TAKE TWO

Today's twin-spindle machining centers deserve a second look

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3a. What is the primary end product manufactured (or service performed) at this location?
   331 ☐ Primary Metal Manufacturing
   332 ☐ Fabricated Metal Product Manufacturing
   333 ☐ Machinery Manufacturing
   334 ☐ Computer/Electronic Product Manufacturing
   335 ☐ Electrical Equip/Appliance & Component Manufacturing
   336 ☐ Transportation Equipment Manufacturing
   337 ☐ Furniture and Related Product Manufacturing
   339 ☐ Miscellaneous Manufacturing
   423 ☐ Wholesale/Trade/Durable Goods
   999 ☐ Other Manufacturing NEC

3b. If your company does NOT manufacture AT THIS LOCATION, specify company’s primary product or service performed. (please specify)

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

5. Which of the following market segment(s) does your company serve? (check all that apply)
   1. ☐ Aerospace
   2. ☐ Communications, Computers, Electronics
   3. ☐ Defense
   4. ☐ Energy
   5. ☐ Heavy Equipment
   6. ☐ Medical
   7. ☐ Transportation (including automotive)
   8. ☐ Other (please specify)
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To maximize productivity, a twin-spindle machining center is great, but a shop must be prepared. Cover image courtesy of Chiron America Inc.

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Cutting Tool Engineering regularly features writing by numerous industry experts and practitioners, such as Jeffrey Badger, Keith Jennings, John Saunders, Christopher Tate and Brandt Taylor.

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CTE Publisher Dennis Spaeth visits Southfield, Michigan-based Ecoclean Inc. to learn more about its newest innovation in cleaning equipment, the EcoCvelox.

cplus.delivr.com/2zwrh

Watch a Tormach 1100M CNC mill machine an aluminum block for a prototype mold destined to produce aftermarket carbon-fiber intake manifolds for Corvettes.

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Tungaloy America Inc.'s CVD grades in the T9200 series feature innovative PremiumTec post-surface treatment technology that is said to make T9200 hard to break.

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Help us congratulate KV Tooling Systems LLC on winning the Anca Tool of the Year competition, which celebrates the skills and imagination of cutting tool craftspeople. Eshed Advanced Cutting Tools Ltd. was runner-up, and Zakłady Mechaniczne Kazimieruk won for most creative tool. See this and more on CTE social media.
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MANUFACTURING’S WHITE COLLAR

Manufacturing has long been viewed as an industry that provides a route to the middle class for people with only a high school education. For those who are mechanically inclined and like to work with their hands, a manufacturing career, such as working at a machine shop, enabled them to start earning a decent wage after graduating from high school. While people who attended college to earn a degree envisioned greener pastures four or more years later, factory workers might be seen tooling around town in a shiny new pickup as their college-going peers scrimped and saved and took public transportation.

That scenario appears to be changing as more manufacturers introduce automation and advanced equipment into their operations. A December article in The Wall Street Journal reported that within the next three years, U.S. manufacturers are — for the first time — on track to employ more college graduates than workers with a high school education or less. Currently, more than 40% of manufacturing workers have a college degree, up from 22% in 1991. This change from blue- to white-collar is part of a shift toward automation that has increased factory output, opened the door to more women and lowered prospects for low-skilled workers.

While the movement of manufacturing jobs to countries with low labor costs has reduced the U.S. manufacturing workforce, the main cause has been automation, noted Jeff Mello, dean of Rhode Island College School of Business in Providence, in an article on the college’s website. “Manufacturers are investing in high-end machinery, and they’re looking for white-collar employees who can program the machines and repair them if necessary.”

However, a bachelor’s degree in engineering or computer science isn’t needed to do that kind of work, he added. Instead, industry-recognized certification or an associate degree is enough to prepare anyone with a high school diploma to begin a career in manufacturing.

Middle-skill jobs, which require education beyond high school but not a four-year degree, make up the largest part of the U.S. labor market, but key industries are unable to find enough sufficiently trained workers to fill these jobs, according to the National Skills Coalition.

One avenue to obtaining a middle-skill job at a manufacturer is by participating in an apprenticeship program, which involves working as an apprentice for a company and attending classes at an educational institution of higher learning. After completing an apprenticeship program, some participants use their associate degree as a stepping stone to obtain a higher degree.

Nonetheless, not all manufacturers are like Pioneer Service Inc., the Addison, Illinois, machine shop that was profiled in the WSJ article because of its need for workers with advanced degrees. T.J. Donlin, president of Elmhurst, Illinois-based Comet Die & Engraving Co., which was profiled in CTE’s March issue for the moldmaking article, said the only people at his company with college degrees are his brother, who is vice president, and himself. “I could be wrong, but I don’t see a kid graduating college and saying, ‘I want to be a moldmaker and start at that pay.’”

about the author
Alan Richter is editor of CTE. Contact him at 847-714-0175 or alanr@ctemedia.com.
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**Metalworking Product Review**

**CUTTING TOOLS PERFORM MULTIPLE FUNCTIONS:** Tungaloy America Inc. offers the TungBoreMini tool for drilling and OD and ID turning. The insert and pocket feature a dovetail interlocking design to enhance insert clamping and stability. Eight tool body diameters are available: 10 mm (0.394"), 12 mm (0.472"), 14 mm (0.551") and 16 mm (0.63"), each in right- and left-hand models.

Tungaloy America Inc.; www.tungaloy.com/us

**CLAMPING SYSTEM DELIVERS HIGH PRECISION:** Carmex Precision Tools LLC’s CIM system provides a high level of accuracy and repeatability through an internal tool indexing mechanism that locates a tool in the correct orientation. The collet securely holds the tool, and changing it does not require removing the holder. The system fits standard and special Carmex Tiny Tools.

Carmex Precision Tools LLC; www.carmexusa.com

**CNC LATHES FEATURE MONOBLOCK BEDS:** C series heavy-duty, flatbed CNC lathes from Romi Machine Tools Ltd. have gray cast-iron beds for enhanced rigidity, accuracy and performance. The cast-iron headstock has a spindle with Timken bearings. There are nine models in the series.

Romi Machine Tools Ltd.; www.romiusa.com

**CYLINDRICAL GRINDER HAS SMALL FOOTPRINT:** Supertec Machinery Inc.’s Mini Genie CNC cylindrical grinder has a footprint of 1,981.2 mm × 1,981.2 mm (78" × 78"). The machine has a grinding capacity of 228.6 mm (9") in diameter, 203.2 mm (8") between centers and a workload capacity of 20 kg (44 lbs.). The grinder comes in two styles.

Supertec Machinery Inc.; www.supertecusa.com
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ID GRINDER HAS HYDROSTATIC GUIDEWAYS: Hardinge Inc. has introduced the Voumard 1000 universal CNC internal grinding machine. It features Hydrolin hydrostatic guideways on all axes to enhance precision and productivity. The grinder offers up to five fully functional CNC axes with positioning accuracies in the nanometer range. Optimized thermodynamics in the direct linear-drive motor system improves cooling management.

Hardinge Inc.; www.hardinge.com

OD CLAMP REPEATS WITHIN TENTHS: The concentric OD clamping tool from Mitee-Bite Products LLC is compact, making the tool suitable for high-density applications. The clamp can be machined to hold any shape completely through the clamp and fixture plate, as well as gripping a workpiece above the compression nut. This ability allows more than one operation to be run on the same OD clamp.

