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# New Technology Powers Performance at U.S. Mold Shops

*Five-axis machining, programming, hybrid tools and laser processes lead the way*

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Contributing Editor

**T**here's growing evidence that some of the moldmaking business that fled the U.S. chasing cheaper sources offshore is returning. Moldmakers are not finding enough of a favorable cost differential to offset poor mold performance and the need for rework of faulty molds.

At the same time, advanced machining processes, tooling, controls and programming have moved the needle on the improvements possible in surface finish, accuracy and productivity for moldmakers. Shops gearing up to improve their competitive moldmaking capacity are looking to the latest advances in technology that can deliver faster, more accurate and more productive manufacturing of molds. Accordingly, shops are taking a hard look at what processes like enhanced EDM, high-speed five-axis milling, laser processing for additive manufacturing and texturing, and new hybrid cutting tools have to offer to improve moldmaking.

To the familiar alphabet soup of AlTiN and TiAlN coatings for cutting tools, for example, you can add silicon-doped coatings, such as AlTiSiCN, that have a higher hardness, greater resistance to heat and improved wear characteristics for moldmakers machining hard materials. The following targets the highlights of new moldmaking technology.

## **Catching Up to Five-Axis**

The U.S. die mold industry has been slower than Europe to catch up with five-axis machining, which is used more for aerospace and medical applications, but U.S. die

**Hurco's conversational programming removes the obstacle of complicated G-code programming.**  
(Provided by Hurco)

moldmakers are finding that five-axis machines are very applicable for die mold work, according to Jeff Wallace, general manager national engineering, DMG Mori, Hoffman Estates, Illinois.

“CNC controls are a key component because of the fine surface finishes that are required. You need a dynamic control and one that can handle a large amount of data for the large programs required for large cores or cavities for body stamping dies or door panel dies or for complicated molds like headlights, lens reflectors and lenses for automotive applications,” Wallace said.



**With machines from DMG Mori's Lasertec Shape Series, geometrically defined surface structures, fine contours and filigree cavities for injection molds, extrusion dies, inscriptions and other engravings can be produced with high quality and without tool wear. (Provided by DMG Mori)**

DMG Mori offers a variety of five-axis machining centers for machining both large and small workpieces, ranging from 6" to 6-m cubes. Additive manufacturing (AM) machines are available for both build and repair work. The company has expanded its AM lineup with the Lasertec 30 SLM powder bed machine that allows building molds with conformal cooling, significantly improving cycle time for molds and significantly reducing lead times for castings.

“When machining a body panel mold is complete, the mold traditionally goes out for texturing with a chemical

etching process, which these days isn't too environmentally friendly,” said Wallace. “The Lasertec Shape line of machines puts textures in the molds.”

For mold repair, especially for die cast molds that get damaged over time, the Lasertec 3D lays down material like a 3D printer. It can be used for building medium to large sized components in an initial mold build. That capability is especially valuable if the workpiece is complex. Rather than removing a lot of material and producing scrap, the workpiece can be machined on the same platform, eliminating handling.

A hybrid version of the machine, the Lasertec 3D Hybrid, with metal cutting and additive capabilities, features both material removal for manufacturing core cavities and putting the texture on in the same machine. The need for a secondary operation is eliminated, reducing cycle time and handling of the mold, with the result being the reduction of overall production time.

DMG Mori's CELOS control is a common HMI that provides commonality for different CNC controls. There are a total of 27 CELOS apps for planning, preparation, production, monitoring and service to create consistent digital workflows for efficient production. “Users don't have to relearn a new control and we are able to deliver 70-80 percent commonality,” said Wallace. “For moldmaking, the Technology Application Tuning Cycle has been developed to allow fine tuning the machine while cutting the mold. The operator can take speed, surface quality and accuracy [into account] to make program adjustments on the fly about semi-finishing and finishing.”

### The Big Easy of Programming

Traditional mold machining is also improving. For example, the BXi line of bridge-style machining centers from Hurco Companies Inc., Indianapolis, comes in three sizes of three-axis versions and a BXi 40U five-axis model with an BC trunnion table. According to Michael Cope, product technical specialist, the double-column, ladder design of the Z-axis, and the overall machine weight provide high accuracy, improved thermal stability and outstanding surface finish capabilities. Equipped with an HSK dual-contact 18,000 rpm spindle and Hurco's patented UltiMotion technology, the BX40i is designed for high speeds and tight tolerances with roller-type rails on all axes for added rigidity and direct-coupled ballscrews for increased speed and accuracy.

