CUTTING TOOL ENGINEERING

December 2019 | Vol. 71 | Issue 12

Hybrid machines put ‘done in one’ on the table

Also in this issue

› Economic predictions for manufacturing in 2020
› The lead angle’s impact on indexable facemills
› Finish tight-tolerance holes with reaming
The Complete CHAMELEON Line for Holemaking!
The Only Range of Indexable Heads from 4*-40mm

with 2 or 3 Effective Cutting Edges for Robust Drilling

**SUMO CHAM**
Chamdrill Line
4 - 32mm

**LOGIQ 3 CHAM**
Three Flute Chamdrill
12 - 25.9mm

**CHAM 10 DRILL**
250 Line
33 - 40mm

* The smallest indexable drilling head in the world

Download ISCAR WORLD Now!
All ISCAR’s online apps, interfaces, and product catalogs in a single space.

www.iscarmetals.com
Solution for Chip Control in Grooving!

Stable Locking System for your grooving application!

Excellent stability allows for increased depth of cut!
Superior breaker designs for better chip control!

✓ grooving
✓ face grooving
✓ deep grooving
✓ side turning
✓ cut off
✓ internal & external applications

Call or e-mail to request a copy of our Flo-Cut catalog!

800-345-2815 or sales@toolflo.com
www.toolflo.com

Call us! We have it!
For over 50 years, Hurco has been empowering machinists of every generation with cutting-edge control technology that’s easy to learn and easy to use. See which one of our 65+ models of CNC machines is right for you.

Hurco.com/MyGeneration
CUTTING TOOL ENGINEERING®

You know you want it.

C’mom, be a subscriber. Sign up today and start receiving the magazine for metalworking professionals.

Choose your option:

1. Text or email your completed form below to cte@stamats.com.

2. Go to ctemag.com, click the Subscribe button and follow the instructions.

3. Fax your completed form to 319-364-4278.

SUBSCRIBE NOW!

1. Do you wish to receive/continue to receive CUTTING TOOL ENGINEERING free of charge?  ❑ YES  ❑ No

Your subscription serves as authorization for future notices via fax or email.

Signature ___________________________ Date ____________

Name ___________________________ Title ___________________________ Company ___________________________

Address ___________________________ City ___________________________ State ______ ZIP________

Phone ___________________________ Fax ___________________________ Email ___________________________

2. Your job title (check one):
   1. ❑ Corporate Manager (Owner, Chairman, President, VP, GM or other corporate manager);
   2. ❑ Engineering Manager (Supervise Engineering Personnel);
   3. ❑ Engineering Department (Non-Supervisory Position);
   4. ❑ Production Manager (Supervise Production Personnel);
   5. ❑ Production Department (Non-Supervisory Position);
   6. ❑ Design, R&D;
   7. ❑ Purchasing;
   8. ❑ Quality Assurance, Control;
   9. ❑ Other (please specify)

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.
   1. ❑ 1-9  ❑ 10-19  ❑ 20-49  ❑ 50-99  ❑ 100-249  ❑ 250-499  ❑ 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)
Table of Contents
December 2019 Volume 71 Issue 12

COVER STORY
24 Add It Up
Are hybrid machine tools the next big step in the evolution of manufacturing?
Cover image courtesy of Okuma America Corp.

FEATURES
32 Solid, Not Stellar
Industry experts foresee a respectable 2020 for manufacturing.

DEPARTMENTS
8 Lead Angle
10 Metalworking Product Review
14 Manager’s Desk
16 Machine Technology
18 Shop Operations

38 Taking the Lead
How the lead angle of an indexable facemill influences its use.

46 Regarding Reaming
Reaming is a cost-effective, reliable way to finish tight-tolerance holes.

51 Video Showcase
Companies and products are highlighted.

52 Ask the Grinding Doc
55 Advertisers Index
56 Look-Ahead

DECEMBER 2019  Volume 71  Issue 12
Alberti is the master craftsman behind the most innovative angle heads on the market, with products that ensure reliability and enhance machining performance.

**ANGLE HEADS**

Built for speed and designed for ultimate precision, Tsudakoma rotary tables diminish user error and amplify productivity. Our integration team handles all installs on-site, so you can start increasing production today.

**ROTARY TABLES**

From entry level to advanced models, Koma Presetters are designed to reduce set up time & optimize manufacturing performance at an affordable price.

**PRESETTERS**
What's new at www.ctemag.com

The Grinding Doc cautions shops about improving coolant in all grinding operations. Depending on the type of grinding and the job requirements, less coolant can be more. 

With LaserPlus from Anca Inc., operators can measure tool geometries in process to within ±2 µm.

Terry Iverson, author of Finding America’s Greatest Champion, discusses manufacturing careers with a millennial who attended the fall meeting of the United States Cutting Tool Institute.

Give a round of applause to Index Corp., Noblesville, Indiana, for hosting its first Manufacturing Day event in October. More than 150 students visited technology and education stations throughout the facility. See this and more on CTE social media.
Two world leaders in industrial process fluids, Quaker Chemical and Houghton International, have come together as one company to keep our metalworking customers ahead in a changing world.

As Quaker Houghton, we are proud to partner with metalworking industries around the world that are driving a sustainable, more prosperous future. We work with your teams to deliver expertise, service, and advanced technology related to industrial process fluids.
As additive manufacturing and 3D printing of metal and composite parts continue to make inroads into production environments, the need to efficiently and effectively finish-machine parts when that step typically is required gains importance.

One way to do it is with a hybrid machine tool, which performs both additive and subtractive operations. A feature article about these machines by contributing writer Kip Hanson appears on Page 24, and the Look-Ahead column by freelance writer Ken Schnepf covers the MasterPrint 3D printer from Rockford, Illinois-based Ingersoll Machine Tools Inc. The machine 3D-prints and mills extra-large, single-piece composite and metal parts. (See Page 56.)

Other times, printed parts that require machining are moved to another machine for material removal after the build process. Nonetheless, they first must be cut from the build base, such as with a conventional wire EDM or a bandsaw. An alternative method is from GF Machining Solutions LLC, Lincolnshire, Illinois. The machine tool builder offers the new AgieCharmilles Cut AM 500 horizontal wire EDM for cutting off additively manufactured parts from build bases. The EDM cuts parts without pressure, damage or material alteration, and there is minimal material waste, according to the company. See contributing writer William Leventon’s Machine Technology column on Page 16 to learn more.

I had the opportunity to see the Cut AM 500 during a GFMS-sponsored trip to company facilities in Switzerland, which included a tour of its EDM factory in Losone. My fellow travelers included GFMS customers and some of their spouses, as well as a few other members of the trade press. While at the EMO Hannover trade show in Germany, I saw the EDM demonstrated. It was the first time I attended the massive metalworking event.

Another highlight of the trip was the tour and inauguration of the company’s new innovation and production center in Biel. After a two-year construction period, the factory for building milling machines was completed in May at a cost of about $100 million. The center has an area of about 44,000 sq. m (473,612 sq. ft.).

“From this new location, we will be able to strengthen our position as a global player and at the same time rely on our Swiss roots,” said Pascal Boillat, president of GF Machining Solutions Management SA, during his speech at the event.

In addition to seeing two milling machines that the company has not officially launched yet, the new Uniqua human-machine interface and a presentation about factory digitization, I learned more about GFMS’ DMP Flex 350 and DMP Factory 500 metal 3D printers. GFMS designs the machines for industrial applications, and 3D Systems Inc., Rock Hill, South Carolina, handles the printing portion. That sounds like a hybrid partnership.
Introducing an all new Oil Hole Design
Allowing Better Coolant Flow for Longer Tool Life!

REVOlutionizing Drilling

NACHI’S New Aqua REVO Drill

www.nachiamerica.com
888-340-8665
Metalworking Product Review

CNC SENSOR MONITORING SYSTEM FOR NUMEROUS APPLICATIONS: Caron Engineering Inc. has increased the versatility of the DTect-IT system so it now can communicate with multiple sensors, including vibration, strain to measure force, high precision power and analog. The latter allows connecting any sensor with a 0 to ±10 VDC analog signal and 4 to 20 mA current signals. Using limit analysis, the user can set limits to monitor any of the compatible sensors.

Caron Engineering Inc.; www.caroneng.com
Greenleaf Corporation is ISO 9001 Certified.

Kick your automotive machining into overdrive. Accelerate your performance with the high-temperature and abrasion resistance of XSYTIN®-1, a revolutionary phase-toughened ceramic insert grade.

DUST AND FUME COLLECTOR CONNECTS INTO METALCUTTING SYSTEMS: The Gold series X-Flo Package dust and fume collector from Camfil Air Pollution Control integrates with CNC laser and plasma cutting systems. The compact collectors are prewired, and ship fully assembled, which enables a user to plug them directly into the cutting line. It is equipped with two, four or six HemiPleat eXtreme Gold Cone X-Flo filter cartridges. Camfil Air Pollution Control; www.camfilapc.com

XSYTIN®-1

Kick your automotive machining into overdrive.