Mitee-Bite Products LLC; www.miteebite.com
HEAVY-DUTY AIR GRINDERS DELIVER POWERFUL PERFORMANCE: Hy-Tech Engineered Solutions Inc. offers ATP Cyclone industrial air grinders in power ranges from 0.4 kW to 3 kW (0.5 hp to 4 hp). The 44 standard models feature governed motors. The grinders have stainless steel governors to resist corrosion. Standard and extended-length horizontal models are available, with up to 914.4 mm (36”) extensions.

Hy-Tech Engineered Solutions Inc.; www.hy-techinc.com

ANVIL VISE FOR FLATTENING OR FORMING METALS: The No. 9629749 anvil vise from Palmgren features a horn, step, hardened face and hole. The combination anvil and bench vise comes with replaceable serrated jaws, pipe jaws and a machined slide bar. The vise is precision-machined to provide a smooth working surface and secure clamping.

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A spindle protection system based on magnetic force could exert a pull on part manufacturers experiencing costly machine crashes.

If a collision occurs during heavy-duty cutting, a machine spindle can be subjected to tons of force. Besides breaking a spindle, a crash can damage a tool and workpiece and result in significant machine downtime.

The chances of a collision are greater than normal during the initial phases of a machining process. At these times, crashes can be caused by setup mistakes and programming errors in tests of new CNC programs.

“Programs for CNC mills are made up of thousands of instructions, and there is a high risk of something not being perfect,” said Dante Payva, New England sales manager for GF Machining Solutions LLC, Lincolnshire, Illinois. “If something is not correct and the machine makes an unexpected move, it could damage the spindle.”

Preventing damage caused by collisions is the aim of the Machine and Spindle Protection system developed by GFMS. The self-contained MSP system relies on permanent magnets in the spindle housing. During standard machining operations, the strong magnets hold the spindle in position. In the event of a collision that generates sufficient force, however, the magnets disengage, allowing the spindle to deflect either to the side or into the machine’s z-axis housing. At the very outset, he explained, this disengagement is detected by location sensors that trigger emergency braking action within nanoseconds, bringing the machine to a stop. The idea is to halt the machine before the spindle moves far enough to break, as illustrated below.

The system normally activates when a machine is operating in a setup or safety mode that lowers the maximum feed rate.

“Typically, you’d have the system on during the testing or prove-out phase of your new program or process,” Payva said. “Once you have run it once or twice and feel confident about it, the risk decreases substantially. Then you can turn the system off, and the machine would go back to its max feed rate.”

However, some shops always leave the system on for constant protection, he said, at the cost of a small amount of the feed rate they otherwise could achieve.

If a collision occurs, the system can reduce the resulting force on a spindle by 90%, according to GFMS. The system protects spindles in all and result in significant machine downtime.

A crash involving a machine spindle (left) can cause costly damage and downtime. The MSP system, however, allows a spindle to deflect after a collision, giving the system extra time and distance to take emergency braking action before a spindle breaks. $V$ is the linear spindle velocity during a machining operation. Breaking distance is the amount of spindle movement after a collision that causes breakage.
five axes of machine motion.

“Many other systems protect the machine and spindle from a crash in the direction of the spindle axis,” Payva said. “But with our system, you can crash in any direction, and it has the same safety impact.”

He said other protection systems take the brunt of collision energy and thereby damage themselves to prevent a spindle and other machine components from being damaged. So even if they do their job, those systems need to be replaced after a crash, resulting in machine downtime and added costs for users.

By contrast, the MSP system doesn’t need to be replaced after a crash.

The magnets and spring action bring the system back to its original position, “and it’s ready for another crash immediately,” Payva said.

In addition, the system does not wear and requires no maintenance.

The system is currently an option for three GFMS mills.

“The option pays for itself after the first crash,” Payva said. “Spindles cost between $20,000 and $40,000, so you could easily have at least $20,000 of damage” in the event of a crash.

Adding to the risk of spindle crashes is the shortage of skilled machine operators.

“Companies are investing in high-performance machine tools and then handing them off to people who may not have all the capabilities needed to operate them,” Payva said.

Under such circumstances, opting for the system “is a nice way to protect yourself,” he said.

——

about the author

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MACHINING A HARDENED RING GEAR

By John Saunders

Incorrect speeds and feeds are a surefire way to make terrible noises, break tools and scrap parts. Our initial attempts to machine a hardened ring gear made noises that would make any machinist shudder. Through experimentation, we optimized reliable recipes that result in an excellent surface finish and provide good tool life.

These ProvenCut recipes were performed on a Tormach 1100, a 499-kg (1,100-lb.), 1.1-kW (1.5-hp) CNC mill. It has similar capabilities as a Bridgeport. Tormach machines target the “prosumer” market and often are found in garage shops and R&D departments.

Although cutting tools designed specifically for hard milling are available, we chose a standard four-flute carbide endmill that many machinists already have on hand. Our testing focused on avoiding cutting tool vibration and ensuring that excessive heat was not created. We pushed the tool and machine to achieve an aggressive but sustainable roughing recipe and concentrated on the surface finish of the workpiece for the finishing recipe. Machining 8620 alloy steel hardened to 55 HRC can leave an outstanding surface finish.

**RECIPE IDs: 502 and 505**

- **Machine:** Tormach 1100 series 3
- **Tool:** Lakeshore Carbide Inc. 6.35 mm (0.25") four-flute endmill (1700014X30R)
- **Material:** 8620 alloy steel hardened to 55 HRC
- **Cut type:** adaptive pocket clearing, finishing
- **Material removal rate:** 655.5 mm³ (0.04 in.³)

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**about the author**


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The setup is shown for a Tormach 1100 CNC mill.

with luster even when cut on a small CNC machine.

Recipe 502 was a Fusion 360 adaptive roughing strategy run at 12.2 m/min. (40 sfm) and 0.033 mm/tooth (0.0013 ipt) with a 15.875 mm (0.625") axial DOC ($a_x$) and 0.508 mm (0.02") radial DOC ($a_e$). Recipe 505 was a 2D contour finishing strategy run at 15.2 m/min. (50 sfm) and 0.025 mm/tooth (0.001 ipt) at the same 0.625" axial DOC to remove the 0.02" radial stock left after roughing, imparting an excellent surface finish.

Larger machine tools with more rigidity can handle higher removal rates and higher surface footage. ProvenCut recipe 81 was a great example of using a Haas VF-2 and a seven-flute, 12.7 mm (0.5") carbide endmill at 45.7 m/min. (150 sfm) to machine 60-HRC D-2 tool steel.

ProvenCut’s website provides pictures, videos and cutting information for each speed and feed recipe.

All images: J. Saunders

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STAYING SHARP
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TOOLS TO BRIDGE THE SKILLS GAP

By Jason Ray

There is no denying that a manufacturing skills gap has existed for years in the U.S. A skills gap is caused by not having people trained to perform a task when and where they are needed. London-headquartered consultancy Deloitte predicts that this gap will grow to an estimated 2.4 million unfilled manufacturing jobs by 2025. It is going to take technology that drives both efficiency and workforce development to ensure that the gap does not hurt U.S. manufacturing, which made up over 11% of gross domestic product in 2018.

