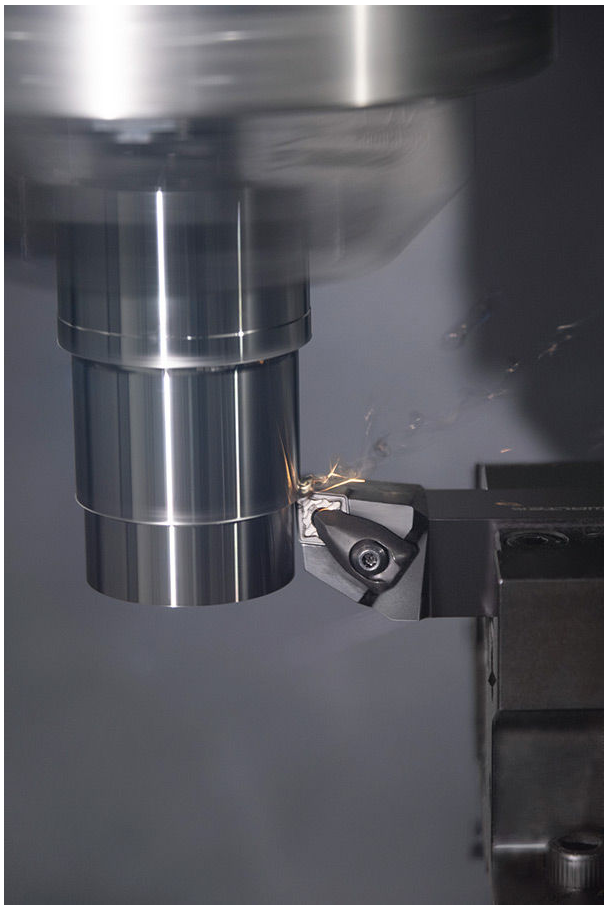
CNC Turning Technology Targets Its Many Facets

September 20, 2023

By **Jim Lorincz**
Contributing Editor,
SME Media

CNC turning, on all of its machine platforms—Swiss, conventional and multitasking—is getting smarter, faster and more versatile through cleverly designed tools and software combinations. Which companies and solutions are vying for leadership all depends on what knotty problem is being addressed.



Tiger·tec Gold grades for Steel 2023. (Provided by Walter USA LLC)

Chip control, especially for difficult-to-machine and so-called “gummy” materials, is always a prime target for ways to break bird-nesting chips into easy-to-handle, tiny, steel-mimicking chips. Unique, high-frequency cutting capability on CNC controls is leading the way. New tooling concepts for high-volume turning operations and

View All Articles

CONNECT WITH US

Enter CNC Turning and Swiss Style

When it comes to turning machine solutions, it's hard to argue with Mazak Corp., Florence, Ky. The company supplies sophisticated Integrex five-axis, multitasking machines to produce complex workpieces for aerospace, as well as its most recently introduced QT-Ez 12MY multitasking systems.

Aimed squarely at the job shop market, the QT-Ez is "putting Mazak quality and reliability within reach for virtually any shop with productive, space-saving efficiency at an affordable price," according to Greg Papke, vice president, sales and marketing for Mazak's Advantec Product Group. The QT-Ez fills a niche right below Mazak's ubiquitous Quick Turn machines.

For multitasking processing capability, Papke cites the QT-Ez's milling and Y-axis off-centerline capability. "For still more productivity, QT-Ez machine seamlessly integrates with a range of automation solutions. These include simple bar feeders and parts catchers as well as full cooperative robot installations such as Mazak's Automation Systems Cobot Cell," Papke says.

Targeting the growing market for high-mix/low-volume production of small and slender precision parts, Mazak has introduced its Syncrex series of Swiss style machines also manufactured in the Florence facility. The Syncrex machines feature improved design for machining of smaller parts from 12'- (3.66 m-) long bar stock in diameters of 1.5" (38.1 mm) or less. The series features one-piece-polymer, casting-machine base that is said to be 10% more rigid than cast iron with thermal control that reduces part variation by 25%. In addition, Mazak Dynamic Chip Control reduces long, stringy chips that can foul tooling and mar surface finishes, according to the company.