Accelerate your performance with the high-temperature and abrasion resistance of XSYTIN®-1, a revolutionary phase-toughened ceramic insert grade.

For more information, visit www.greenleafcorporation.com/xsytin-1.
Metalworking Product Review

PIVOTING EDGE CLAMP FOR TALL PARTS: Carr Lane Manufacturing Co.’s pivoting edge clamp is suitable for holding large castings and other tall workpieces. It converts easily from manual to hydraulic operation. The pivoting jaw simultaneously exerts clamping force forward and downward. The slotted base enables adjustment and has a tapered top surface to prevent the clamp from moving.
Carr Lane Manufacturing Co.; www.carrlane.com/pec

JAW NUTS AND KEYS IMPROVE CHUCK ACCURACY: Manufactured from 4140 heat-treated steel, Dillon Manufacturing Inc.’s jaw nuts and keys enhance wear resistance, impact resistance, tensile strength and jaw life. They are available to fit all popular chucks from 152.4 mm to 609.6 mm (6" to 24") in diameter and are suitable for workholding applications that involve high-speed machining. Standard sizes are stocked for immediate shipment.
Dillon Manufacturing Inc.; www.dillonmfg.com

TAPPING ARM THREADS QUICKLY, CONSISTENTLY: FlexArm Inc. offers the GH-45 hydraulic tapping arm with a 38.1 mm (1½") capacity in mild steel. The GH-45 reaches from 508 mm to 1,981.2 mm (20" to 78") and operates at variable speed from 110 to 500 rpm. The arm works from a 480v power source and includes five quick-change tapholders.
FlexArm Inc.; www.flexmachinetools.com

ENDMILLS WITHSTAND ABRASIVE WEAR: Inovatools USA LLC says its HQ line of CVD diamond-coated endmills is effective for machining abrasive materials, such as graphite and composites. The smooth diamond coating enhances chip evacuation and swiftly dissipates heat from the tool/workpiece interface, making the cutters suitable for minimum quantity lubrication and dry machining.
Inovatools USA LLC; www.inovatools.eu
**SHRINK-FIT SYSTEM IS INDUSTRY 4.0-READY:**
Haimer USA LLC’s Power Clamp Comfort i4.0 shrink-fit toolholder system enables digital connectivity and communications of tools and machines. The system is network-compatible and comes with a 177.8 mm (7”) touch display. Standard equipment includes a rotary table with three stations, a cooling manager and single-spider chuck support for the rotary table.
Haimer USA LLC; www.haimer-usa.com

**DIGITAL HARDNESS TESTERS ARE AUTOMATED:**
The L.S. Starrett Co. has introduced the 3823 and 3824 (pictured) digital Rockwell/superficial Rockwell benchtop hardness testers with automated load/unload procedures. The models feature a closed-loop control unit with a load cell, a direct current motor and an electronic measurement and control unit.
The L.S. Starrett Co.; www.starrett.com/hardness

**AUTOMATIC GUIDED VEHICLES FOR PARTS PRODUCTION:**
Liebherr Automation Systems Co. combines AGVs and bin picking to transport workpieces from unfinished parts to finished parts between the respective stages of production. After a 3D vision system optically scans the workpiece environment, a robot uses this information to unload randomly stored parts from a container and position them on an AGV.
Liebherr Automation Systems Co.; www.liebherr.com

**SPADE DRILL INSERTS ENHANCE STABILITY:**
SV-Point spade drill inserts from YG-1 Tool Co. Ltd. are suitable for machining a variety of workpiece materials, including steel, stainless steel and cast iron. The inserts have an H-coating for high heat and wear resistance and a positive rake angle to impart a fine hole finish.
YG-1 Tool Co. Ltd.; www yg1usa.com
It’s hard to believe that December is already upon us, but the calendar on my wall reminds me every day. Reflecting on 2019, it has been a busy and, at times, crazy year from a business standpoint. Much was accomplished, but some tasks were not quite achieved. For me, 2019 also represents the realities of life for which people rarely are prepared.

The year included the unexpected passing of several friends and acquaintances. Employees encountered similarly dramatic circumstances. Parents aged. Even a few valued contacts in the machine tool industry retired or changed careers.

These events brought a serious degree of reality into my life — that is, the realization that time marches on and eventually something unexpected will negatively impact our lives and the activities at our shops.

Thankfully, though officially retired, my parents remain healthy and active and continue to share their valued advice from many years of operating a machine shop. It’s a continuous endeavor that I still try to improve.

Eventually, my wife became more involved in the business after our kids grew up, and the reality of running such an operation set in with her as well. From interpreting financial statements and meeting with insurance agents and accountants to dealing with employee issues and greeting guests, one must do it all — among numerous other duties — with a smile. And like it or not, work doesn’t always stop after leaving the office. Work continues at home, providing time for important discussions and decisions.

Way back when, my parents did a good job handling the responsibilities and shielding the rest of the family from the related stress. But understandably, they grew ready to retire and transfer these responsibilities to the next generation.

That scenario brings me back to my original point of facing the unforeseen. What would happen if someone important at your company suddenly passed away or was incapable of working? If you have a family business, do you have a contingency plan for losing a family member or key employee?

Years ago, these possibilities seemed distant and not deserving of much thought. But now, it’s me, my wife and my brothers providing personal information to financial institutions, signing contracts and guarantees, negotiating deals, collecting receivables from deadbeat accounts, filing tax returns and generally protecting our assets.

Because so many machine shops are small or family-owned, survival of these businesses depends on the ability to deal with unexpected emergencies. The roles for me, my wife and my brothers will continue to evolve as we become the glue that holds it all together. Hopefully, our parents can enjoy retirement without worrying about the business. They certainly deserve that.

This year, I’ve seen unexpected events impact companies, lives and families. This has brought into focus the realization that any of us could be next — prepared or not. As we conclude the year and decade, I’m thankful to end this one and embark on another. 2020, here we come. Happy holidays from my family to yours.

Keith Jennings is president of Tomball, Texas-based Crow Corp., a family-owned company focused on machining, metal fabrication and metal stamping. Contact him at jennings4176@yahoo.com.

about the author

Keith Jennings is president of Tomball, Texas-based Crow Corp., a family-owned company focused on machining, metal fabrication and metal stamping. Contact him at jennings4176@yahoo.com.
HPM+ FOR ALUMINUM APPLICATIONS
HIGH-RPM MACHINES

Higher Speeds & Feeds
Increased Productivity
Improved Tool Balance
Reduced Machining Time
Radial Coolant Holes (available upon request)

Now Improved with Firm Hold Shank
Maintains shank concentricity and h6 shrink-fit tolerance.
Stronger grip to reduce tool pull-out and increase tool performance

www.pct-imc.com | 562-921-7898

PRECISION CUTTING TOOLS
Member IMC Group
ADDITIVE MANUFACTURING MAKES THE CUT

By William Leventon

To separate additively manufactured metal parts from build plates, a new wire EDM is billed as a dramatic improvement over traditional cutoff methods.

Unveiled at EMO Hannover 2019 by GF Machining Solutions LLC, Lincolnshire, Illinois, the AgieCharmilles Cut AM 500 quickly and efficiently separates 3D-printed parts from build bases, thereby speeding up production and lowering operational costs, according to the company. Accommodating part sizes up to 510 mm × 510 mm × 510 mm (20.08”×20.08”×20.08”), including the baseplate, and weighing up to 500 kg (1,102.3 lbs.), the machine uses 0.2 mm-dia. (0.008”-dia.) molybdenum wire to cut off additively manufactured parts at a maximum speed of 300 mm²/min. (0.465 in.²/min.).

The Cut AM 500 is a horizontal wire EDM for separating 3D-printed metal parts from build plates.

The system was developed to solve problems, such as part damage and geometrical inaccuracy, encountered by manufacturers that use bandsaws to separate additively manufactured parts from build plates. Employing a fully submerged wire EDMing process, the
Cut AM 500 cuts without pressure, part damage or material alteration. The process delivers ±0.1 mm (±0.004") cutting accuracy and a surface finish finer than 6 µm Ra (236.2 µin. Rₙ), GF Machining Solutions reports.

In addition, the Cut AM 500 reduces part contamination, which is especially important to risk-avoiding industries, like aerospace and medical. A key to success in this area is the dielectric fluid used in the machine, which isn’t as dirty as bandsawing coolants, said Eric Ostini, senior EDM product manager.

Besides taking the place of bandsawing, the horizontal Cut AM 500 is an alternative to standard vertical wire EDMs used to cut off additively manufactured parts.