In custom parts manufacturing, one cause of the gap is the moving target of skills required to support the ever-increasing complexity of produced components. The complexity is due to the rapid evolution of product design software, specifically 3D CAD. This software has given flexibility to designers to quickly create, collaborate and iterate on highly complicated components and assemblies.

This capability has increased the burden on manufacturers to efficiently make items with more intricacy and requirements for accuracy. Manufacturers simultaneously have been limited often to working with antiquated software, which has formed an imbalance.

While the evolution of 3D CAD partly caused the skills gap, proper utilization of this software across the manufacturing value chain can be the key to bridging the gap. Models produced with 3D CAD represent one of the most powerful communication tools ever created in manufacturing. Leveraging these models allows an engineer to more effectively communicate design intent and more clearly convey an enormous amount of geometric metadata. The challenge facing manufacturers is that these files frequently are translated into 2D drawings with geometric dimensioning and tolerancing before being sent to job shops for quoting and production. The first step in bridging the gap is for all parties involved with part production to have access.

Whether in an office or on a shop floor, workers should be able to securely access 3D models and supporting files anytime for any job.

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to the same level of communication tools.

3D CAD is protected by expensive licenses and proprietary formats that make the technology inaccessible to most employees at an average U.S. job shop. Many companies have developed viewers with limited functionality to aid accessibility, but the functionality often is geared toward designers, not manufacturers. This reduces the value of viewers in a manufacturing environment and regularly causes them to go unused. These tools also were not designed with collaboration in mind, which keeps them from being particularly useful at a job shop, where communication is crucial.

Paperless Parts Inc. was launched to help bridge the skills gap. Our platform enables manufacturers to share tribal knowledge, communicate with their teams and refer to historical conversations through a 3D CAD viewer specifically designed to meet the needs of job shops. Our platform gives everyone at a company a powerful tool to view and communicate about 2D and 3D CAD files. This capability replaces
the call for additional CAD licenses or stand-alone viewers that lack the functionality needed to be useful. All job-related files can be uploaded to one secure place, capturing the full technical data package of each job and ensuring that everyone at a shop has what they require.

The platform is cloud-based, complies with International Traffic in Arms Regulations and supports all proprietary file formats. Built to support the effective job shop communication needed to bridge the skills gap, the 3D CAD viewer has chat features that enable team members to internally collaborate on quotes and jobs, along with supplying secure communications with customers and vendors. Examples include:

- Communication between estimators and programmers to verify cycle time estimates.
- Feedback to customers on design-for-manufacturability issues.
- Discussion between experienced machinists about how best to approach production of a part.
- Identification of especially tight tolerances, undercuts and other challenging features.

Many industry experts talk about Industry 4.0 and what new technology means for the future gap. They say connecting machines to gather data for better decision-making is a way to use technology to improve productivity and reduce the need for skilled people. We believe that the first step toward implementing Industry 4.0 and bridging the gap is to connect a shop’s most valuable asset: its people.

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**about the author**

Jason Ray is co-founder and CEO of Boston-based Paperless Parts Inc. For more information about its manufacturing platform to streamline communication and quoting for custom parts manufacturers, call 617-858-5731 or visit www.paperlessparts.com.

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Bakers use double ovens to whip up twice as many cakes and cookies each day. Double martinis get the job done in half the time. A bicycle is safer than a unicycle. There are many other examples in which two of something is better than one, but possibly nowhere is this more quantifiable than with twin-spindle machining centers. After all, for a slight increase in floor space and additional tooling expenses, having two spindles can effectively halve production costs for a variety of parts compared with a single-spindle machine. So why don't twin-spindle machining centers rule the production floor at machine shops everywhere?

Gemini Man

In some situations, twin-spindle machining centers do rule. Graham Roeder, national product manager at Jtekt Toyoda Americas Corp., Arlington Heights, Illinois, said primary users of the company's Gemini XL line of twin-spindle machining centers make automotive parts, such as steering knuckles and brake caliper components.

"But twin spindles present significant advantages to pretty much any high-volume shop, automotive or not," he said.

Roeder said the number of sales inquiries for twin spindles has been rising. Even like many twin-spindle machines, Chiron America's DZ16 W has an independent w-axis, which is used to compensate for differences in tool length and fixture height.
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According to Jtekt Toyoda Americas, Gemini XL twin-spindle machining centers present significant advantages to any high-volume shop.

companies that replace antiquated twin-spindle machines can look forward to dramatic performance improvements. Today’s twin spindles are better in every respect, with larger tool magazines, higher accuracy, faster spindle and traverse speeds and, perhaps most importantly, integrated automation.

There’s just one problem: These new and improved machine tools are no easier to set up than those of yesteryear. The tool length and diameter on the right-hand spindle must match those of the left-hand spindle, and fixture placement and construction must be equally precise. He said accomplishing all this requires enhanced planning and a high level of engineering skill, which is why many customers purchase machines as turnkey systems — tooled up, programmed and ready to get to work.

“We’re typically building complete packages to order, with most going out with rotary tables and some level of automation,” Roedder said. “Compared to the typical 40”×20” (1,016 mm × 508 mm)
single-spindle machining center you can find in any job shop, twin spindles are purchased with one thing in mind: maximum spindle utilization. For that, you want either a pallet changer or robotic part handling."

Why W?
An additional difference in the world of twin spindles is the presence of a w-axis. In Jtekt Toyoda Americas’ case, this provides up to 20 mm (0.787”) of independent z-axis travel to compensate for any differences in tool length. A w-axis is a nice feature, though it’s probably less important than it once was.

The people interviewed for this article said offline tool presetters have made setting up a twin spindle easier. So has zero-point workholding, which allows shops to tool up a range of parts and quickly swap fixtures and vises as needed. For these two reasons above all others, twin spindles deserve a second look from those who’ve discounted them as “only automotive” machine tools.

Chiron America Inc., Charlotte, North Carolina, is enjoying similar demand for twin spindles and has released a machine model, the FZ/DZ 25, in response. Ross Clark, account manager and product specialist, said the FZ/DZ 25 is a bridge-style machine that boasts 800 mm (31.496”) between spindles, with each spindle able to traverse independently in the x- and z-axes. Tool changes are independent as well, and the machine can be equipped with either a dual five-axis trunnion or a “w-style table,” or rotary pallet changer.

“The FZ/DZ 25 targets large electric vehicle parts — battery trays, for example,” he said. “As a country, the U.S. has been slow in committing to this market. Automotive manufacturers, however, have finally woke up to the fact that EVs are coming and begun investing...
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Doosan Machine Tools America offers the XC 4000DA, a 12,000-rpm HSK 63A twin-spindle machine equipped with a servodriven, rotary-style pallet changer.
in equipment to meet the need. Everybody’s seen how much ground Tesla is gaining. And because of that, the commitment to new gasoline engines is nearly nonexistent. Everybody’s preparing for electric vehicles.”

Experience Matters
Whatever the application, Clark suggested key attributes to look for when shopping for twin-spindle machines, especially ones as large as the FZ/DZ 25.

“Geometric alignment between the spindles is critical, as is thermal compensation to eliminate potential growth,” he said. “Without this, you’re going to face problems maintaining accuracy on one side or the other. It’s for this reason that we recommend a stable foundation with any high-precision machine tool — a concrete slab is best — but particularly with a twin spindle since any geometric errors will be multiplied.”