High frequency oscillation cutting breaks the gummiest materials into tiny manageable chips. (Provided by Absolute Machine Tool)

Targeting Tooling Solutions

Finding cutting solutions for precision turning applications—whether for conventional CNC, multitasking machining of complex workpieces or high-volume, Swiss-style production—means considering all relevant parameters of the application, says Sarang Garud, product manager, turning, drilling, boring, Walter USA LLC, Waukesha, Wisc. “I don’t take the shotgun approach. I prefer the rifle when it comes to formulating a cutting solution strategy with our latest technologies,” Garud says.

Walter’s turning tools cover ISO turning, grooving and parting off, as well as thread turning. Precision turning tools, boring bars and parting blades are available with standard ISO square shanks, as well as with all interfaces that are standard in turning applications.

“Turning is very specific,” Garud notes. “Everything matters and there are many parameters to consider. It all comes down to feeds and speeds and how our newest technologies fit the application’s specific requirements.

To learn the ins and outs of the shop’s turning application, Garud advocates an extensive checklist of questions about a shop’s process capabilities and operations. What kind of machine? How old? How robust? What kind of cut finishing/medium/roughing? Interrupted or not? Coolant? Material (steel, cast iron, stainless)? Difficult to machine? Chip control, chip breaker?

Walter’s latest innovation is the Tiger-tec Gold CVD grade, which can be used for applications from low-carbon steels to high-alloy steels. Steel and cast-iron solutions are closely related.

“The biggest challenges that shops face are still feeds and speeds, chip breaker and chip control, tool life and productivity improvement,” Garud notes. “Multilayer coating technology has introduced sophisticated ways

and TiAlN, multilayers of these coatings used in various combinations and thicknesses are able to reduce cracking that leads to tool breakage and flaking. A cobalt enriched substrate also adds to a tough substrate, further preventing chipping while not compromising the hardness and high-speed capabilities of the grade.

“One mechanism is achieved by introducing elasticity with a layered coating that includes TiCN that helps resist crack formation. Additional grain-oriented Al2O3 coating layers further improve crater wear resistance, allowing the grades to run much faster cutting speeds. The benefits to the shop are high process reliability, excellent surface finish and dimensional stability over the production run of steels or cast irons,” Garud says.

GWS’s form tools include all geometries and angles of the workpiece in the form tool. (Provided by GWS)

Confounding Chip Breakage?

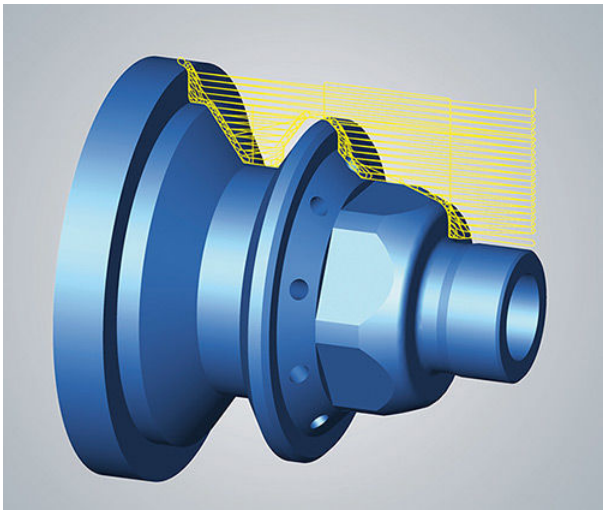
Chip breakage of exotic materials, stainless steels and those with high nickel content is always a challenge in turning operations, according to David Zunis, director of service and applications engineering, Absolute Machine Tools, Lorain, Ohio. “When turning these materials, chips tend to ball up and nest up, leading to insert and tool breakage, causing all kinds of problems, including broken tool arms for cutoff detection. The best condition you can have is breaking those chips into tiny little chips so that they fall away much like chips for carbon steel,” Zunis says.

Absolute Machine Tools’ solution is offering three of its CNC turning machine lines with CNC control options that feature oscillation cutting. All three Absolute brands—Nexturn Swiss machines, LICO CNC screw machines and Quick Tech hybrid-production turning machines—feature either the Mitsubishi CNC or the FANUC CNC with their oscillation cutting

“The difference between the two is that FANUC uses software to achieve its high-frequency cutting action, while Mitsubishi uses hardware to achieve the same results,” Zunis says. “The technique is achieved by oscillating the cutting axis at a frequency in the kilohertz range. It isn’t something that you can easily program using traditional programming practices. The action is to feed a little bit in any axis that is cutting, dwell or reverse a little, then feed a little more, then dwell and reverse, etc. A traditional program would be extremely long and labor intensive to prepare.”