“All the problems with a vertical wire EDM machine have been taken care of by this horizontal machine,” Ostini said.

Thanks to the horizontal orientation, he said, it’s easy to take a build plate from a 3D printer, place the cut part to fall away from the EDM wire. In contrast, when vertical EDMs perform this task, the part typically drops onto the wire, causing either a wire break or short circuit that results in machine downtime, Ostini said.

To speed up the separation process, the Cut AM 500 features what GF Machining Solutions calls fast wire technology, which helps make the system at least three times faster than standard EDMing, according to the company. Crucial in this regard is a different flushing process.

While conventional EDMs flush the cutting area with regular deionized water directed by nozzles, the Cut AM 500 uses a water-soluble chemical solution that the molybdenum wire drags into the cutting zone for flushing, Ostini said.

“If you can get really good flushing, you will optimize the speed of the process,” he said. “We run the moly wire at about 20 rpm, which is very fast.”

To reduce the cost of consumables and operator intervention in the process, the Cut AM 500 is equipped with dual wire spools that allow reuse of the molybdenum wire. The wire travels back and forth through the cutting area between the two spools until it breaks, which is usually after cutting off parts from about 12 build plates, he said. In cutoff processes employing standard EDMs, he said, the wire is disposed of after passing only once through the cutting zone.

GF Machining Solutions also offers a clamping and referencing option that permits users to move printed parts from one secondary subtractive process to another while they remain attached to the build plate. For example, the build plate could be palletized before the additive process begins and then stay on the pallet as the printed part is moved to a milling machine for additional work and finally to the horizontal wire EDM for cutoff.

The idea is to eliminate the normal remeasuring and other setup work required for secondary operations. In addition, palletizing build plates improves accuracy and repeatability and facilitates production automation.

Although currently uncommon in additive manufacturing, Ostini said, when industry “really starts to utilize this palletizing process, we will be ready for it.”
**Shop Operations**

**ENHANCING WORKER HEALTH, SAFETY**

By Alan Richter

Conventional metalworking fluids are effective at providing cooling and lubrication during machining, but they have critics. One is Fusion Coolant Systems Inc., which offers products for supercritical CO₂ (scCO₂) as an alternative to those fluids.

“Traditional metalworking fluids have had a place in this market for a long time at the expense of health and safety that goes along with the workers,” said Craig Happel, vice president of sales for the Canton, Michigan-based company. “It’s almost been a necessary evil.”

The well-documented risks to worker health and safety include respiratory harm and skin damage, such as dermatitis, and workers must be shielded from overexposure to chemical compounds in metalworking fluids, such as biocides, defoamers, chelating agents and surfactants. “It is basically a cocktail of chemicals that workers have been exposed to for many years,” Happel said about traditional coolant.

The company offers two scCO₂ products: Pure-Cut and Pure-Cut+. The former is a dry lubricant without oil. Pure-Cut is marketed primarily to medical device manufacturers, which often strive to avoid introducing contaminants to machined surfaces, Happel noted. “It’s a solvent, so it cleans while it machines.”

On the other hand, Pure-Cut+ has oil, but only a minute quantity, about 0.5 ml (0.017 U.S. fl. oz.), is applied each minute to achieve the necessary level of lubrication, he

With Pure-Cut+, about 0.5 ml (0.017 U.S. fl. oz.) of oil is applied each minute to achieve the necessary level of lubrication.
said. The oil, however, completely dissolves inside the scCO₂ stream. “It’s almost like a coating or film being released, so we are able to get into microstructures,” Happel said. “Our particles are microsized, chilled ball bearings.”

The warm stream travels through the machine tool and then quickly becomes cold when released from pressure as it moves to the cutting zone, he added. The standard operating temperature is -31.7° C (-25° F), which can be independently controlled, along with the lubrication level.

Happel contrasted that temperature with two metalworking fluids that are applied in a cryogenic state. The temperature for liquid nitrogen is about -196.1° C (-321° F), and the temperature for traditional CO₂ is about -78.3° C (-109° F). The temperature of scCO₂ makes it relatively safe to touch. “If you touch liquid nitrogen, that’s pretty much a guaranteed trip to the emergency room, and it’s not a fun day for you,” he said. “We are not cryogenic. That’s a very important point.”

Happel emphasized that scCO₂
isn’t minimum quantity lubrication. “When you talk MQL, you have lubrication, but you don’t have the cooling effect that is needed in the machining process to keep those tools chilled.”

According to Happel, scCO$_2$ is effective for potentially any machining operation. “I’m sure there will be operations that we come across, such as broaching, that we just haven’t had the time to touch. But for your traditional machining operations — turning, milling, drilling, boring, reaming — we are all over them.”

The same holds for workpiece materials. The company began by targeting the technology toward the military and medical industries and the difficult-to-machine exotic alloys those manufacturers frequently cut, said Director of Engineering Scott Jones. Since then, Fusion Coolant Systems has branched out into other industries, such as aerospace and automotive, where aluminum and carbon steel alloys are common.

“We are consistently surprised and excited by the results,” he said. In addition, the technology isn’t just for metalcutting applications. “We have done a lot of machining of plastics lately for the medical implant industry and are seeing phenomenal results there as well,” Jones said.

The technology is scalable and therefore suitable for one machine or multiple machines, but Happel said the main challenge of getting scCO$_2$ onto a factory floor is manufacturers’ resistance to change. “You need a company that is looking for innovation, a company that

---

**about the author**

Alan Richter is editor of CTE. Contact him at 847-714-0175 or alanr@ctemedia.com.
is looking to improve their process, the environment and worker safety and health.”

Fusion Coolant Systems also implements the infrastructure that supports the technology, including CO₂, CO₂ storage tanks and CO₂ pumps, which aren’t foreign to many manufacturers, according to Jones. “It is equipment that most factories are well familiar with and completely comfortable having in their facility.”

He noted that because such a small quantity of CO₂ is released with scCO₂, the overall impact on a facility’s CO₂ concentration is essentially unchanged. Additionally, the company uses recycled CO₂ that is produced as a byproduct of other industrial processes, such as ethanol or ammonia production. “We are giving CO₂ a second life before it is released into the environment.”

Nonetheless, protecting the environment and health and safety of workers isn’t the primary reason part manufacturers turn to scCO₂, said Steve Skerlos, chairman, chief technology officer and founder. “The driver for Pure-Cut has been faster speeds, higher material-removal rates and longer tool life.”

A hole is drilled 30 diameters deep with the assistance of scCO₂.
Dear Doc: I cylindrical plunge-grind carbide with diamond wheels and steel with CBN and Al₂O₃ wheels. There’s disagreement in the shop about what to do with the workpiece rpm when burn occurs. Some say speed it up. Some say slow it down. Which is correct?

The Doc replies: The typical philosophy for many grinders is “When something bad happens, slow things down.” When it comes to burn in cylindrical plunge grinding, this is absolutely wrong. Let’s look at the general trends.

Increasing the workpiece rpm leads to: lower workpiece temperature and lower risk of burning or cracking (almost always); more wheel wear (usually); rougher (higher \( R_s \) ) surface finish (almost always, but often the change isn’t that large, and spark-out frequently negates it anyway); and increased risk of chatter (usually).

Conversely, decreasing the workpiece rpm leads to: higher workpiece temperature and greater risk of burning or cracking (almost always); less wheel wear (usually); smoother (lower \( R_s \) ) surface finish (almost always, but often the improvement isn’t that large, and spark-out frequently negates it anyway); and decreased risk of chatter (usually).

Keep in mind that all these trends are for cylindrical plunge grinding. If you’re doing cylindrical traverse, then everything I’ve written here is wrong. To further complicate things, if you’re doing cylindrical plunge with oscillation, all these trends apply if the workpiece always stays on the wheel — provided that you don’t have significant wheel wear, such as in grinding PCD or PCBN with diamond or grinding high-vanadium HSS with Al₂O₃. If the workpiece leaves the wheel or if there’s huge wheel wear, then the trends may apply. If you have a swivel on your wheelhead — for example, the typical 30° swivel — then all these trends apply on both the OD and the shoulder. Finally, they all apply for both cylindrical OD plunge and cylindrical ID plunge.

A common situation with my customers who grind carbide with a diamond wheel is as follows: They want to increase feed rates, but when they do, they get too much wheel wear or form breakdown. This is caused by the increase in aggressiveness — or if you prefer, chip thickness — when they increase the plunge velocity. The figure shows a quick, easy formula to keep aggressiveness constant while increasing the feed rate.