In addition, fixture positioning must be exact as there’s no way to adjust the distance between spindles. The presence of a tilt rotary table only exacerbates this situation, Clark said, and the fixture data therefore should be perfectly square and parallel with the machine axes and spindle centerlines. This is not as difficult as it might sound.

“We’re doing a good deal of that today with our turnkey packages,” he said. “The problem is getting everything trued up again after the inevitable crash, but there are proven strategies to address this challenge. This is one example of how proficiency and experience are even more critical throughout installation and setup with multispindle machines, so choose partners wisely.”

Bringing Work Home
As referred to earlier, automation goes hand in hand with twin-spindle machining centers. Dual-spindle machine tool builders typically offer robust material handling and part loading capabilities, ranging from Lazy Susan-style pallet changers to

**Double Duty**

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Doosan Machine Tools America Corp., Pine Brook, New Jersey, is no exception.

“The reshoring trend has resulted in a couple of industry shifts,” said William Carr, director of key accounts and engineered applications. “One is that jobs coming back to the U.S. must be automated. That’s because the cost of robotics is the same everywhere in the world, but the cost of machine operators is dramatically different. Automation levels the playing field. The second thing is that plant expansion is becoming very expensive in America. Consequently, there’s a growing call to produce more parts per square foot in your plant. Manufacturers don’t want to bring work back by having to expand the factory floor. Not only is the ROI too slow, but they can’t wait a year or more for new construction to be completed. They want an immediate hit and want to maximize available floor space.”

Enter twin-spindle machining centers with automated material handling. Most machines aren’t that much larger than a single-spindle vertical machining center, doubling production output per square foot. They are more expensive but not twice the price, and they are far less costly than punching out the side of a factory to expand.

A Helping Hand

Doosan Machine Tools America’s XC 4000DA machining center is a good example. Launched late...
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Last year, the 12,000-rpm HSK 63A twin-spindle machine comes with a servodriven, rotary-style pallet changer with rotary table (a-axis) and trunnion (a+c) versions available. An open design allows the use of a front-mounted robot or an overhead gantry loader. Carr said the machine is suitable for high-throughput machining, with particular attention paid to coolant flow, chip management and 24/7 reliability.

However, he recommends that shops not go it alone on a twin-spindle purchase, automated or not.

“These are not commodity machines,” Carr said, “and for good reasons. Some people think they can easily manage their own integration, their own engineering efforts. And in some cases, this is true. Yet twin spindles are a different animal. Things can get ugly when a shop buys a machine and is unhappy a few months down the road because the decision-makers there didn’t fully understand the application or accept the fact that they didn’t have the resources needed to make it into a productive solution.”

He said it’s the job of machine tool partners to look closely at customer requirements.

“This means studying the manufacturing and engineering requirements, yes, but it also requires studying the culture of the shop, the skill level of the people, and making sure that we don’t sell them a piece of equipment they can’t adapt to,” Carr said. “This is true for any machine tool but even more so with complex machinery like twin-spindle machining centers.”

‘Twin spindles are purchased with one thing in mind: maximum spindle utilization.’
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Spindles are the heart and soul of machine tools and the most precise, heavily stressed components of a machine. Special care therefore must be taken to ensure that spindles are designed and built to provide the required accuracy and longevity. When a spindle degrades, a machine tool either does not hold specified tolerances or does not produce parts at all. In any case, it costs money.

When a spindle goes down, it is natural to want a machine back up and running as soon as possible. Having a spindle down in the middle of a job with a tight delivery is not a good feeling. However, although you need a spindle repaired quickly, it must be repaired correctly. A fast but substandard repair is not much consolation if part tolerances do not hold or a spindle quickly fails again.

Trust, but Verify

So how do you know that a spindle will be repaired as quickly as possible without cutting corners or taking shortcuts regarding the quality and completeness of a repair? The answer is transparency. A spindle repair company should provide proper documentation so customers know they are deriving value from spindle repairs.

In most machine tool spindles, there are 250 to 300 individual component and assembly characteristics that impact performance and longevity. For a comprehensive repair, each of these must be checked and evaluated for suitability. Since many tolerance measurements are in microns, components should be absolutely clean and at the proper temperature to accurately inspect.
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them. To accomplish this, a 24-hour turnaround for a proper spindle rebuild is hardly sufficient. It can take that long for individual components to reach the proper temperature for inspection. A basic expedited repair should take three days from receipt of a spindle to shipping it back to a customer.

All these significant characteristics should be documented clearly by a spindle repair company for a customer to see. Photos of spindle components that show conditions and damaged areas are important for the knowledge and understanding of a customer. The cause of spindle failure, including analysis, should be noted so spindle performance or longevity can be assessed for potential improvement. It is often possible to make changes to bearings or sealing systems to enhance spindle performance or durability.

Test and Measurement
After a spindle is reassembled, test bar runouts should be measured and documented. Drawbar pull forces should be set and documented during a complete run-off. Documentation should include the spindle’s steady-state operating temperatures, details of the

In most machine tool spindles, there are 250 to 300 individual component and assembly characteristics that impact performance and longevity.

Heart and Soul Repair

Test and Measurement
After a spindle is reassembled, test bar runouts should be measured and documented. Drawbar pull forces should be set and documented during a complete run-off. Documentation should include the spindle’s steady-state operating temperatures, details of the

about the author
Bob Hodge is president of Advanced Spindle Technology LLC, a spindle service company with facilities in Winston-Salem, North Carolina, and Cuyahoga Falls, Ohio. For more information, call 833-854-2579 or visit www.astspindles.com.

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bearings used in the repair and running vibration and balance characteristics. The vibration spectra at each end of the spindle also provide valuable information, which can be used as the baseline for a predictive maintenance program.

If all this sounds like a lot, that is because it is. Proper documentation usually requires about 20 pages. However, that gives enough information so a customer can understand what a suitable spindle assessment and rebuild looks like — specifically, what was wrong with a spindle and what was done to repair it. This level of transparency allows a customer to know that a comprehensive repair was performed and the cost was justified.

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Selecting the right machine or system to clean parts can be complicated.

By Yesenia Duran

Almost all machined parts coming out of a machine tool are covered in some type of metalworking fluid residue. Depending on the next step in a part’s life, a certain amount of cleaning is in order. A major factor in determining the type of necessary cleaning is the degree of cleanliness specified by a customer. Other considerations include the workpiece material, the type of debris to be removed and the level of complexity for part features.

“It really depends on which stage of the manufacturing process you’re on,” said Sandro Siminovich, director of sales for Ecoclean Inc., Southfield, Michigan.

Cleaning parts generally involves a combination of cleaning time, a solution and the solution temperature. The two main drivers of solution chemistry are the debris, or soils, that must be removed and the workpiece material. Some materials, such as aluminum, brass and bronze, can be harmed when cleaned with an incorrect solvent. And some cleaning agents can affect post-machining processes, such as plating, said Bernie Santerre, manager of Ecoclean Inc.

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outside sales and business development for Graymills Corp., Broadview, Illinois.

“The right machine also needs to factor in load size and throughput goals,” said Cheryl Larkin, Northeast regional sales manager for Miraclean Ultrasonics, Ashville, New York.

Finding the right parts cleaner ultimately can be just as complicated as the cleaning process itself.

