cover story ➤ BY BILL KENNEDY, CONTRIBUTING EDITOR

Moldmaking's DARK SIDE

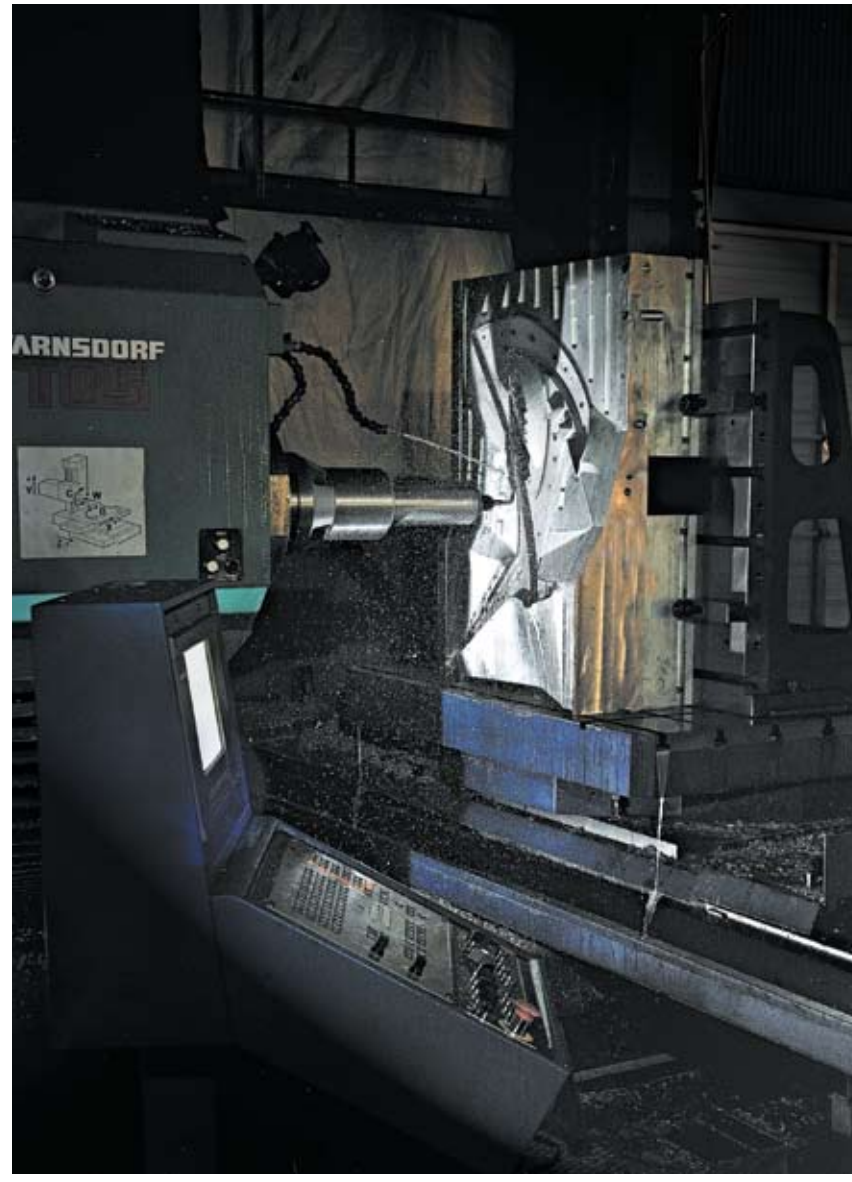
It's 2 a.m. Do you know what your moldmaking operations are doing? Today's moldmakers can apply equipment, processes and strategies that let them turn on the machine, turn off the lights and go home.

Competitive pressures have brought big changes to moldmaking, one of the more labor- and time-intensive metalworking crafts. Creating a complex mold traditionally required the time, skill and constant attention of an individual craftsman. Now, labor-cost competition from offshore manufacturers as well as demands from domestic customers for shorter lead times are prompting moldmakers to adopt untended "lights out" machining methods.

"The biggest sin we can commit is to leave a block sit still," said Pete Manship, president of Mold Craft Inc., Willernie, Minn. "We get the steel in the door and that block's got to be moving around the shop."

The blocks need to be in motion even when no one is in the shop, and untended machining allows for that. Running untended, Manship said, "allows us to sell more hours with the same capital equipment, with little or no overhead increase."