Let’s say you’re cylindrical plunge grinding...

about the author

Dr. Jeffrey Badger is an independent grinding consultant. His three-day High Intensity Grinding Course will be held Feb. 18-20 in Columbia, South Carolina, and April 6-8 in Springfield, Massachusetts. For more information, visit www.TheGrindingDoc.com.
EcoCvelox

The Modular CNC Solution for Parts Deburring and Cleaning

- Optimum ratio of process time to machine cycle time
- Easy implementation of new part types
- Intuitive user interface for quick and easy operation
- Linear-motion deburring process with 5-axes
- Short cycle times of 15 seconds per pallet
- Wide variety of part types
- Compact and modular layout
- Automatic or manual loading

www.ecoclean-group.us

ECOCLEAN
technology that inspires
By Kip Hanson

Additive manufacturing — particularly metal additive manufacturing — is having a profound effect on the way companies make things. U.S. aerospace manufacturer Pratt & Whitney, for example, 3D-prints production quantities of the compressor stators and sync ring brackets for its PurePower Geared Turbofan engine. Medical manufacturer Mantiz Logitech Co. Ltd. of South Korea uses additive manufacturing to produce titanium spinal implants. U.K.-based HiETA Technologies Ltd. specializes in metal 3D-printed modular heat exchangers. That’s just a small sampling.

There’s only one problem with these and countless other 3D-printing applications: The metal parts coming off these machines often...
require extensive post-processing. At the very least, this means slicing parts off the “build” plate, heat treating to remove internal stresses, then bead blasting or vibratory finishing. Various features demand machining as well in most instances. Threaded holes must be reamed and tapped. Cosmetic surfaces necessitate a cleanup pass. Critical dimensions need milling, turning or grinding. All this drives up costs and extends lead times.

In this era of multitask machine tools, wouldn’t it be wonderful to eliminate some or all of these secondary operations and produce finished parts in a single operation rather than many?

Greater Than the Sum of Its Parts
Paul Kingsley, senior applications engineer for additive manufacturing at Okuma America
Corp., Charlotte, North Carolina, answered that question. The MU-V Laser Ex five-axis machining center and Multus U Laser Ex series lathe are equipped with a Trumpf-powered laser metal deposition system, providing AM and subtractive machining in one CNC machine tool.

It can be thought of as a cladding process, he said, except that blown powder metal and a laser are used to apply metal rather than wire feedstock and a welding gun. As with other additive processes, laser metal deposition deposits individual layers of material to build part features or even entire workpieces from the bottom up. The thickness and width of these layers depend fully on the machine builder, operating parameters and laser and nozzle configuration, but deposition rates are often 10 to 20 times that of competing powder bed fusion additive technologies, with 6.8 kg/hr. (15 lbs./hr.) or more not uncommon.

The difference is that a hybrid machine allows an operator to finish-machine 3D-printed layers or part sections anytime during the build process. This not only eliminates most secondary operations but permits the creation of part features that otherwise would be impossible to produce with purely AM or subtractive machining. In some cases, the laser also can perform other operations, such as drilling, texturing or hardening.

Despite these mind-blowing possibilities, hybrid isn’t for the faint-hearted.

“Just because you’re able to build a part doesn’t mean you’ve accomplished your goal,” Kingsley said. “Because the workpiece is constantly going from cold to hot and back again, there are metallurgical properties to consider. Also, the CAM people are still playing catch-up, so the programming can be a bit challenging. And you’d better have good involvement from your customer, especially if you’re making aerospace or medical parts. It’s a completely different way of making parts. You have to learn...”
new techniques and have the time and money for a good bit of testing and process development.”

Adaptive Cruising

Nils Niemeyer, product manager at DMG Mori USA Inc.’s Additive Manufacturing Excellence Center in Hoffman Estates, Illinois, said in-process machine monitoring makes things much easier. That’s one reason why the company equipped its Lasertec 3D hybrid five-axis machining centers and turn/mill lathes with melt pool monitoring and sensor-based software tools. (The melt pool is the area where the laser and powder meet.) He said these features aid in preventing build failures while providing more homogeneous metallurgical properties in the completed part.

“We developed AM Monitor to continuously track and manage the additive manufacturing process, allowing the user to adjust laser power and other build parameters in real time or automatically based on different operating conditions,” he said.

“For instance, there’s a camera that monitors temperatures throughout the machine chamber. We have sensors for powder flow, can detect whether there’s any material adhering to the nozzle and have a distance sensor that helps to maintain a consistent gap between the nozzle and workpiece. It’s like the adaptive cruise control feature on a newer car.”

DMG Mori USA also is addressing the aforementioned CAD/CAM gap, working with Siemens NX to develop onboard additive and subtractive programming and simulation software and making a complicated process relatively easy to use. Because of this, Niemeyer said hybrid production is gaining popularity for a range of applications.

about the author

Kip Hanson is a contributing writer for CTE. Contact him at 520-548-7328 or kip@kahmco.net.
including fixing damaged turbine blades and worn tooling. In one example, an automaker used the technology to increase die-casting mold life by a factor of five, replacing numerous machining operations and inconsistent manual welding with a single repair process.

Another possibility is the layering of dissimilar materials in a workpiece to enhance its thermal or wear properties, in essence creating a metal sandwich that has been virtually impossible to produce via conventional means.

“Rocket nozzles are another big application,” Niemeyer said. “Instead of waiting nine months for a casting, they’re simply building up an entire rocket nozzle within a few days. They can quickly prototype multiple designs, select whichever one shows the best performance, and because these are very much end-use parts, they can then go directly into flight-level production.”

Ambidextrous Manufacturing
What if a shop doesn’t have the budget for a new hybrid machine tool? Well, mainstream hybrid CNCs were pioneered as add-ons to existing CNCs, and Jason Jones, inventor of the Ambit laser cladding head and co-founder of Hybrid Manufacturing Technologies Inc., McKinney, Texas, said his company can turn most machining centers into metal

‘Just because you’re able to build a part doesn’t mean you’ve accomplished your goal.’

**Ambidextrous Manufacturing**

What if a shop doesn’t have the budget for a new hybrid machine tool? Well, mainstream hybrid CNCs were pioneered as add-ons to existing CNCs, and Jason Jones, inventor of the Ambit laser cladding head and co-founder of Hybrid Manufacturing Technologies Inc., McKinney, Texas, said his company can turn most machining centers into metal
3D printers for a fraction of the cost of a new hybrid CNC machine.

An Ambit head looks much like any other 40-taper toolholder and fits in any standard automatic toolchanger. Once in a machine spindle, the head connects with an auxiliary high-powered laser and powder metal feeder and can be used in the same manner and for the same purposes as a dedicated hybrid CNC machine.

Hybrid Manufacturing Technologies has taken the hybrid definition one step further, however, by offering Ambit laser drilling and ablating heads, Ambit heads with eddy current and ultrasound capabilities for nondestructive inspection and an Ambit head that 3D-prints polymers at rates “up to 200 times faster than a desktop printer and can be installed in a few hours,” Jones said.

He compares the state of 3D printing to the computer industry before the internet.
“Additive gained traction early on as a design tool and prototyping technique and because of that never followed the mainstream manufacturing ethos,” Jones said. “Because of this, the different additive technologies that have evolved over the years don’t work with one another, they don’t talk to one another and even companies that produce multiple types of additive systems wouldn’t think of combining them in the same machine. Our goal is to help break those barriers with a system that’s cost-effective and easy enough to use that anyone with a CNC machining center can leverage it.”

Hybrid Factory
GF Machining Solutions LLC, Lincolnshire, Illinois, also believes in hybrid manufacturing, albeit using a different approach. Jon Carlson, product manager of advanced manufacturing, said the machine tool builder chose not to establish its own 3D-printing capabilities but instead partnered with one of the pioneers of AM, Rock Hill, South Carolina-based 3D Systems Inc. to develop two additive machines.

“The DMP 500 and DMP 350 solutions are for manufacturers that need a scalable, production-grade metal additive system,” Carlson said. “We worked with 3D Systems to develop a co-branded,
co-manufactured 500 mm$^3$ (0.03 in.$^3$) printer equipped with three lasers and a quick-change powder management system, then equipped it with a System 3R carrier and an automated handling system. Each of the various components within the DMP 500 communicates with one another, and parts can seamlessly be passed from 3D printer to heat treating to a machining center, a mill/turn lathe, a grinding operation or whatever other post-processing is required."

Like the other companies in this article, GF Machining Solutions, in collaboration with 3D Systems, has addressed the unique challenges to AM. A DMP Monitoring tool set and a vacuum chamber help ensure part quality during the build process while 3DXpert software manages every aspect of the additive workflow — from part design and print preparation to optimization and execution — in the same file format.

“It’s a complete modular manufacturing solution,” Carlson said, “one where raw powder goes in and finished workpieces come out with minimal human intervention.”

Like the other companies in this article, GF Machining Solutions, in collaboration with 3D Systems, has addressed the unique challenges to AM. A DMP Monitoring tool set and a vacuum chamber help ensure part quality during the build process while 3DXpert software manages every aspect of the additive workflow — from part design and print preparation to optimization and execution — in the same file format.