The Cleaning Process
To select an appropriate cleaning agent, the maxim “like dissolves like” applies. If a shop uses a non-polar cutting fluid, such as mineral oil or grease, a solvent might be the correct choice. When ultrasonic cleaning, for example, chips and particles, which are polar contaminations, no longer adhere to a part after the oil or grease is removed and are carried away by the cleaning action.

The ultrasonic process uses ultrasound, usually 20 to 40 kHz, to agitate a fluid. Ultrasonics introduces microscopic bubbles into a cleaning solution. They implode and take the soil with them. The bubbles travel wherever a solution goes, making ultrasonics suitable to clean parts with complex geometries and apertures.

Water-based detergents also effectively break the soil bond when properly matched to substrates and soils based on the pH level, solution concentration and temperature.

The higher the temperature, the better, Siminovich said. Solvent-based machines typically work with a temperature of about 65.6° C (150° F) during the liquid phase. With vapor degreasing, the temperature is about 121.1° C (250° F). For water-based cleaning, the temperature is usually about 37.8° to 48.9° C (100° to 120° F).
Increasing cleanliness requirements and achieving consistent cleaning results are common demands, he said.

Two main criteria measure how clean a part must be: the visible particle size and weight, which are measured in microns and milligrams, and the invisible surface tension, which is measured in millinewtons per meter or by contact angle and indicates how much of a chemical is left on a surface.

“At Miraclean,” Larkin said, “we build for a variety of industries, and each customer’s cleaning requirement is unique.”

She said requirements range from visual inspection and particle counts to water break tests and black light or white glove inspections.

The Cleaning Systems

Finding the right parts cleaning machine or system is “shockingly complicated,” said Tom Kucklick, applications specialist at Graymills.

A batch machine is widely used to simultaneously clean a large number of small parts, which are placed in trays or baskets and go into one or more tanks depending on the number of stages. With a single-chamber machine, parts go inside the chamber, and the entire process takes place inside.

One of the most common forms of parts cleaning is ultrasonic cleaning. It can be used with just water, but adding a cleaning agent appropriate for the part to be cleaned and the type of soiling present enhances cleanliness.

The simplest form of water-based ultrasonic cleaning consists of a standard-size heated tank, such as
one measuring 304.8 mm × 304.8 mm (12”x12”). Parts go into a basket, which a user lowers into a tank that contains chemistry. The amount of time needed to clean them is calculated through trial and error. Parts then are rinsed. Some operations use a second tank for rinsing. Others just rinse parts in a sink and blow off excess water by hand with a compressed air hose.

A large facility that deals with heavily soiled items, such as injection molds or remanufactured automotive parts, might need a bigger parts washer that offers more mechanical cleaning action. That may require an ultrasonic tank that heats water and has a platform that agitates up and down. Those parts also must be rinsed and inhibited or dried.

An installation by Graymills involved an aggressive pre-wash, an ultrasonic wash, rinsing and drying. However, less than 10% of the company’s cleaning systems have multiple stages.

Conversely, most of Miraclean Ultrasonics’ systems are automated and have multiple stages for parts that require a high level of cleanliness, such as those for the medical device and aerospace industries.

Kucklick said he also has been seeing more automated parts cleaning, which necessitates proper communication among various pieces of production and cleaning equipment. Most are still manual or semi-automatic, whereby an operator is present at the beginning and end of a cycle but not through the entire period. In addition, there has been a fairly constant shift from solvents to water-based cleaners, especially in locations with strict environmental regulations, such as California, but solvents can be more cost-effective.

All of Ecoclean’s cleaning machines also dry parts.

“Is it always necessary?” Siminovich said. “Nope, but it does make sense to have a drying stage. There’s a blow-off dry process where hot air inside the machine will blow-dry the part. Vacuum dry is more effective because it will remove all of the contamination from the parts. With blow-off drying, that process can reintroduce contamination onto the parts because when you’re blowing air around the part, there’s a risk of sending the particles back onto the parts.”

Depending on the process, cleaning time can vary widely. An equipment supplier typically helps a customer determine which process is needed and how to set up a proper cleaning system for it.

Make an Informed Decision

When looking for a parts washer, an end user must have some information ready for a supplier.

The EcoCore is one of Ecoclean’s best-selling industrial parts washers. The unit shown is a batch cleaning machine.
“I get calls all the time,” Kucklick said. “People tell me they are milling X number of parts, and they give me the length, width and height. They’ll say there’s a mixture of coolants and chips that need to be removed before the parts go to a plating process or an anodizing process. With a request like that, we first ask what process they currently have in place.”

He said companies sometimes don’t have formal processes, or perhaps a company simply cleans parts with rags but has a customer with newly stringent cleanliness specifications.

“You have to ask what their goals are,” Kucklick said. “What is the part, and how many are they trying to clean at once?”

The quantity of parts to clean dictates machine size and how fast the cycle time needs to be.

“Let’s use an aluminum bar with holes in it as an example,” Kucklick said. “I would look at the drawing of the part. If it had a lot of small blind holes, I would look at an ultrasonic-type machine because of the ability of an ultrasonic machine to get the grease out of blind holes where debris loves to settle.”

When performing fine cleaning, such as ultrasonic cleaning of medical and aerospace parts, filtration of the wash is critical. As parts are cleaned, debris may float around a tank and be redeposited back onto them and subsequent parts. Debris can be removed by a recirculating filter loop that traps particulates and extends tank life.

Kucklick said changing the cleaning fluid in a machine can be quite an undertaking.

“You can lose anywhere from a half day to a full day of production,” he said, “so you want to extend the life of that fluid as long as possible. Because when that machine is not running, you’re not cleaning parts.

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**Ultrasonic cleaning process checklist**

Particular needs and goals for parts cleaning determine the appropriate ultrasonic cleaning equipment and chemistry for a job. Answering the following questions will help decide the best process for one’s needs.

- What is the largest part that you need to clean?
- What are the part substrates?
- What are the soils?
- Are there blind holes or other complex part features?
- How many parts do you want to clean per batch?
- What is the estimated weight of a batch?
- How many batches need cleaning in an eight-hour shift?
- How many shifts are there per day?
- How clean is clean?

— Miraclean Ultrasonics
‘You can lose anywhere from a half day to a full day of production, so you want to extend the life of that fluid as long as possible.’

Clean Machine

And when you’re not cleaning parts, you’re not selling parts.”

Criteria in Check

There are a lot of criteria for selecting the most appropriate machine. (For instance, see the sidebar on Page 45.) What contamination is coming from the upstream process, and what is the required cleanliness for the downstream process? In other words, where is a part coming from before it is cleaned, and where is it going next? Is a part coming from an oil-based grinding process or a water-based machining process? What specifications does a client desire? These initial questions must be answered to determine which cleaning agent to use.

“There are two main things that will help you determine the size of the machine,” Larkin said. “What are the parts in terms of size and geometry, and what’s the throughput?”

She pointed out the need to ascertain if there would be any chemical reactions between a part and the chemical in the cleaning agents being considered.

Larkin said if a parts manufacturer already has a machine or process and wants to see whether the same machine or process could be used for a new customer’s part, Miraclean Ultrasonics will evaluate the situation.

“It’s always a discovery process,” she said.

For its part, Ecoclean has a showroom in Michigan with several machines so current and potential customers can visit or send parts for testing.

Graymills and Miraclean Ultrasonics visit customer facilities to help them set up equipment and to explain the process so operators understand what occurs at each stage.