Mold Craft's untended operations have grown year after year. Manship said: "Last year we had almost a 50 percent increase in unattended machine hours. This is mold manufacturing.



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This Varnsdorf WH 105 CNC horizontal boring mill often runs lights-out when machining the large molds produced by blow mold maker Accu-Mold.

It's a factory; it's not a craft anymore."

Confidence is the Key

Ken Baeszler, product manager for the Agie EDM brand of Agie Charmilles Corp., Lincolnshire, Ill., said the key to successful lights-out operations is maintaining accuracy and reliability over extended periods of time. He made a distinction between automation and autonomy. "Automation typically refers to the mechanical aspects of unloading and loading electrodes and workpieces; autonomy covers all the components necessary to run an EDM around the clock," he said. "Just having an EDM that runs overnight is pretty easy. But having an EDM that runs long campaigns over a weekend or even longer is another story altogether."

The shop must have full confidence that the machine is going to run the parts exactly as expected. "On a die sinker EDM, for instance, you have to make sure the machine is going to protect itself from any arcing or workpiece damage while running efficiently. The physical protection functions have to be 100 percent secure and reliable because if an operator does not have confidence that the cavity is going to come out totally correct, he is not going to leave the machine," Baeszler said. "If an autonomous EDM senses a deteriorating condition, it has the means to correct the problem." For example, the machine "will see that it is not able to discharge sparks because it's dirty, and it will automatically clean itself out through the plunging action of the ram. That's part of autonomy," Baeszler said.

A Complete Process

The key to achieving high levels of predictability in untended operations is integrated process development, according to Keith Kauzlarich, vice president of Single Source Technologies, Auburn Hills, Mich. SST is a consultancy for machine tool products used in moldmaking and other niche industries. The mechanical elements of an integrated process for CNC machining typically include a machine tool with high volumetric accuracy, a high-speed spindle with high stiffness and cooling systems to control thermal growth; low-runout tooling; and CAM software that can generate toolpaths with resolutions measured in microns.

Marposs

Combining touch probe technology with advanced software such as Marposs' 3D Shape Inspector can permit a shop to perform CMM inspection of a part without removing it from the machine tool, saving time and eliminating errors that may result from the move between machine tool and CMM. Additionally, because the part remains on the machine, immediate remachining of out-of-tolerance part features is also possible.

The integrated process' use of advanced technology should be thoroughgoing, too. Applying improved technology in a piecemeal fashion can actually increase the potential for error. For example, as cutting tools become smaller and more precise, determining their dimensions and location and entering that data in the machine's control becomes more difficult. For example, Kauzlarich said manually measuring a 1mm-dia. tool by bringing the spindle to a gage block is a potential source of error. Detecting the breakage of such a small diameter tool can be difficult as well. In an untended machining operation, an automated tool measuring and detection system will help eliminate errors in applying small tools.

A variety of automated measuring technologies help implement lights-out strategies. Sharad Mundra, product manager for the MIDA line of probing products from Marposs Corp., Auburn Hills, Mich., outlined basic choices for toolsetting technologies and automated probing methods for workpiece setup in untended operations.

While contact toolsetting probes can automatically determine tool length and diameter and check for breakage, more advanced laser toolsetting systems provide the same information while also generating tool wear data and even measuring thermal changes in machine axes. For example, depending on the model, MIDA laser systems can measure tools as small as 0.05mm in diameter, with repeatability of 0.2µm. Mundra said lasers provide a new level of tool measurement, allowing a user to look deeper into the tool profile, including checking the tool while it is rotating. In an untended operation, laser-generated data can initiate compensation actions or tool changes without operator intervention.

For setup applications, infrared and radio frequency data transmission systems permit a probe to be stored in the machine's toolchanger so inspection routines can be carried out by the machine control via G code. Touch probes can determine part location before machining and inspect the part after machining. When using multiple fixtures, a probe can identify each fixture

and automatically pick the CAM program required to machine the fixtured part.

Mundra said combining touch probe technology with software such as Marposs' 3D Shape Inspector can permit a shop to perform coordinate measuring machine-level inspection of a part without removing it from the machine tool, saving time and eliminating potential errors from the move between machine tool and CMM. Because the part remains on the machine, immediate remachining of out-of-tolerance part features is also possible. Mundra said that for shops without a separate CMM, on-machine CMM inspection can save outsourced inspection costs.