“It’s a complete modular manufacturing solution,” Carlson said, “one where raw powder goes in and finished workpieces come out with minimal human intervention.”
Industry experts foresee a respectable 2020 for manufacturing.

By Michael C. Anderson

For people prone to worry about the state of the economy going into 2020, there has been news that could exacerbate concerns. For example, in September the closely watched Purchasing Managers’ Index hit its lowest point since the Great Recession. The index, calculated by the Institute for Supply Management, Tempe, Arizona, declined to 47.8% that month. October’s figure — the last available before this article went to press — saw a 0.5 percentage point increase but remained under 50%, which is the demarcation line between economic contraction and expansion. Timothy Fiore, chair of ISM’s Manufacturing Business Survey Committee, said October marked seven straight months of contraction in manufacturing. In a news release, he stated that in that month all but one of PMI’s subindexes registered at levels associated with contraction.

Along with these developments have been scores of headlines about the slowing global economy and worries regarding the effects of tariffs and the ongoing trade war with China. Also, after a record economic expansion of 124 months — over twice as long as the average length of 60 months — isn’t the economy overdue for a recession anyway?

Come in from the ledge. The good news is that, while acknowledging definite headwinds, industry prognosticators nonetheless see a solid if not stellar year ahead for manufacturing.

“The Fed is anticipating that 2020 is going to be similar to what we’re experiencing right now — about a 2% growing economy,” said...
Low Frequency Vibration (LFV) technology from Citizen

Avoid the problem of spiraling chips, entanglement of chips and built-up edges

- Handles broad range of shapes and materials
- Ideal for difficult-to-cut materials
- Increases tool life
- Reduces heat generation and power consumption

Laser System L2000 – THE Complete Manufacturing System

Laser Cutting, Welding and Conventional Machining on a Single Machine

- Faster than EDM machining
- Minimal burrs
- Near endless geometric shape possibilities
- Internal pulse generator with endless parameter possibilities
- Head assembly is completely liquid tight

www.marucit.com
William Strauss, senior economist and economic adviser at the Federal Reserve Bank of Chicago. “Which will be decent but not impressive, kind of trendlike. It’s like getting a B on your report card.”

He said the contraction needs to be viewed in context of what’s come before, namely huge growth. The 2% growth rate in 2019 is quite a step down from 2.9% in 2018, he said. However, 2018 benefited from the tax reform stimulus passed at the end of 2017.

The stimulus “kind of gave a sugar high to the economy that got us growing a bit more rapidly,” Strauss said. “But like all sugar highs, we came off of it. And we’re heading back down to the more trendlike rate of growth.”

Eli S. Lustgarten, president of ESL Consultants Inc., St. Louis, said the impact of the 2018 boom was so strong that almost every industrial sector built up a backlog of orders. “They couldn’t ramp up production fast enough” to meet the jump in demand, he said, meaning that orders will trail shipments in most markets heading into 2020. “They’re shipping to fulfill backlogged orders, but new orders have softened. Therefore, we’re looking at a peak of production. Production cuts are coming, and (production) will continue to decline into 2020. Next year will be a softer year in manufacturing. There’s little debate about that. But not terrible.”

With industrial production probably continuing to be sluggish for the foreseeable future, cutting tool demand will weaken in response, Lustgarten said. “Month-over-month demand has been volatile through most of 2019 but has trended downward since January,” he said. “We can expect cutting tool activity to continue to decelerate if not actually contract for the remainder of 2019 and likely into next year.”

Automotive and Aerospace

“Not terrible” isn’t exactly high praise, Lustgarten acknowledged, so he elaborated using the automotive sector as an example. Year-to-date sales of light vehicles in the U.S. have been 17 million.

“It’s been running at very high levels for the last couple of years,” he said. “The industry expectation is that over 17 million is above normal. So now it will trend downward to a more normal rate. The forecast for 2020 is in the 16.5 million range for sales and production, which is down but still mighty good.”

The aerospace market, despite distressing headlines about Chicago-based Boeing Co.’s 737 Max airplane, is also solid, said Richard Aboulafia, vice president of Teal Group Corp., Fairfax, Virginia. As of mid-2019, both Boeing and Airbus Group, Leiden, Netherlands,
had backlogs of firm orders: $444 billion for Airbus and $393.6 billion for Boeing. The industry is enjoying low interest rates, as well as a sweet spot for fuel prices.

“When fuel prices are high, ticket prices go up and/or airlines lose money,” he said. “On the other hand, when fuel is cheap, airlines will tend to hang on to older planes. They don’t have as much incentive to invest in lighter, more fuel-efficient models.”

Besides the industry being in a Goldilocks zone of “just right” for interest rates and fuel prices, Aboulafia said strong defense spending is helping.

Regarding the 737 Max, he pointed out that although deliveries are stalled while a safety investigation plays out, production of the plane has slowed but not stopped. He expects any technical issues to be resolved within about a year, though political complications may linger longer. More importantly, he doesn’t anticipate the issue to result in further major cancellations or deferrals.

“The Max is still a 12- to 14-year program,” Aboulafia said.

Global Headwinds

In addition to the tax stimulus wearing off, Strauss said the big change to the economy has been “a ramped-up headwind coming from the trade story. We began seeing tariffs put on the economy in early 2018 — steel, aluminum and appliances — but the economy largely seemed to absorb the initial jolt. But as we moved into 2019, there was a lot of stepped-up rhetoric of additional tariffs coming.”

That rhetoric has caused uncertainty for manufacturers as they’ve tried to figure out their global
supply chain logistics.

“They had to wonder how long would these tariffs persist?” Strauss said. “Would they change further? Would another country be added in? Questions that made planning extremely difficult.”

He said manufacturers have responded the way businesses typically do when faced with uncertainty: by delaying every decision they can delay. The result has been a drop-off in capital spending.

Along with the tariff issue are concerns about the ailing global economy.

“It’s not that the weakness that we’re seeing in our manufacturing sector is because some other part of the world is eating our manufacturers’ lunch,” Strauss said. “In fact, most manufacturers around the world are really struggling.”

He said Germany is probably in the worst position, with PMI figures showing that manufacturing in that country has been in the recessionary range for about seven months. And because Germany’s economy is a big engine for Europe’s economy, there are worries about potentially weak European performance affecting U.S. exports going into 2020.

Given how challenging global growth is now, “we might not be happy with trend growth here, but we’re still, all in all, the envy of the rest of the world,” Strauss said.

**Domestic Tail Winds**

There are positive influences on the economy too. These include still solid consumer spending and job growth, a pickup in residential investment and continued monetary easing, said Erik Lundh, senior economist at The Conference Board Inc., New York City. He expects consumer spending to soften slightly in the coming quarters but to keep propping up economic growth.

“Job growth remains on a slowing trend but is still growing fast enough to further tighten the labor market,” he said. “The unemployment rate now stands at a 50-year low.”

Gad Levanon, head of The Conference Board’s Labor Markets Institute, sees good news in the most recent employment numbers from the U.S. Bureau of Labor Statistics, pointing out that total nonfarm payroll employment increased by 128,000 in October.

“This is a stronger than expected gain given the negative impact from the GM strike,” he said, “which probably lowered overall employment by more than 50,000.”

The numbers for August and September were revised up significantly as well, Levanon said, showing that the trend in employment growth is higher than expected, probably in the range of 150,000 to 200,000. Such statistics portend a labor market that continues to tighten, which has the effect of pulling more

---

**Solid, Not Stellar**

Manufacturing employment increased by 49,000 workers in the 12 months after September 2018.
people into the workforce, including those from underrepresented demographic groups.

“With such solid employment growth,” he said, “consumer spending is likely to remain strong into the holiday season and keep the U.S. economy growing despite cautious spending by businesses.”

Also helping the economy are low interest rates. Strauss cited the Fed’s three interest rate cuts in the latter half of the year.

“That should probably add a little bit of wind to the sails of the economy and hopefully bring our inflation rate, which has been below the target of 2%, up closer to that target as we go into next year,” he said.

The interest rate situation should make consumers less wary when buying big-ticket items and let manufacturers invest more easily in capital equipment. And as for the longest economic expansion in U.S. history, there is no inevitable end.

“A lot of people note that the average expansion is about five years, or 60 months, and as we’ve gone twice that long now, we’re due for a recession,” Strauss said. “But that’s not how recessions happen. Nobody gets tired of making money. Nobody gets tired of growing. What actually happens is that the economy gets some kind of negative economic shock, and if it is bad enough, recession follows. But when it isn’t that bad, the economy recovers and keeps growing.”

He mentioned the equity market crash in fall 2018 as an example.