Pricing

The most uncomfortable question might be, “What’s the budget?” However, sometimes people have no idea what their budget is, Kucklick said.

The least expensive machines
don’t always provide the desired results, Siminovich said.

The ultrasonic cleaning method may produce unsurpassed levels of cleanliness but can be expensive. The cost for water-based machines, which are generally cheaper than solvent-based machines, ranges from a few thousand dollars to more than $1 million. A solvent-based machine costs $400,000 to $500,000, depending on volume and size, and removes all grinding oils.

“While the solvent-based machines carry a higher upfront investment point, it has considerably less running costs,” Siminovich said. “So your payback on the equipment will be faster — on average it’s about two years — than that of a water-based machine.”

Others have found that developments in water-based cleaning — since the 1988 Montreal Protocol, which led to reductions of regulated solvents — have produced cleaned parts that rival or surpass solvent cleaning and have a similar payback. Regarding water-based ultrasonic cleaning, a common misconception is to imagine a tabletop-size tank, but some ultrasonic systems are over 9.1 m (30’) long. All Ecoclean machines incorporate ultrasonic as an option.

“In our experience,” Santerre said, “a lot of cleaners cost less than $10,000, even $1,000, but single units can sell for up to $60,000. But the worst-case scenario is having the machine operator do the cleaning because an expensive worker is being used for a low-skill task.”

A small shop might be able to get by with one machine, but some facilities require dozens of washers.

Washing parts is only one of the critical steps in today’s manufacturing processes, yet it is vitally important to many industries. Armed with the necessary information, any shop can figure out which parts cleaning system would best meet its needs.

“There are times when a cleaning method simply fails for some reason,” Kucklick said. “Our ability to change gears and try up to three other types of cleaning is a tremendous benefit when attempting to solve a cleaning mystery.”

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Avoid mishaps with best practices in oil mist control.

By Mike Meyer

Metalworking applications that require coolants or lubricants produce aerosolized particulates composed of tiny oil droplets. While they are often too small to see with the naked eye, they can jeopardize worker safety and productivity.

Metalworking fluids generally can be categorized as one of four types based on their different properties and recommended applications.

1. Straight oil. This can be mineral — that is, petroleum — or vegetable oil and mainly lubricates rather than cools.

2. Soluble oil. Composed of 30% to 85% refined petroleum-based oil, along with emulsifiers and other additives, soluble oil lubricates and cools but may result in more smoke and residue than straight oil produces.

3. Semisynthetic. This contains 5% to 30% petroleum-based oil, along with a complex emulsifier package. Semisynthetic provides good lubrication and heat reduction and is cleaner than soluble oil.

4. Synthetic. This is composed of detergent-like compounds rather than petroleum. Synthetic is usually the cleanest option and effectively reduces heat.
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Oil mist characteristics vary according to the type of oil and the machining process. Petroleum-based oil tends to produce more solid particulates, as well as aerosolized oil particles, than other metalworking fluids, creating a dirtier oil mist.

Low-speed cutting and grinding produce relatively large, mechanically generated particles that are easy to collect in filters and consequently of less concern. The particles are generally about 10 µm (0.0004”) in diameter.

On the other hand, high-speed processes likely cause a lot of heat, creating thermally generated droplets. It vaporizes the liquid, which results in aerosols that tend to be less than 1 µm (0.00004”) in size. This oil mist usually looks more like smoke and is harder to filter than mechanically generated droplets.

As the speed of production continues to increase and cycle times decrease, more heat is being created. That means there are more processes in which mists are generated thermally, resulting in smaller particles than before. This change presents a filtration challenge. The smaller the particle, the more difficult it is to clean the air. More efficient filters therefore are needed to mitigate the problem.

Slip and Slide
The most obvious, immediate safety issue occurs when oil mist causes workers to slip and fall. It often hangs in the air before forming a layer of grease on floors and other surfaces. Heavy oil mist droplets coalesce as they cool and fall onto horizontal surfaces.

Oil mist also poses health problems when inhaled. This risk varies.
with the type of oil used, the additives in the metalworking fluid and the way the mist is generated. Some mists contain chemicals that irritate lungs, as well as skin, eyes, the nose and the throat.

As previously noted, widely performed high-speed thermal processes tend to produce small droplets that can be inhaled deep into lungs. All oil mists can produce respiratory irritation, and prolonged exposure has been linked to asthma, chronic bronchitis, impaired lung function and pulmonary fibrosis of the lungs. Some metalworking fluids cause skin irritation or contact dermatitis when they settle on skin.

Finally, there is evidence that some metalworking fluids increase the rates of certain cancers, though this has not been proven definitively.

Fortunately, appropriate collection and filtration reduce potential health risks and increase worker satisfaction and productivity. Machining processes often can be contained under hoods to reduce worker exposure to hazardous oil mist. But even if humans are not exposed, it is important to control oil mist in enclosures to protect equipment. As oil mist builds up in an enclosure, oil mist can make its way into electronic components, such as programmable logic controllers, leading to premature failure. Potential losses can be minimized by keeping moisture levels low in enclosures.

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The most obvious, immediate safety issue occurs when oil mist causes workers to slip and fall.

A Fluid Situation

An operator must be able to reach into an enclosure to load and unload parts. If it is not evacuated correctly, a worker may come into contact with a misty area. Parts also can drip oil as they travel on a bin or tray, creating an additional hazard. Furthermore, many machine tools have optics to measure surface quality. Any mist in an enclosure can affect them.

Limiting Exposure

To reduce the risk of adverse health effects, the Occupational Safety and Health Administration sets permissible exposure limits for workers at facilities where contaminants are a concern. These limits set the amount of a substance that a worker can be exposed to over the course of an eight-hour shift.

For mineral-based oil mists — paraffin oil mists, heavy mineral oil mists, white mineral oil mists and petroleum-based cutting oils — the permissible exposure limit for general industry, including automotive manufacturing, is set at 5 mg/m³ (0.005 ppm) as an eight-hour time-weighted average. All other metalworking fluids fall under general OSHA requirements for “particulates not otherwise categorized.” The permissible exposure limit for these oil mists is 15 mg/m³ (0.015 ppm).

OSHA establishes the only regulatory limits for oil mists. However, the National Institute for Occupational Safety and Health and the American Conference of Governmental Industrial Hygienists have established stricter recommendations for oil mist limits, especially for metalworking fluids that are not mineral-based.

NIOSH’s recommended exposure limit for all metalworking fluid aerosols is just 0.4 mg/m³ (0.0004 ppm) for thoracic particulate mass as a time-weighted average concentration for up to 10 hours per day during a 40-hour workweek.

ACGIH, which is made up of a group of industry professionals, maintains its own list of air quality
standards. These are typically more stringent than OSHA’s standards, and OSHA often changes its standards to match ACGIH’s guidelines.

ACGIH’s threshold limit value for mineral oils is 5 mg/m³ for an eight-hour time-weighted average and 10 mg/m³ (0.01 ppm) for a 15-minute short-term exposure limit. Other metalworking fluids do not have a specific threshold limit value, but keeping exposures as low as possible is recommended.

As more manufacturers switch from straight oil to synthetic, it’s important to note that plenty remains unknown about the exposure risks related to synthetic oil. This is also true of the detergents, emulsifiers and other additives used to enhance performance.