Both controls are actuated by G-code, Zunis adds. There is a syntax that tells the number of vibrations, the frequency, the length of cut and how far the tool moves in one rev of the spindle. “Experience will help determine parameters to get in the ballpark,” Zunis continues. “It’s related to how far the tool moves in one revolution of the spindle to the feed rate. You want to break the chip at least once per revolution. That’s a good starting point. Some materials you can go around hundreds—or even thousands—of revs before chips become a major problem. Oscillation cutting capability works well on smaller machines where chips can have a major impact on machine operations.”

Robot Cells for One-Off, Serial Production



Simultaneous use of different axes in combination with round indexable inserts and advanced CAM software are the keys to trochoidal turning’s success. (Provided by Ceratizit and Open Mind Technologies)

For Hainbuch America Corp., Germantown, Wis., the acquisition of Vischer & Bolli Automation (VBA) expanded the automation technology available for turning and milling robot cells. VBA robot cells for turning and milling small parts up to 10 kg, VBA Robilo cells for 80-kg workpieces and even modular cells as large as 500 kg are available.

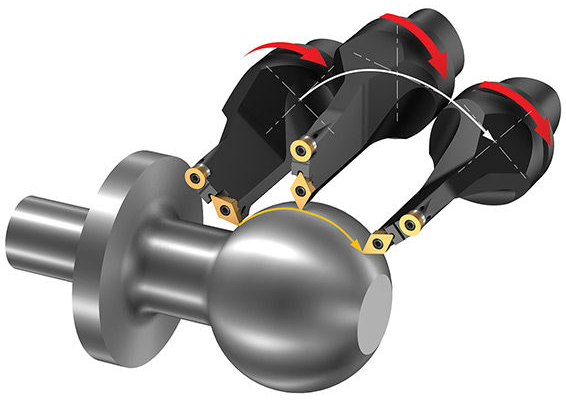
design of the cells lends itself to choosing the extent of functionality. Options include pallet-, workpiece- and toolholder-handling systems, as well as a master computer for entire cells.

Manufacturing processes can be completely flexible with the automated changing of mandrels and chucks. Clamping device changeover includes zero-point clamping systems for both turning and milling. In addition, Hainbuch's intelligent IQ clamping devices, both as a chuck for O.D. clamping and as a mandrel for I.D. clamping, facilitate upstream and downstream measuring processes. Workpieces are continuously measured for diameter, temperature, workpiece contact and clamping force. Measurement data are relayed to the machine controller for analysis via contactless data and energy transmission, closing the production loop.

Y-Axis Turning is Speedy, Versatile

Cutting tools that can improve quality, reduce cycle time and handle the most complicated shapes and pockets are difficult—if not impossible—to find, unless you are looking at the latest iteration of all-directional, Y-axis turning with a single tool from Sandvik Coromant US, Mebane, N.C. The Y-axis turning method continues to add to the company's earlier capabilities, such as its all-directional Prime Turning, non-linear turning and interpolation turning.

As the name implies, the new method makes use of the Y-axis and all three axes used simultaneously when machining. The tool rotates around its own center. The insert is placed for machining in the Y-Z plane and the milling spindle axis interpolates during turning. This allows intricate shapes to be machined with a single tool.



A combination of more capable modern machine tools and sophisticated CNC programming are driving the search for improved part quality. All-directional turning enables finishing complex shapes in a single cut without blend points. Wiper

Coromant)

surface to also produce a wiper effect on tapered surfaces, the company says. In Y-axis turning, the main cutting forces are directed into the machine spindle, offering high process stability. Maintaining a constant entering angle during machining means chips can be optimally controlled.

Two new tools have been developed to support Y-axis turning. The new CoroTurn Prime variant is suitable for shafts, flanges and components with undercuts. The CoroPlex YT twin-tool, featuring CoroTurn TR profiling inserts and CoroTurn 107 round inserts with rail interface, can be used for components with pockets and cavities.

Y-axis turning can also be used in static mode with a locked spindle for flexible two-axis turning with fast insert indexing. The method is suitable for all materials and requires a multitask machine, turning centers or vertical lathe with options to allow interpolation of the milling spindle axis during turning.