Hurco's conversational programming removes the obstacle of complicated G-code programming and allows the machinist to program the machine. "Today's conversational programming is very advanced. It's easy to learn and use and it's very easy to teach," said Cope. "For shops that are doing 2D or 2.5D work and have



**GF Machining's iGAP generator sensor technology helps moldmakers achieve a smaller, and therefore more precise, spark gap at higher speed with a die sinking EDM. (Provided by GF Machining Solutions)**

a blueprint in front of them, all you need to do is type in the numbers. If that's the kind of work the shop does and it has the blueprint, it's fantastic because it frees up the programmer who doesn't have to write code in any CAM system. I'm able to program on the floor and get jobs on and off very quickly," Cope explained.

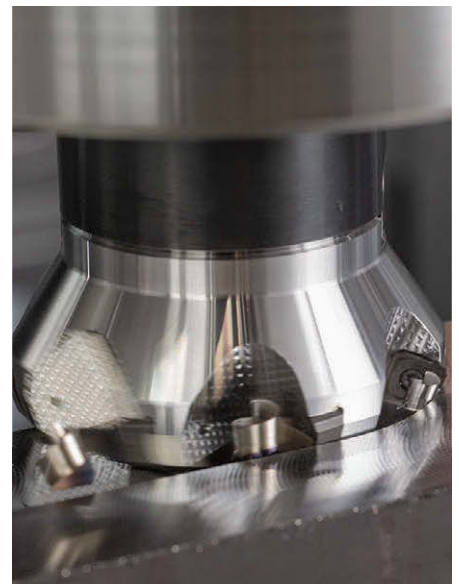
"However, if the shop gets mostly solid models from its customers and not paper prints, that's where we see a lot of use of CAM systems," he continued. "We pride ourselves on our versatility. We can do conversational very well, we can do NC very well or we can combine the two together with our NC Merge. For the customer that only gets solid models, our 3D Import allows the customer to bring in an actual solid model into our control, a step file, and program directly from that conversationally."

### **Not Your Father's Sinker EDM**

Advances in EDMs are also enabling more productive moldmaking. For example, advanced features for die sinker EDMs for both the entry level FORM E die sinker and high-precision, high-end FORM P series from GF Machining Solutions, Lincolnshire, Illinois, are increasing speed, reducing electrode wear and improving productivity.

Eric Ostini, product manager, EDM, explained that the iGAP generator sensor technology that has been added to the FORM E series EDM helps moldmakers use die-sinking EDMs to achieve a smaller, and therefore more precise, spark gap at higher speed. The iGAP varies the spark power from the front and sides of the electrodes as needed. Spark power increases only when necessary, helping preserve electrodes.

Ostini explained how the iGAP sensor works: "We are now able to sense on the electrode whether we're doing a frontal spark or a lateral spark. Frontal means the direction we're burning in and lateral means the sides of the electrode that are causing the



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cavities. We are able to sense where the spark is occurring and literally turn off any lateral spark that occurs. We can't get them all, but most of them," Ostini said.

"We can burn quicker and keep the gap tighter between the electrode and the cavity, reducing the amount of removal laterally that we have to do to open up the cavity to size," he continued. "We can have an electrode that is almost the same size as the cavity we want to produce, maybe two thousandths under size per side, and burn straight down into the cavity with just frontal sparking and then do very little orbiting to bring it finally into size. This reduces time,



**Barrel cutters, like this one from Iscar, can reduce finishing operations up to 60 percent in moldmaking operations, according to the company. Mastercam recently introduced the capability to recognize these special forms and create a toolpath using them along multiple surfaces. (Provided by CNC Software Inc.)**

increases cutting speed, and cleans up the cavity—the cavity is so close to final size that we don't have any offset issues."

To maximize electrode utilization in the FORM P series, GF Solutions offers a Smart Tool. "For an electrode that is being used as a rougher, there is a sister tool in the rotary tool changer or other automation that will replace the rougher, if needed, due to wear. The semifinisher becomes the rougher and by staggering the use of the tools, the number of tools that are needed to do a series of mold cavities is reduced," said Ostini.

### Roll Out the Barrel Cutters

Moldmakers face the constant challenge of improving machine utilization and cutting tools have a big impact on achieving this goal and helping moldmakers remain competitive, according to Tom Raun, national product

manager-milling for Iscar Metals Inc., Arlington, Texas.

