shift to B-Cool MC 660 resulted in measurable financial and operational benefits. Lower top-off rates led to a 15% improvement in tool life, delivering savings of more than \$30,000 in the first year. "It's been in their machines for a year, and they've had no issues," White said.

Due to improved bio-stability and lower consumption, coolant-related waste disposal is projected to drop by more than 50%. With less coolant clinging to the chips, the environmental impact is reduced. Cleaner chips simplify scrap metal disposal while increasing the value per pound.

"The right metalworking fluid does a lot more than you think,"

White said. "The cost is a small fraction of the total investment into any machining process. At the same time, coolant has a big effect because it touches virtually everything in the shop, from tools and machines to parts and people."

As a sales manager, he added that it's important to get potential customers to look beyond the initial price of the coolant. "If you can sell on performance, you are going to win every time."

By adopting B-Cool MC 660, Watchtower achieved a breakthrough in its manufacturing process. The switch not only improved part surface finishes and coolant stability but also enhanced operator satisfaction, reduced maintenance efforts and delivered substantial cost savings. **CTE**


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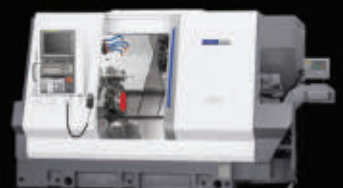
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