“The collapse led to a 20% drop in the stock market (in) the fourth quarter last year,” Strauss said, “and there were people out there saying, ‘Ah, here comes a recession. The time has come.’ And of course it just didn’t turn out to be that way.”

Recessions occur because of drastic events, not the flipping of a certain number of calendar pages. He said the Fed expects growth to continue at about a 2% rate through 2022.
Facemilling with indexable tools is common at shops. One does not have to look deeply into the offerings from indexable tool suppliers to realize that there are many tool designs. How to select the correct one for an application can be challenging. However, if the effects from the face-mill's main design features are understood, choosing a suitable cutter body becomes much easier.

One such feature is the lead angle of a tool. The lead angle is an angular dimension...
READY TO REDUCE YOUR COST PER PART?

The VCN-570C provides the ideal combination of precision, speed and power to maximize your output over the widest range of applications. Paired with the versatile and easy-to-use MAZATROL SmoothG Control you can achieve unmatched productivity.

Shape your future profitability with Mazak.

MazakUSA.com  |  (859) 342-1700
measured parallel to the cutting edge of the tool and to the face of the part being produced (Figure 1). The angle affects the way the tool performs, how it should be applied and how the finished part looks. Typical lead angles available in standard tools are 90°, 60°, 45° and 15°.

**Calculations**

It is worth trying to understand how a lead angle impacts the way that cutting forces are directed (Figure 2). The generated net cutting forces always react in the direction perpendicular to the cutting edge. Mathematically, to make it easier to comprehend these forces, they can be broken into two vectors: one in the horizontal direction and one in the vertical direction.

\[
F_A = F_N \cos (K) \\
F_R = F_N \sin (K)
\]

Figure 1 (left): The lead angle of a facemill can have a big impact on the way it performs. Figure 2 (right): Net cutting force can be divided into axial and radial components.
The amplitude of each vector shows where the larger of these two forces exists (Figure 3). Using a formula from basic trigonometry, how these forces should be divided can be calculated. Multiplying the net force ($F_{net}$) by either the sine or cosine of the lead angle tells what percentage of the forces is acting vertically and what percentage of them is acting horizontally.

Horizontal forces, which act perpendicular to the tool

<table>
<thead>
<tr>
<th>Lead angle ($K^\circ$)</th>
<th>Radial force ($F_R$)</th>
<th>Axial force ($F_A$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>88</td>
<td>99%</td>
<td>1%</td>
</tr>
<tr>
<td>75</td>
<td>93%</td>
<td>7%</td>
</tr>
<tr>
<td>45</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>21</td>
<td>13%</td>
<td>87%</td>
</tr>
<tr>
<td>15</td>
<td>7%</td>
<td>93%</td>
</tr>
</tbody>
</table>

This eye-opening fact shocks our competition.

100% of CTE subscribers request our magazine.

That’s right. 100%. No padding. No filler.

With limitless cutting tool modification and customization options at GWS Tool Group, there’s nowhere for your productivity to go but up.

MODIFY. SOAR. REPEAT.

CUTTING TOOL ENGINEERING

Get our 2020 MEDIA KIT NOW at ctemag.com.

custom comes standard

GWS TOOL GROUP

GWSTOOLGROUP.COM

100% of CTE subscribers request our magazine.
axis, are less desirable than vertical forces. Think of it as trying to push the facemill off-center. Forces moving in this direction can cause deflection, chatter and spindle tilt, all resulting in poor tool life and part quality. Vertical forces are much more desirable because they are parallel to the tool axis. This means they are directed straight up in line to the spindle axis, which has the entire rigidity of the machine opposing these forces. The machine is better equipped to handle forces in this direction, so the operation does not lose stability.

Axial Chip Thinning
The lead angle is also involved with a phenomenon called axial chip thinning, which is a result...
of the lead angle geometry and the feed rate. When the lead angle is equal to 90°, physical chip thickness is equal to the advance per tooth programmed into the machine. Because chip thickness is measured perpendicular to the lead angle, as the lead angle increases, chip thickness becomes thinner with the same advance per tooth (Figure 4).

Regardless of how much the chip thickness is influenced by chip thinning, chip thickness should adhere to the recommendation of the cutting tool manufacturer. This means increasing the advance per tooth \( F_z \) as the lead angle increases so the recommended chip thickness is maintained. If it becomes too small, the tool can rub and not actually cut the workpiece.

A second negative of not properly counteracting the effects of axial chip thinning relates to managing the heat produced when facemilling. If the chip becomes too small, it loses the ability to hold heat, which ideally should go into the chip and be carried away. When this heat transfer does not happen, the heat goes into the part or tool. Either is undesirable because that would hurt part quality or tool life.

Comparisons
Every choice brings advantages and disadvantages, so consider...
trade-offs among 90°, 45° and 15° facemills.

The biggest benefit of using a facemill with a 90° lead angle is that it can produce a square shoulder. (These tools sometimes are called shoulder mills.) Many times, particularly when finishing a part, the call is for a square shoulder. This could be not only at the bottom of a pocket but, if a taller wall is to be produced, by stepping down the cutter and taking multiple passes to produce the wall. This application would call for a true 90° lead angle. If it was not a true 90°, such as a facemill with a square insert, which typically can produce an 89.75° shoulder, it would not meet most finished part specifications. That small deviance would be visible in a tall shoulder.

The sacrifice is that 100% of the load would be in the axial direction, making chatter easy to generate. This limits the feed rate and explains why most 90° facemills have positive insert geometry to free up cutting forces. The lack of axial chip thinning restricts feeds and speeds as well.

It frequently has been said that every shop should have at least one 45° lead facemill because it evenly splits cutting forces, with 50% in the axial direction and 50% in the radial direction. Managing cutting forces this way provides stable, consistent cutting, allowing speeds and feeds to be maximized. The lead angle also furnishes good chip thinning. Because the actual chip is approximately 30% thinner, the feed rate must be increased by 30% to maintain the recommended chip load.

Not being able to produce a square shoulder in a finished part is the main disadvantage of this facemill, which is why it should be considered a roughing tool. Especially when preparing a part, an operation often calls for roughing material and has no shoulder requirement. In this case, it is much more efficient to use a 45° lead facemill to get higher material removal rates and a better balance of the cutting forces acting on the spindle.

Facemills with lead angles of 15° generally are considered high-feed mills. In other words, the application changes slightly from standard facemills. The lead angle is so extreme in this event that cutting forces and axial chip thinning become one-sided. Regarding cutting forces, 93% are in the axial direction, which is directed up through the spindle.
This makes a 15° lead cutter quite stable even with long overhangs or when machining deep pockets. Only 7% of cutting forces are in the radial direction.

The term high-feed mill describes the way a facemill with a 15° lead angle needs to run. The increase in the required advance per tooth compared with a 90° facemill is about 93%, so it is common to see recommended cutting parameters in the range of 1.27 mm to 1.52 mm (0.05” to 0.06”) advance per tooth. This generates high removal rates.

When parts are not clamped properly or have thin bottoms, cutting forces in the axial direction can have negative consequences. Remember the adage “For every action, there is an equal and opposite reaction”? Directing the majority of cutting forces into the spindle causes an opposite reaction in that the same forces push down on the part. So it has to be somewhat rigid and able to accept large cutting forces in the axial direction.

When an insert is tipped at an extreme 15° lead angle, it usually requires a very light DOC. The true DOC depends on the size of the insert. While this frequently is viewed as limiting, the intense feed rates can more than make up for the light DOCs, and the overall removal rates still can exceed that of a 90° facemill taking heavy DOCs at slower feeds and speeds.

Facemills come in different configurations. The varied designs are for specific intentions. Comprehending the reasons behind design characteristics helps an end user choose the correct tool for an application.

The lead angle is a trait that greatly impacts the way a cutter performs and the appropriate applications for a tool. The angle affects the shoulder left in a part, the direction in which cutting forces are applied and the actual chip thickness produced. Understanding these effects aids with selecting a cutter body and maximizing productivity.
By Christopher Tate

Creating close-tolerance holes is common at machine shops. Boring, grinding, broaching and EDMing are a few ways to produce these holes, but reaming can be most efficient depending on the application.

Multiple Methods

Boring and grinding generate geometrically accurate holes with fine surface finishes. But unlike reaming, boring and grinding require machinists to closely monitor tool condition. Boring tools are adjustable and call for a user to watch hole size and correct for tool wear. They must be reset after an insert is changed or indexed or the cutting edge is sharpened.

Grinding requires a user to periodically dress the grinding wheel, which necessitates adjusting the machine to maintain hole size. Because reamers typically do not allow diametric adjustment, they demand less attention than boring tools and grinding wheels, resulting in a more robust

This reamer has a replaceable carbide head, making sharpening easy and allowing users to quickly change sizes with minimal downtime. This style is efficient for repair operations in which volume is low and fast changeover is desired.