So, what's new, you might ask. "We're in the process of developing hybrid tools for milling that are a combination of geometries (taper and large radii along the cutting edge). These hybrid tools, known as barrel cutters, will be a game changer that will improve finishing applications in moldmaking," said Raun.

These hybrid tools work by engaging a huge radius and generating much smaller cusp heights, unlike that taken by ball mills. As long as the surface of the workpiece and the machine tool and CAM programming allow it, the

barrel cutter has the capability to work off a large radius, for example 10" (254 mm), along the side of the tool. As a result, much larger stepovers are possible.

"A number of CAM systems have developed the ability to program and recognize these hybrid tools; we're seeing finishing operations being reduced by dramatic amounts, like 50 and 60 percent for finishing operations that typically make up most of the production time for moldmaking," said Raun.

Mastercam recently introduced the capability to recognize these special forms and create a toolpath using them along multiple surfaces,

overcoming one of the possible bottlenecks of only being able to program one surface at a time and getting these surfaces to blend correctly, according to Raun.

"This can be a huge benefit within the die and mold industry, where programmers often deal with geometries consisting of many tapered or curved surfaces (e.g., core/cavity designs and stamping dies)," he said. "The ability to take a tool, tilt it over and fit it into these geometries while taking much larger steps between each pass is quickly becoming a proven method for significantly reducing cycle times for finishing operations."

### Thermal Stability Critical

When it comes to producing molds with the required surface quality and accuracy, it's critical that heat generated in the machining process is controlled for the long periods

## Five-Axis Needs Barrels of New Tools

**THE BEAUTY OF** five-axis machines lies in the simple fact that you can do more with less — more machining in one setup, less downtime and fewer touch points, according to GWS Tool Group, Tavares, Fla. This formula (fewer setups + increased metal removal rate = reduced overall cycle time = more profit) is the reason many shops are going to five-axis machines when they replace old equipment (or even sooner if they want to bid on new parts more competitively), according to the company.

Of course, no transition to a process that adds a couple more axes and variables to typical X-Y-Z programming is that simple. First, programming with five axes is more complex and requires additional training for programmers used to only three-axis machines. Another issue is the physical reach constraint that is often created where none was present in a three-axis machining plane. Entirely new toolholding and cutting tools are often needed to avoid collisions.

Something else to consider is that the work materials often machined in the industries most frequently using five-axis machines tend to be more exotic and expensive by nature. From stainless steel and titanium to Inconel and cobalt-chrome, these materials have higher price tags and consume more tooling.

The solution, of course, is finding the right tool—in this case custom tooling that GWS supplies. Tools include barrel end mills, tapered end mills, spherical end mills, and bullnose high-feed end mills.

One caveat from GWS—increased metal removal rates won't happen if you're using a standard ball nose tool. There's just not enough cutting edge surface area. Spherical-type end mills, however, can take a greater length of cut with each pass than traditional ball end mills. Pivoting the tool and workpiece (which five-axis machining makes possible) brings more of the cutting edge into contact with the part. Longer cutting-edge engagement means a dramatic increase in metal removal rates. ➔

of time needed to machine a mold, according to Dante Payva, product manager-milling, for GF Machining Solutions. “We pump chilled fluid throughout the machine base and column to maintain machining stability. On our Mikron machining centers, we have introduced Cool-Core to our 42,000-rpm spindles as a way to control the points where a 42,000-rpm spindle generates a lot of heat.”

Cool-Core spindle technology takes traditional spindle cooling, which typically cools the outer jacket and bearings, a step further. Cool-Core chills the rotating shaft of the spindle,

which is the central core of the spindle that is in contact with the toolholder and cutting tool.

High-speed, five-axis machining brings some finesse into moldmaking, Payva said. “Conventional milling attacks with an aggressive toolpath and cut. In some cases, you're removing a lot of material and you're adding a lot of heat and a lot of forces to the final part, where with high-speed milling you're removing the same amount of material but in smaller steps and at a faster rate.”

According to Payva, investing in high-end tooling can be beneficial with



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tool life reportedly as much as 25 to 50 percent higher. Also, in some cases introduction of barrel cutters can complete a part faster. “They remove material faster due to cutter design,” he said. “Rather than having a ball or bull nose end mill removing material restricted by the diameter of the size of the tool, the barrel cutter has a longer curvature so that side milling removes more material.”

### Direct Milling of Gates

Sometimes it pays to examine new options for machining mold features. For example, Roku-Roku high-speed, high-precision three-axis machining centers and OPS Ingersoll Eagle series five-axis machining centers from MC Machinery Systems Inc., Elk Grove Village, Illinois, offer an option to EDM for machining gates for injection molds.