Form Tools vs. Indexables

Hainbuch's intelligent IQ clamping devices, both as a chuck for O.D. clamping and as a mandrel for I.D. clamping, facilitate upstream and downstream measuring processes. (Provided by Hainbuch America)

For CNC turning, whether Swiss-style or multiple spindle machines, GWS Tool Group, Nashville, Tenn., has developed a custom profiling inserted tooling system that replaces standard, single-point indexable tools with form tools. Cycles on CNC machines are reduced by replacing single-point tooling with toolholders that hold form or profile tooling that make a plunge move rather than making several passes with IC indexable inserts.

The benefits of highly engineered form tooling for turning include shorter cycle times, fewer tools, reduced number of setups and significantly

GWS's form tools include all geometries and angles of the workpiece. Carbide form tools allow more intricate profiles with tighter tolerances and improved cutting geometries, resulting in two to three times faster cycle times, Freeze says. Form tools that replace multiple IC indexable inserts reduce the chance of error and improve tool life, with form tools lasting for 1,500 to 5,000 parts compared with only several hundred for IC indexable inserts. Form tool life is two to three times that of single point tooling, according to Freeze.

GWS offers a number of profiling products, each featuring quick change replaceable heads and adjustable movements. They include:

ThriftTurn—approaching from the end, this two-flute inserted tool will profile the part with the ability to adjust each insert independently. Think face, radius/angle and a thread blank, similar to a welding tip.

ThriftPoint—approaching from the end, this single flute inserted tool will profile the part with the support of a bushing. Think face, radius/angle, similar to a needle valve.

Thrift Edge—approaching from the side, this inserted tool will profile the part. Think multiple grooves, cornerbreaks/radii, similar to a piston (four grooves at once).

Another important benefit of form tooling is that with all geometries and profiles of the part in the form tool, inspection can be done without checking every feature. "First and last piece inspection (per insert change) are enough to guarantee that all the parts in between were up to spec," Freeze says.

Applications for profiling with form tools include aerospace components, automotive workpieces such as bearings and shafts, hydraulic components, medical components and industrial products.

Lighter, Faster

Few among us would turn down turning results that produce a much higher metal removal rate when cutting difficult-to-machine materials such as stainless steels and nickel and titanium-based alloys. That is the promise of trochoidal turning, a machining strategy in which tool paths and the entry and exit movements are optimized to maximize metal

trochoidal turning's success.

Trochoidal turning is essentially separated into two strategies: "simple" done on conventional turning machines, and "simultaneous" performed on machines with B-axis movement. These turning strategies are similar to trochoidal milling, which combines a spiraling cutting path with straight-ahead motion. Turning similarly features lower depths of cut, higher feeds and faster cutting speeds than conventional turning.

Standard round turning inserts increase toolpath flexibility and permit smooth entry and exit from the workpiece. The insert is always in the cut, eliminating the time lost returning to a set point after every pass. Trochoidal turning performs longitudinal and face turning as well as radial and axial grooving. Because of the possibility of using high feed rates to get good chip breaking, the approach is also beneficial when turning soft but tough ductile materials that normally produce long chips that endanger operators and wrap around the tool.

Software provider Open Mind Technologies AG engineered hyperMILL software to expedite trochoidal turning on conventional CNC turning machines, enabling easy programming of trochoidal turning on standard three-axis turning machines. Using a multitasking machine with B-axis capability enables a shop to take full advantage of the benefits of trochoidal turning strategies.

Programming the additional axis is somewhat more complex than that for a three-axis machine, but the moving axis provides greater accessibility when turning complex parts and as a result is faster and more efficient. The round inserts combined with light depths of cut and the ability to rotate/swivel the cutting tool relative to the workpiece axis effectively creates more cutting edges and increases tool life. Regarding insert geometry and style, global toolmaker Ceratizit Inc. typically recommends its RCMT and RCGT inserts for trochoidal turning and GX24 inserts for trochoidal grooving using 4-6 mm nose radii and M3 chip breakers.

Increased feed rates put greater stress on machine tool components. Feed rate is directly proportional to metal removal rate and higher metal removal rates place larger demands on the machine tool spindle. However, round positive style inserts generally are softer cutting, so in most cases trochoidal turning is suitable for lower power machines.

including axles and shafts.

Turn-Mill, Mill-Turn on One Platform

Development of CNC control technology for multitasking machines brought turning and milling together on one platform for Siemens, according to Daniel Vitullo, business development territory manager for Siemens Industry Inc., Elk Grove Village, Illinois. “We developed turning and milling on a single platform, which makes transition from one technology to the other seamless,” he says. “Whether a turn-mill or a mill-turn, depends on which is primary functionality.”