Reaming is a cost-effective, reliable way to finish tight-tolerance holes.
NTK can handle all your Aerospace machining needs using our winning hand of cutting tool grades.

**SiAlON Ceramic**
For a variety of HRSA applications

- **SX3** Roughing / Semi-finishing
  - Best Grade for Turning and Milling even newest HRSA Materials
- **SX5** Roughing / Interrupted cut
  - Best Grade for Roughing Waspaloy Scale
- **SX9** Roughing / Semi-finishing
  - Best Grade for Roughing Inco 718 Scale
- **SX7** Semi-finishing
  - Best Grade for Milling Inco 718

**BIDEMICS**
World’s new grade for HRSA materials

- **JX1 / JX3** Semi-finishing / Finishing
  - Cut HRSA @ 1600 SFM
  - Longer tool life vs. whisker
  - Produces mirror surface finish

- **JP2** Finishing
  - Cut HRSA @ 1700 SFM
  - 10-15x speed vs. carbides
  - Produces mirror surface finish

**Whisker Ceramic**
Versatile grade for HRSA materials

- **WA1** Semi-finishing / Finishing
  - General Purpose Grade

Wixom, MI | Toll free: 866-900-9800 | ctinfo@ntktech.com | WWW.ntkcuttingtools.com
Boring, grinding, broaching and EDMing are a few ways to produce these holes, but reaming can be most efficient.

**Regarding Reaming**

process. Reaming is not only more stable but faster than boring and grinding.

Broaching is efficient and accurate. However, broaching tools are expensive, and reconditioning them takes skilled toolmakers and specialized equipment. These costs can be difficult to justify in low-volume, high-mix environments. Reamers are relatively inexpensive and just as accurate with modest reconditioning costs. Machines and personnel for reconditioning reamers are common compared with those for broaching tools, which makes reaming tools more cost-effective.

Reaming and EDMing differ a lot and generally do not have overlapping applications, but the comparison is still worth mentioning. EDMing is excellent for creating tight-tolerance holes, especially in hard materials, yet reaming can be as accurate. Unlike EDMing, which requires a specialized machine tool, reaming may be performed on all traditional machine tools, such as knee mills, lathes and drill presses.

Really Reaming

Reamers are typically made of carbide or HSS and are available in countless diameters and flute styles, so reaming processes have a broad range of applications. In a testament to the efficiency and reliability of reamers, one tool manufacturer offers over 11,000 combinations on its website.

When used correctly, a reamer produces a round,
accurately sized hole with a glass-like finish. Reaming operations reasonably should hold diameters to within a ±0.0127 mm (±0.0005”) tolerance.

Reamers are end-cutting tools. Although their flutes appear capable of side cutting, like endmills, the lip of a flute does not cut. The corner where the flat end and the flutes meet is where work is done. Corners are never square. They usually are chamfered and sometimes have a radius. Corner geometry of the reamer allows it to enter the hole in a way that prevents it from altering the center location of the hole. The noncutting lip of the flute acts as a guide that supports the body of the reamer while in the hole, which stops the tool from wandering off the toolpath. The burnishing action gained from the noncutting lip also enhances surface finishes. When speeds and feeds are optimized, reamers impart a fine finish.

Reaming is a repeatable process and far easier to manage than similar methods, such as boring. Designing a repeatable reaming process is straightforward, but users should consider a few factors.

Key Considerations

Reamers must be sharp. Dull ones result in excessive tool pressure, which causes issues with hole geometry. In relatively soft materials, like aluminum, a dull reamer can deliver oversized holes because of built-up edge. In hard materials, such as tool steels, a dull reamer can lead to galling from poor chip formation.

Hole condition is important. Reamers are finishing tools and do not like taking heavy cuts. Delivering a hole with the optimal amount of stock is critical. Holes need enough stock to allow proper chip formation but not so much stock that a reamer has to exert too much tool pressure. Talking with an application expert at a tool manufacturer may be very helpful.

Before reaming, a hole must be straight. Reamers tend to follow the existing hole, so reaming a crooked hole typically yields another crooked hole. Reaming a crooked hole also can result in an oversize hole diameter.

Minimizing runout is crucial when reaming. Consider a 12.7 mm (0.5”) reamer with 0.0127 mm runout. The 0.0127 mm runout would cause the tool to create a 12.7254 mm (0.501”) circle when rotated. It can be difficult to maintain a 0.0254 mm (0.001”) tolerance when the runout of the tool drives the cutting edge past the upper end of the tolerance before entering the hole.

Some applications absorb small amounts of runout, but it is always
Ball Gage
instead of a cylindrical plug gage

Save time with the self centering spherical surface of the ball gage. When measuring a large number of holes it can be 100 times faster.

Put one or two flats on the ball and find any out-of-round holes. Measure how parallel the space is between two surfaces and or the size. You can get into inside diameters or inside spherical surfaces of rod end bearings.

- Bend the stem to reach inaccessible locations, in confined areas, down in a hole, inside a cavity or in a buried feature which cannot be seen.
- Mount the ball on a wire for flexibility to go around corners in pipe and tubing, for example.
- Easily measure the width of grooves or the surfaces of spherical and toroidal features.
- Accurately measure the pitch diameter of bearing races, threaded surfaces and of gears.

Ball Gage
instead of a cylindrical plug gage

Regarding Reaming

best for a tool to run true. Using floating reamer holders that mitigate runout is one way to overcome runout and misalignment. Certain reamers used in high-production, close-tolerance work rely on tool holders that do not float but instead have axial and radial adjustments, which allow removal of almost all runout from a tool. Some of these adjustments are sufficiently critical that they are performed on the machine tool so the reamer is “tuned” to the machine spindle.

I have found that reaming is the most cost-effective, reliable method of finishing close-tolerance holes. Tools are available in countless configurations, making them suitable for low-volume specialty work, like that found in a toolroom, or for high-volume activity, like that found at an engine manufacturing facility.

Known as a chucking reamer, this is by far the most common type of reamer. It is inexpensive and effective for the majority of applications.
FINISHING. In finishing applications, the DOC usually is fixed at one finish pass, so only the cutting speed or feed can be addressed. This video shows how CVD-coated cermet tools compare with PVD-coated and uncoated cermet and CVD-coated carbide when finishing 1045 steel. Kyocera Precision Tools Inc.’s latest CCX CVD-coated cermet grade maintained great wear resistance and was able to run at higher cutting speeds.

Kyocera Precision Tools Inc.; www.kyoceraprecisiontools.com

MULTITASKING. Mazak Corp.’s HQR-250MSY multitasking turning center features a very productive twin-spindle and -turret configuration for part processing and high-volume throughput. Watch the turning center demonstrate its ability to completely machine parts – from raw materials to finished parts – in a single setup.

Mazak Corp.; www.mazakusa.com

CUTTING. Low-frequency vibration is Marubeni Citizen-Cincin Inc.’s widely applicable cutting technology for avoiding spiraling chips, chip entanglement and built-up edge. With LFV cutting, "air cutting" time prevents the machining temperature from rising, which gives relief from various problems caused by chips and virtually eliminates the need for high-pressure coolant. LFV is ideal for difficult-to-cut materials in a broad range of shapes.

Marubeni Citizen-Cincin Inc.; www.marucit.com
To effectively serve boat building customers and remain competitive, Roswell U.S. LLC must design products, produce them and bring them to market as quickly as possible. At its Rockledge, Florida, facility, the company accomplishes that with flexible, productive machine tools.

CEO and Chairman Robert Os- well started the company, which does business as Roswell Marine, in Canada in 1998. He opened the Florida facility, which employs 48 people, in 2007. The company’s line of more than 400 products includes towers and accessories for wakeboard and water ski boats, swiveling board racks, Bimini tops and marine audio systems.

All manufacturing operations always have been performed in-house to better control product quality.

“From napkin sketch to customer-
ready product, we control all aspects of the product life cycle,” Os- well said. “Product and manufacturing flow is determined according to current industry best practices and all internal past captured data. We look for the best equipment and software that will keep us efficient and competitive.”

When the Florida facility needed additional equipment to increase its machining capabilities, the company compared offerings and selected machine tools from Mazak Corp., Florence, Kentucky. Roswell Marine’s most recent Mazaks include an HCN-8800 horizontal machining center and two HCN-5000 HMCs. The HCN-8800 has a built-in two-pallet changer. The HCN-5000s have 120-tool changers and are part of Mazak’s two-tiered 24-pallet Palletech automation system.

The modular palletized manufacturing system further boosts productivity of many of the company’s horizontal, five-axis and multitask machines. System configurations include one-, two- or three-pallet stockers; tilting load stations; centering load stations; part wash stations; and material storage. Overall, a system can accommodate up to 16 Mazak machines, six to 240 pallets and as many as eight loading stations for unattended operation.