According to MC Machinery’s William Gillcrist, machine tool technology, cutting tools and CAM packages are

Direct milling of the gates overcomes some of the limitations of EDMing, which include generating a recast layer, inconsistent gate shape due to electrode wear, micro cracks on the gate surface and altered layers on the tapered surface of the gate.

“The emergence of high-speed hard milling with machining centers capable of following precise and complex toolpaths at high feed rates has made direct milling cost effective for shops as an alternative to EDM in many moldmaking applications involving hard metal, intricate details and smooth finishes,” said Gillcrist. “There is no accuracy versus finish tradeoff that needs to take place, unlike with an EDM where accuracy declines as finer surface finish is approached.”

He recommends using high-end CAM software, high-end cutting tools and toolholders, and a rigid, well-built machine tool for the best results. “A successful milling process is the result of all the elements working together. It involves

software creating code, the CNC crunching the code and holders and cutters being able to hold tolerances for hard milling,” Gillcrist said.



**Direct milling of gates for injection molds like this banana gate overcomes some of the limitations of EDMing. (Provided by MC Machinery)**

making high-speed milling competitive with EDM for direct milling of gates for injection molds using carbide tools with special coatings. The Eagle V5 and V9 models feature up to 42,000-rpm spindles, and the Roku-Roku models, with up to 90,000-rpm spindles, provide more than enough speed to handle the small cutters and surface footage requirements, he said.

### Lasers Play Expanding Role

Lasers continue to carve out niches for the technology in both expected and unexpected ways. GF Machining Solutions’ use of texturing with laser ablation has already transitioned from creating leather and wood grain texture for automotive applications to creating geometric patterns for electric and hybrid cars, according to Jon Carlson, product manager, advanced manufacturing. GF Machining

has entered into a partnership with 3D Systems to offer a new integrated additive and subtractive manufacturing solution that will include automation and post-processing to provide more efficient workflows for advanced manufacturing.

“Lasers are good for geometrics,” he said. “If you’re trying to drop a film in a mold by hand, it’s almost impossible to minimize stress points or pinch points as you go around the



3D shape or contour. Laser texturing, on the other hand, is done digitally on a computer that can compensate for any stretch points and pinch points that might show up. What you see on the computer is what you see in the mold, namely a nice geometric pattern. It's like a giant puzzle that our Smart Patch software feature solves. Smart Patch ensures that the geometric patterns that lie outside of the marking field will be picked up so that no patching is needed."

In addition, laser ablation does texturing and engraving as well as functional texturing for medical applications, and for such diverse applications as serrations in bottle caps for water bottles and putting thread pitch into a mold, he said.

At IMTS, GF Machining announced the partnership with 3D Systems to offer additive manufacturing machines. "When we talk to a customer or end user, we want them to be able to complete a part," said Carlson. "Typically, there is always some type of post-processing that has to be done on a part, including heat treating, die sinking, lasing or micro machining it. We can build the part [via 3D printing] and we can talk about the whole flow of the part, from five-axis milling to putting a texture or engraving on it. Our goal is to be able to fully build a plate with a [single part] or 16 individual build plates [for multiple parts] in one 3D printing." In the latter scenario, "the customer could take the 16 parts from AM to heat treat to milling." Both companies offer two co-branded models, the DMP Flex 350 with an 11 x 11 x 15" (279 x 279 x 381 mm) build platform and the new DMP 500 with a 20 x 20 x 20" (508 x 508 x 508 mm) build platform.

## Five Axis for Hard Metals

Jeff Johnson, product manager, Mitsui Seiki USA Inc., Franklin Lakes, N.J., believes that his company's Dynamic Power Cutting process has an important role in the future of moldmaking. There are considerable time savings in five-axis machining of hard metals, especially for aerospace applications, that are being achieved.

"There's a big difference between high-speed machining and Dynamic Power Cutting, which requires a rigid machine and a rigid spindle to take a deeper cut at slower spindle speeds. Using the best tools and best programming software available is very important to achieve the best results," Johnson said.

Dynamic Power Cutting, which has been successful in aerospace applications, offers the same benefits to moldmaking, where a predictable process and cycle time reduction are highly valued and sought after. Johnson believes that Dynamic Power Cutting in 3+2 or five-axis machining will be revolutionary in mold manufacturing. ➔

### FYI

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