Lights-Out EDM

Sinker EDM characteristics facilitate its application in untended operations. Cutting tool breakage is not an issue, electrode life is predictable and electrode replacement can be easily handled via a toolchanger.

Lights-out EDMing can be relatively simple or quite sophisticated. Agie's Baeszler said, "A lot of people do nothing more than use the toolchanging capability of the machine tool."

Then there are robot-serviced EDM systems. Mold Craft's Manship said his shop has an Erowa Multi Twin robot that changes both electrodes and workpieces, servicing the shop's Agie Hyperspark HS sinker EDM. "Our robot holds 45 workpieces and 210 electrodes," he said.

The Agie EDM features pulse-management technology that speeds erosion while limiting electrode wear. Mold Craft personnel use a Zeiss CMM to set up workholding and electrode-holding devices offline, then take completed molds and worn electrodes from the robot and replace them with the preset units.

Continual enhancement of automation is good business, according to Manship. "If you've got a $300,000 sinker EDM, it needs to be running 24 hours a day or as close to 24 hours as you can get it," he said. "If you are only going to run it 8 hours a day, you'll need three of them to put out the same amount of work. With the robot, the machine is capable of running nonstop."

Software Support

Accu-Mold Inc., Latrobe, Pa., specializes in blow molds for large industrial parts. Overseas competition at this point is minimal because the molds are large and heavy and the parts they produce are bulky and expensive to ship, said owner Dennis Holby. Lead times, however, are a challenge. "Everything is a big hurry," he said. "Ten years ago, we could say it's going to take 10 weeks and everybody accepted it. Today they don't." Companies can meet the shorter lead times through lights-out machining. "It's nothing to have a program in there that will run for 24 or 48 hours nonstop. You don't want to babysit a machine while it's doing that," Holby said.

It follows that untended machining is an important element of Accu-Mold's work. The shop has employed lights-out operations since it opened in 1994. Over the years, Holby and other users have pressed suppliers to make improvements in CAD/CAM software to facilitate untended work. "We go back to the vendors saying, 'we have to be able to do this better,' and they listen to us. They have done their homework and come up with software that works."

For example, although larger cutters generally do not have center-cutting capability, some CAM programs would nonetheless direct the cutters into plunge cuts. Holby said feedback from users prompted CAM software upgrades that eliminated the problematic toolpaths. Accu-Mold uses SURFCAM to program its parts and is ramping up its SolidWorks capabilities.

Machining simulation packages also facilitate untended operations. Bryan Jacobs, marketing communications manager for CGTech, Irvine, Calif., said the company's VERICUT software "fits the lights-out machining concept." Moldmakers use the software to help eliminate the prove-out process. By running the machining program through VERICUT software as part of a process assurance system, "they know it's going to be correct; they send it out to the shop floor, turn out the lights and go home," Jacobs said.

VERICUT can utilize the G code generated in the postprocessor stage, so it verifies the same NC program that runs the machine tool. When the software is in full machine simulation mode, the user enters machine, workpiece and tooling information, and the simulation provides machining time estimates, error checks and other process information. The simulation employs a 3-D solid model that represents chip thickness, which can be used to

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According to Accu-Mold's Dennis Holby, feedback from users has prompted CAM software upgrades that eliminate problematic toolpaths and facilitate lights-out operations. Accu-Mold uses SURFCAM to program its parts and is ramping up its SolidWorks capabilities. Here, designer Jessica Hooper lays out a mold in SolidWorks.

set cutting parameters that maximize productivity and tool life.

Scheduling Concerns

Richmond Tooling Inc., Colonial Heights, Va., builds multicavity molds for medical, electronics and packaging products. Owner Roger McGinnis said untended machining enables his shop to cut labor costs and quote shorter deliveries, adding that decreasing the time required to build a mold improves cash flow through faster invoicing.

EDM operations provide Richmond Tooling with some of its best opportunities for lights-out work. "We can put 16 electrodes in our newer sinker. We have run it for 100 hours unattended," McGinnis said. He cited the case of a mold with large cavities that "we burned from the solid over Thanksgiving weekend, from Wednesday night to Sunday night." However, that is not typical for the shop. "Ideally, I'd like to think we could work during the day to set up our sinker and then run it at night. But it rarely works that way. We may get one evening a week where we can run unattended," he said.