To Vitullo’s way of thinking, the seamless connection is a major enhancement for machine-tool builders when it comes to adding processes like skivving, hobbing, grinding and other processes for customers. Adding functionality is a matter of opening up cycles and filling in the blanks. Simulation on the SINUMERIK ONE control helps operators know what’s going to happen when they run a complex part, Vitullo notes.

“For example, I have this complex part, and what I’m doing is opening up cycles and filling in the blanks adding turning to a mill,” he continues. “Tool orientation is managed by the cycles and the cycles manage the tools so I don’t have to. All I have to do is run the part. Visualization will show what’s going on.”

A significant piece of the machining puzzle is provided by the Digital Twin that resides within the SINUMERIK ONE CNC. “We’re not talking about conventional two-axis lathes. These machines represent million dollar and more investments in advanced machining technology,” Vitullo points out. “Our digital twin is native to the control. It simulates the operation of the multitasking machine. If I flip a tool around, the digital twin will recognize it and simulate the operation of the machine.”

Vitullo says, “It’s physically the SINUMERIK ONE control which is driving the machine, and the digital twin is driving that simulation with the same control. The digital twin and the physical machine use the same parameters and settings, this also includes travel limits and drive settings. For us, the digital twin is a true real-world simulation. This means when using the SINUMERIK ONE digital twin you have full-cycle support. If you call up the cycle for drilling or high-speed milling, the

machine's control. What most others do, they look at how our cycle works and they emulate it off the code from the post we run the same cycle in both simulation and at the machine," Vitullo explains.

"You can eliminate fear about running a complex part because all the travels, axis values and centers of operation are set up the same as the physical machine," he continues. "By combining cycle support and the digital twin, you get almost a fully closed loop process from development and testing of the part to running the part. The only thing that's missing in this scenario is inspection."

CASTING GRINDING & DEBURRING MACHINING & METAL CUTTING

Recommended For You

SMART MANUFACTURING

Collaborating with Robots

Between "Blade Runner," "Terminator," "The Matrix" and other blockbuster movies, Hollywood has painted a frightening picture—one in which intelligent machines attempt to destroy humanity.

By **Kip Hanson**

TOOLING & WORKHOLDING

Machine Tools for Toolmakers

Shown here: OPS Ingersoll's Eagle V5C, a "high-speed, ultra-rigid 5-axis vertical machining center (VMC) with enhanced cooling controls." (Provided by MC Machinery.

By **Kip Hanson**

MACHINING & METAL CUTTING

Mazak Brings Precision Machining to PRI 2023

Florence, Ky.—At this year's Performance Racing Industry (PRI) show, Dec. 7-9 in Indianapolis, Mazak will demonstrate three automation-ready machines designed with motorsports part production in mind.

By **Mazak Corp.**

MACHINING & METAL CUTTING

Building Better Blisks

The DVF-series five-axis machining centers are designed for high-precision machining of complex parts like this turbine component in a single operation. (Provided by DN Company.

By **Kip Hanson**

MEASUREMENT & METROLOGY

Measurement on the Move

The XM Series shop floor CMM from Keyence is said to simplify and speed up inspections, provide easy 3D and GD&T measurements, and is both portable and shop floor ready. (Provided by Keyence Corp.

By **Kip Hanson**

Headquarters

1000 Town Center, Suite 1910
Southfield, MI 48075
313.425.3000

Cleveland Office (Tooling U-SME)

3615 Superior Avenue, East
Building 44, 5th Floor
Cleveland, OH 44114
866.706.8665

Toronto Office

7100 Woodbine Avenue, Suite 312
Markham, ON L3R 5J2
888.322.7333

SME-Related Websites

- SME Education Foundation
- SME Media
- SME Connect
- Tooling U-SME
- Store
- SME Blog

SME Event Websites

- AeroDef Manufacturing
- Canadian Manufacturing Technology Show (CMTS)
- EASTEC
- FABTECH
- FABTECH Canada
- FABTECH Mexico
- HOUSTEX
- Montreal Manufacturing
- Technology Show (MMTS)
- North American Manufacturing Research Conference (NAMRC)
- RAPID + TCT
- Smart Manufacturing Experience
- SOUTHTEC
- WESTEC
- Western Manufacturing Technology Show (WMTS)