Pressure Point

The first step to mitigate the problem is to control submicron aerosol mists that tend to stay airborne in an enclosure. The mists should be evacuated from a machine and transferred to a controlled device, minus the big droplets. Use a high-pressure nozzle like a small garden hose to flood a part with coolant. The connection of the mist controller should be placed strategically on an enclosure, keeping in mind that you want to capture only the particulates that likely will stay airborne—not the large splashes of water.

Place a baffle plate in front of the connection to minimize any splashes going into the ductwork. Big, splasy particulates will hit the baffle plate and run off.

When coolants splash around a machine, they often drain down and recirculate. This minimizes the amount of liquid that ends up as waste and reduces the cost of lubricant.

It’s also important to transfer the mist and air on the machine to a device that separates liquid aerosol from clean air. The goal is to move the mist where you want it to go without using too much energy in the process.

Filter mediums should be chosen based on the particle size of the mist. Make sure a filter effectively
can remove submicron particles from the airstream. To be effective, a filter medium will use high pressure and require high energy costs to force air through.

Devices that use coalescing mediums as a mode of filtration need less energy and can last up to 10 years. The other filtration method uses noncoalescing mediums, which are fibrous mediums that must be thrown away once saturated. While these filters do not demand much energy, they are not very efficient and must be replaced continually.

Oil mist requires specialized equipment for collecting wet particulate matter, along with a different type of filter. Filters created for dry particulates, such as dry grinding dust, quickly become clogged and ineffective if used for oil mist. Wet mist collectors pull mist-laden air into the bottom of a collector, where larger droplets can fall out before air is pulled into a filter medium.

Packed-bed, or coalescing, filters are most effective for most oil mists. These filters capture tiny droplets on fibrous mediums, and the droplets then coalesce into larger droplets. When enough liquid accumulates, it simply drains off the filter medium into a collector. These filters continue to work even when fully saturated, and they continually clean themselves as liquid drains off. The collected metalworking fluid then can be further filtered or for reuse.

Fantastic Fan

Using the right fan is critical to eliminate 80% of the problems behind mist control. When the people who design the equipment do not use the correct fan, they miss the right amount of pressure, the right ductwork or the right airflow to capture mist. If a fan does not move the right amount of air, mist in a machine will not be evacuated properly. Every component of a system must work correctly to achieve the overall goal.

Because oil mists and solid particulates do not behave the same, they require different approaches to collection. Dust collection equipment made for weld fumes and other solid particulates is not effective against oil mist.

The best way to determine if a system works effectively is to test the air that travels in and out of a collector. Packed-bed filters with multiple layers of tightly woven fibers work well for both mechanically and thermally generated oil mists.

Packed-bed filters can handle some dry-soluble particulates, which simply wash away with liquid as it coalesces. However, if a process generates large amounts of nonsoluble particles that mix with oil mist in the air, you may need to consider a pre-filtering process.

There are different approaches to separate solid particulates and liquid oil mists. Disposable pre-filters can be used to strain out large solids before oil mist reaches

**Modes of mist filtration**

**Electrostatic attraction**

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a packed-bed filter. This is a fairly inexpensive approach but can be maintenance-intensive, mainly because filters need to be changed frequently. Impingement plates or chevron-style pre-filters capture solids and keep them from entering a fiber bed filter. These are periodically washed to remove accumulated solids.

A number of questions should be answered when designing a system:

- What processes are you using?
- Are the mists thermally or mechanically generated?
- What type of metalworking fluid are you using?
- What is the concentration of oil mists in the facility or enclosure?
- What is the total volume of mist produced during a shift?
- Can your processes be enclosed easily?
- What is the total volume of air that must be moved?
- Is your overall goal to comply with OSHA or NIOSH/ACGIH health recommendations?

Source capture should be the first line of defense for metalworking applications that produce oil mist. Ensure that an enclosure is the right size for an application.

Effective system design starts with an effective hood to capture and contain oil mist. The better the hood design, the less airflow is needed to capture oil mist, which ultimately requires less energy. An optimal system design minimizes static pressure so more air can be moved with less energy.

Ductwork design is an important consideration related to system design. Improper duct design and inadequate airflow can allow mist to coalesce on the sides and bottoms of ducts. For some types of lubricants, this may be a fire hazard. Liquids that accumulate in ductwork and drip from seams also can create a significant safety hazard.

Vaporized oil can cause violent fires that rapidly spread. For this reason, look for systems with built-in fire suppressant technology.
CNC machines and CAM software enable advanced milling techniques.

By Christopher Tate

I had the privilege of learning the machining craft at my family’s machine shop. It was a true mom and pop shop where we made anything that would pay the bills. As orders grew larger and parts became more complex, it was clear that our future would depend on successfully integrating CNC equipment into our shop. In 1995, we purchased our first machining center: a small one without any options. Buying it launched our shop to the next level. Five weeks after receiving the machine, we ordered another just like it. I programmed them with a pencil, paper and a calculator, typed codes into the controls and stored all programs in the machine tool controls. We used edge finders and indicators to set parts and measured tool lengths by touching parts with each tool. Compared with today's technology, our methods were crude.

Machining centers and techniques have advanced at a fast pace since I started programming and operating CNC machines. A few significant improvements have transformed the machines into what we use today, enhancing shop and machinist efficiency.

Need for Speed

Our first CNC machine was capable of only a 7,500-rpm spindle speed. Although machines were available with higher-speed spindles, those machines were expensive and rarely found at small shops. When we bought our original machines, we would have needed to use some type of ancillary device, such as an air spindle or a geared spindle speeder, to achieve higher spindle speeds. In addition to being costly, spindle speeders were often unreliable and

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Technology demonstrated courtesy of 3D Systems
underpowered. Today, it is common for machining centers to have 20,000-rpm spindles.

Spindle speed may sound insignificant, but it has a direct impact on the programmed feed rate of a machine tool. High feed rates usually mean high removal rates and reduced cycle times, making a shop more efficient.

Every programmer should know that rpm multiplied by feed per tooth equals inches per minute. So as spindle speeds increased, more dynamic machine tools were needed.

Our initial CNC machine was not high end but had comparable specifications to many other machining centers on the market. In rapid traverse mode, the machine would travel 10.16 m/min. (400 ipm). In a feed move, the machine could go 6.35 m/min. (250 ipm). Machines today are capable of rapid traverse and cutting feed rates in excess of 60.96 m/min. (2,400 ipm) — six times faster than our machine.

As machining centers have become more dynamic, the use of advanced milling techniques, commonly called high-speed machining, has gained popularity. HSM offers many benefits like reduced cutting forces, extended tool life and large depth-to-diameter ratios, all of which increase milling efficiency. HSM toolpaths are based on maintaining uniform chip thickness across a profile, which requires substantial computing power. Therefore, creating HSM paths without software would be impossible.

**Growth of CAM**

Few shops 25 years ago used CAM software as we do today. Small shops relied on conversational controls or — like we did at my shop — used brute force by writing G code on paper and then typing that into a control. Even large companies at the time depended on unwieldy systems, such as Automatically Programmed Tool, a cumbersome Fortran-based language that required thousands of hours to master.

CAM software with a graphical user interface transformed programming into an activity like a video game. Programming is so easy that almost anyone can create a simple toolpath after a few minutes of training. Without modern CAM software, HSM toolpaths would not be possible. And we would not have been able to fully capitalize on increased speeds.
without HSM.