John Runske, program implementation manager at Roswell Marine, said the 800.1 mm (31.5”) pallet size and maximum workpiece height of 1,450.086 mm (57.09”) of the HCN-8800 accommodate large parts, such as cast aluminum billets that may initially weigh 317.5 kg (700 lbs.) and end up at 31.8 kg (70 lbs.) after machining.

“We make parts from billet until we can produce them from a cast...
part,” he said. “The cast parts then allow us to reduce our lead time significantly.”

Lead time is reduced from about 12 to 14 weeks to a few days.

In addition to aluminum, the shop machines stainless steel and plastics. Parts measure from 25.4 mm × 25.4 mm (1”×1”) to 762 mm × 762 mm × 381 mm (30”×30”×15”). A typical day at the shop produces several different parts for up to four separate OEM customers.

“The quick interchangeability and flexibility of the Mazaks, especially the PalleTech system, is key to obtaining the manufacturing agility,” Runske said. “We can be running one part, then two hours later, for instance, we can run a completely different one, then an hour after that another different one.”

He said the palletized system allows the shop to prioritize and schedule prototype parts for the middle of production cycles by allocating some pallets to prototype work in the same cell.

Any finished product might consist of 120 to 150 separate components. The shop produces about 20,000 to 30,000 parts per month and annually introduces about 30 products to market. Product design cycles vary from eight months to two years.

“It is extremely critical that we meet our new product deadlines for our clients, who are comprised of the most premium boat manufacturers in the world,” Oswell said. — Article by Mazak Corp.

The HCN-8800 HMC has a built-in two-pallet changer and is for high-volume production of large, heavy parts.
at 60 rpm for the workpiece, 1,800 rpm for the wheel and a 1 mm/min. (0.04 ipm) feed rate. You want to increase the feed rate to 1.5 mm/min. (0.06 ipm). If you increase only the feed rate, the diamonds will dig in deeper, causing more wheel wear. Do this instead: Keep the wheel speed the same, but decrease your workpiece speed to 40 rpm (60 × 1 + 1.5 × 1,800 + 1,800 = 40). By doing this, your aggressiveness and wheel wear will stay the same.

If you want to get fancy, increase the wheel speed to 2,100 rpm and decrease your workpiece to 54.4 rpm [60 × 1 + 1.5 × (2,100 ÷ 1,800)]² = 54.4). Why increase the wheel speed? With the faster plunge velocity, you can keep the same aggressiveness by either decreasing the workpiece rpm or increasing the wheel rpm. For a fixed aggressiveness, a slower workpiece rpm means higher grinding temperatures. A faster wheel speed doesn’t. What’s more, the square term means that wheel speed has a bigger effect than workpiece rpm.

Play around with it and see what happens. The beauty of this equation is that you can use any units you want — rpm, sfm, meters per second, furlongs per fortnight — as long as you’re consistent.

---

**Ad Index**

<table>
<thead>
<tr>
<th>ADVERTISER NAME</th>
<th>PAGE #</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMAMCO Tool</td>
<td>43</td>
</tr>
<tr>
<td>ANCA CNC Machines</td>
<td>40</td>
</tr>
<tr>
<td>Bal-Tec</td>
<td>50</td>
</tr>
<tr>
<td>Ecoclean Inc.</td>
<td>23</td>
</tr>
<tr>
<td>Fixtureworks</td>
<td>49</td>
</tr>
<tr>
<td>Greenleaf Corporation</td>
<td>10-11</td>
</tr>
<tr>
<td>The Grinding Doc</td>
<td>50</td>
</tr>
<tr>
<td>Guhring Inc.</td>
<td>35</td>
</tr>
<tr>
<td>GWS Tool Group</td>
<td>41</td>
</tr>
<tr>
<td>Hurco Cos. Inc.</td>
<td>2</td>
</tr>
<tr>
<td>Iscar Metals Inc.</td>
<td>Cover 2</td>
</tr>
<tr>
<td>J.W. Done Co.</td>
<td>42</td>
</tr>
<tr>
<td>Koma Precision Inc.</td>
<td>5</td>
</tr>
<tr>
<td>Kyocera Precision Tools Inc.</td>
<td>Cover 3</td>
</tr>
<tr>
<td>Marubeni Citizen-Cincom Inc.</td>
<td>33</td>
</tr>
<tr>
<td>Mazak Corporation</td>
<td>39</td>
</tr>
<tr>
<td>MERSEN</td>
<td>19</td>
</tr>
<tr>
<td>Nachi America (Cutting Tools)</td>
<td>9</td>
</tr>
<tr>
<td>NTK Cutting Tools</td>
<td>47</td>
</tr>
<tr>
<td>NT USA Corporation</td>
<td>48</td>
</tr>
<tr>
<td>Platinum Tooling Technologies Inc.</td>
<td>48</td>
</tr>
<tr>
<td>Precision Cutting Tools</td>
<td>15</td>
</tr>
<tr>
<td>Quaker Houghton</td>
<td>7</td>
</tr>
<tr>
<td>Royal Products</td>
<td>53</td>
</tr>
<tr>
<td>Seco Tools LLC</td>
<td>27, 29, 31</td>
</tr>
<tr>
<td>Star SU LLC</td>
<td>28, 45</td>
</tr>
<tr>
<td>TechMet Carbides Inc.</td>
<td>20, 21</td>
</tr>
<tr>
<td>Tool-Flo Manufacturing Inc.</td>
<td>1</td>
</tr>
<tr>
<td>Tungaloy America Inc.</td>
<td>Cover 4</td>
</tr>
<tr>
<td>Walter USA LLC</td>
<td>37</td>
</tr>
<tr>
<td>Zebra Skimmers Corporation</td>
<td>53</td>
</tr>
</tbody>
</table>

The Advertisers Index is provided as a courtesy to advertisers. Every effort is made to avoid errors, but should one occur, CTE is not responsible.
Look-Ahead

LIVING LARGE WITH 3D PRINTING

By Ken Schnepf

Size matters, and the MasterPrint 3D printer with milling capabilities is living large. Built by Ingersoll Machine Tools Inc., Rockford, Illinois, the printer is part of a new line of additive manufacturing equipment that seamlessly programs, simulates, 3D-prints and mills extra-large composite parts in a single piece.

With the University of Maine, MasterPrint 3D-printed a hollow beam structure 7 m long × 1.6 m wide × 1.8 m tall (23'×5.2'×5.9') with over 2,155 kg (4,751 lbs.) of carbon fiber-reinforced acrylonitrile butadiene styrene, said Piergiorgio Assandri, business director of composites and additive at Ingersoll Machine Tools. The machine prints a wide array of materials in various orientations and finishes parts with five-axis milling. The company says part manufacturers can benefit by combining their traditional skills with MasterPrint's disruptive processes.

He said the platform can handle polymers and aluminum and has a working volume of 12 m × 4 m × 2.5 m (39.4'×13.1'×8.2'). The five-axis milling head runs at 25 kW (33.5 hp) and 18-rpm max spin using an HSK 63A toolholder. Designed for fast prototyping and making aerospace and naval molds, the printer can serve a wider market, namely companies needing wide and tall parts that are cost-effective, quick and reliable. MasterPrint uses a Siemens Sinumerik 840D sl CNC. Everything is fully automated, including changing cutting tools.

Aerospace manufacturers have selected thermoplastics capable of enduring the autoclave process that wings, fuselages and nacelles go through. The lead time for Invar molds was months. Once the molds were made, any refinements to them for the geometries of the related aerostructures added more time and expense. With MasterPrint, lead time is shortened to weeks, he said, and manufacturing costs are reduced by 90%.

“At pretty much the same time, the naval sector … saw the opportunity to print and mill — first their own molds and then their entire boats — with MasterPrint,” he said. “Real boats, tens of meters long, (were) used as models to validate the hydrodynamics of their hulls before building them out of fiberglass.”

In addition, Assandri said the automotive industry plans to use MasterPrint to print and mill electric vehicle chassis and truck cabins.

An employee works with the MasterPrint 3D printer and five-axis milling machine.

about the author

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

The excellent wear resistant CCX turning grade is built for long tool life when high-speed finishing in soft steel, general steel, and cast iron. The unique design of the CCX cermet grade with a thick CVD coating is difficult to accomplish using conventional technology and provides greater wear resistance at higher cutting speeds.

Check it out: kyoceraprecisiontools.com/CCX
Interchangeable Head System with Quick Indexing

New DMC drill head with self-centering point and double margins, able to drill up to 12x D without a pilot hole.

Drill body available in 1.5xD, 3xD, 5xD, 8xD, and 12xD
Drill head available from DC ø0.236" to ø1.02" (ø6 to ø25.9 mm) in increments of 0.1 mm

Tungaloy America | info@tungaloyamerica.com | 888.554.8394
www.tungaloy.com/us