When customer demand and scheduling do match up, McGinnis takes a cautious approach to some aspects of lights-out operations. In CNC machining, if the roughing cutter fails or if for some other reason the roughing operation isn't completed, "it's real ugly when the finishing cutter comes in," he said. As a result, "we'll run the machining centers unattended, but not normally for roughing." Otherwise, McGinnis generally doesn't program parts any differently for lights-out processing. "We don't change anything. If it just so happens that we can get the part running untended, we do."

A good example of circumstances that permitted Richmond Tooling to run untended operations in series involved production of 32 examples of a 0.25"×0.12"×2" curved bypass shutoff insert for a 16-cavity electrical part mold. After hard milling the top 0.25" of the block, requiring approximately an hour untended, the shop then used a sinker EDM in a 12-hour untended operation to produce circular details about 1" deep. Finally, a wire EDM ran overnight to separate the inserts from the S-7 tool steel block.

Electrode Opportunities

At Bruin Manufacturing Co., Marshalltown, Iowa, running lights out is routine. The company machines molds and also uses them to make plastic parts. Customers include manufacturers of appliances, windows, doors, hand tools and HVAC equipment.

"We are literally lights out here," said Chad Dielschneider, executive vice president. "At 4 p.m., we shut the lights off and lock the door. We come back in the morning and remove the parts from the molding machines and the CNC machines." On the moldmaking end, Bruin uses Haas CNC machines and Mitsubishi sinker EDMs, all fitted with toolchangers.

Among the shop's routine lights-out operations is machining EDM electrodes. "With the EDM electrode work, you have to make many duplicates," said Dielschneider. "We utilize quick-change fixturing for our electrode machining. We made a fixture plate to hold six blanks, and we just load it in the machine, touch it off, and let her go. We use two Haas Super Mini Mills to do multiple electrodes. Those will run throughout the night."

More Darkness Ahead

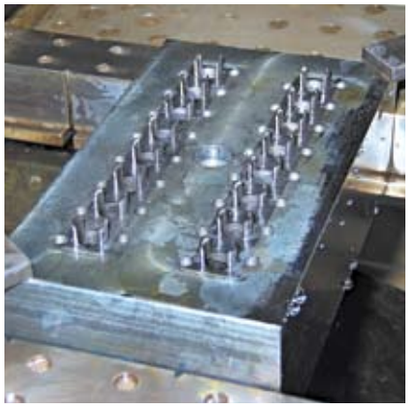
Bruin Manufacturing wants to run more lights-out operations. "We are a ways away from where we should be as far as automation," said Dielschneider. "We've been pretty successful in bringing in new business, and rather than adding more manpower, we are increasing automation, getting every bit of good out of those machines that we can. We've only tapped probably 50 percent of what those things can do for us."

Increased automation hasn't precipitated any layoffs at Bruin, and Dielschneider said employees have "liked it quite a bit. One of our toolmakers said it has turned every toolmaker into an expert. That's because before you had to be an extremely skilled toolmaker to machine certain shapes and contours, but now you learn how to program and the machine does that for you. We use automation to increase productivity without adding people."

Mold Craft's Manship agrees that skilled operators are the key to lights-out moldmaking. To fully exploit the benefits of untended machining, a shop must "think a little differently. It forces you to plan," he said. Teamwork is critical. "If guys are working together, you can do far more than you really think," Manship said. "You have to have your electrodes done, your steel ready and the machine has to be open. All that has to come together at one time."

Mold Craft employees have embraced lights-out operations, said Manship. "They know this is our future, and it will secure our jobs. All that fancy, cool equipment without the good people, you could weld it together and throw it in the ocean." His advice to shops contemplating beginning or upgrading untended operations is "start today. One realization we came to is that we didn't get into this soon enough." △

Richmond Tooling



Richmond Tooling employed lights-out hard milling, sinker EDMing and wire EDMing to produce 32 examples of a 0.25"x0.12"x2" curved bypass shutoff insert (top) for a 16-cavity electrical part mold. The S-7 tool steel workpiece (bottom) is shown after hard milling and sinker EDMing and prior to the wire EDMing operation that separated the inserts from the block.

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