Loading programs and other data into a CNC requires a communication system. At my family’s shop, I typically typed programs directly into a control, which was painfully inefficient. We tried to connect a machine to a computer to improve efficiency, but it never worked properly. We abandoned the project after determining that it was too complex for our skill set.

Machine tool controls now come designed to communicate, and connectivity is simple. Most have Cat5 connections and USB ports, and some have wireless connectivity. At least one builder already allows connection and data transfer with a smartphone. Connectivity, data collection and remote interaction with machines will dominate future control development.

Looking ahead, we will continue to see significant advances in communication, connectivity and data transfer. More importantly, I expect more machining and additive manufacturing processes to be combined into a hybrid platform in which a near net shape component is produced with an additive process and fine-tuned with a machining process. Making a part soon may be as simple as saying, “Hey, Siri, make a widget.”

C. Tate
This eye-opening fact shocks our competition.

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Burrs on machined metal parts come in a variety of shapes and sizes but have one thing in common: They must be removed. JR Precision & Welding LLC generates light, medium and heavy burrs when machining 4140 steel muzzle brakes. Removing the burrs is challenging, said James Mawazeb, director of operations and lead engineer at the Houston-based machine shop, which was founded in 2017.

A muzzle brake, or compensator, is a device connected to the barrel of a rifle or pistol to help control recoil and the rising of the barrel that normally occurs after firing. Muzzle brakes utilize slots, vents, holes, baffles or similar features to redirect a portion of propellant gases to counter recoil. Burrs form on the oval-shaped gas ports of parts.

Mawazeb said the shop initially took additional passes with the cutting tools that had been used to machine the parts.

“It never helped us remove any of the burrs,” he said.

JR Precision & Welding next sought whether another company could deburr the parts with aluminum-oxide sandblasting or even glass beads, but the processes proved ineffective, Mawazeb said. Manually deburring light burrs with a hook-shaped deburring tool and removing large burrs with a Dremel rotary power tool outfitted with a sander were effective but inefficient methods.

“We pumped out 500 parts within about 10 days,” Mawazeb said, “and it took us an extra six days just to deburr all those parts. Even after we got done with deburring them, I still had to make sure every part was right. A lot of people consider me a stickler for that, but if you are going to put your name on a product, you have to make sure it’s right.”

He defined a light burr as one that can be removed with a thumb-nail and said large burrs can’t be. The largest burrs the shop sees are about 3.175 mm (0.125”) high.

Adding to the challenge was that the bar stock JR Precision & Welding previously machined was from a supplier that sold only heat-treated 4140 steel bars, Mawazeb said. The shop eventually switched to a supplier of annealed stock, which is easier to machine and deburr.

For a solution, JR Precision & Welding turned to Houston-based tool distributor Bass Tool & Supply Inc., which suggested testing an abrasive brush with filaments angled down. He said results were unimpressive.

### Challenge
Remove burrs from 4140 steel muzzle brakes for firearms.

### Solution
An abrasive nylon wheel brush.

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A 4140 steel muzzle brake is shown before and after deburring.
“When it would go over the part,” Mawazeb said, “it would be like it was a toothbrush just rubbing over the metal. So it didn’t actually remove anything. It actually scuffed up the part more and left a horrible finish.”

By switching from a four-flute endmill to a five-flute endmill, JR Precision & Welding reduced average burr size but still needed an efficient solution. Bass Tool & Supply recommended an abrasive brush from another toolmaker that the distributor carries: Los Angeles-based Brush Research Manufacturing Co. Inc. He wasn’t convinced that a different brush would do the job but sent parts to test at Brush Research Manufacturing’s surface finishing laboratory. After a test in which an abrasive disc brush didn’t sufficiently remove burrs, Brush Research Manufacturing deburred a part with a 152.4 mm-dia. (6"-dia.) abrasive nylon wheel brush that has filaments made of silicon carbide.

“It was able to easily get into the slots, push the burrs out and remove them,” said Elysha Cole, product support specialist at Brush Research Manufacturing.

The filaments self-sharpen. As a brush contacts a work surface, filament grit wears off and exposes new cutting particles. This action enables a brush to remain sharp even after repeated use.

After the concept was proven in a lab, JR Precision & Welding purchased an 80-grit 76.2 mm-dia. (3"-dia.) brush. The shorter trim fill has less give and delivers a more aggressive deburring force than the larger version. In addition to removing midsize and large burrs without altering the surface finish, the brush provides a soft edge break to the four gas ports so they are not razor sharp. Mawazeb said deburring a part with the brush takes about a minute. The shop purchased the brush in August and had yet to replace the brush after months of use.

To remove light burrs, it’s more efficient to run a secondary operation using a 4.7625 mm-dia. (0.1875"-dia.) two-flute chamfering tool, which would break when removing heavier burrs, he said.

“We eyeball to determine burr size,” Mawazeb said.
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The High-Area Rapid Printing 3D printer is sufficiently big and fast to print objects as large as an adult human in just a couple of hours. The ability to rapidly print parts on demand could make parts warehousing and expensive molds things of the past. Developed by Northwestern University researchers, HARP will be available by next year from Azul 3D Inc., Evanston, Illinois.

"HARP enables machinists to make jigs, tools and molds quickly and efficiently out of durable materials," said James Hedrick, CEO and co-founder of Azul 3D. He said large parts can be made in a single piece from industrial-grade materials.

While Hedrick completed his doctorate at Northwestern under the supervision of professor Chad Mirkin, he worked in a laboratory with postdoctoral student David Walker. The three men started to develop a nano-3D printer. They realized early that the printer could print both large and tiny structures.

“We recognized immediately that with HARP, we had the ability to transform manufacturing," Hedrick said. “We transitioned our focus from nano to macro, and the three of us founded Azul 3D to transition the technology from the lab to the factory.”

The prototype HARP is 3.96 m (13’) tall with a 0.23-sq.-m (2.5-sq.-ft.) print bed and can print about 0.5 m (1.5’) in an hour. The machine is suitable for printing individual large parts or many different small parts at once.

The company has an ever-expanding library of materials that HARP can use, including ceramics and durable, tough elastomeric rubber. The key advantages of the machine are fast throughput and the ability to produce industrial-grade parts at a cost point that enables manufacturers to move beyond prototyping with 3D printing, Hedrick said.

HARP uses a new, patent pending version of stereolithography — a type of 3D printing that converts liquid plastic into a solid. The machine prints on a vertically moving plate and projects ultraviolet light to cure liquid resins into hardened plastic. HARP is in a class of 3D printers that uses high-resolution light patterning to produce parts that don’t need extensive post-processing.

This method can print pieces that are hard or elastic. These continually printed parts are mechanically robust as opposed to the laminated structures common with other 3D-printing technologies, according to Azul 3D.

Thanks to a nonstick liquid that behaves like liquid Teflon, the technology of the machine bypasses the problem of large amounts of heat being generated during printing. HARP projects light through a window to solidify resin. The liquid flows over the window to remove heat and then circulates it through a cooling unit.

“3D printing and HARP offer tremendous opportunities for manufacturing in tooling and for making end-use parts,” Hedrick said.

For more information about Azul 3D, visit www.azul3d.com.

Ken Schnepf is a freelance writer based in the Chicago area. He can be reached at kjsgbp1@aol.com.

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