AUGUST 2003 / VOLUME 55 / NUMBER 8

▶ BY ALAN RICHTER, MANAGING EDITOR

Tool Watch

Tool monitoring saves money by preventing tool breakage and reducing scrap.

A cheap PCD-tool user might seem like an oxymoron, but there's no contradiction in trying to get maximum life from expensive cutters. And tool-monitoring systems can help. Popular tool monitors vary from the relatively simple touch sensor to laser measurement to systems based on tracking vibration and motor horsepower.

Because the initial cost of PCD-tipped inserts is high, Ron Maurer, process engineer for General Aluminum Mfg. Co., wants all the tool life he can get when machining aluminum castings for the automotive industry. He considered monitoring tool life with a "hit counter," but determined an in-process monitoring system that measures specific vibration patterns matched his requirements better. The ATAM-4000 from ATAM Systems Inc., New Albany, Ohio, was the monitoring system chosen.

"We complete 30,000 to 40,000 hits before changing an insert," Maurer explained. "If tool damage occurs at 1,000 hits, the hit counter wouldn't detect it, but the ATAM system shuts down the line until the tool is replaced. You can't get maximum life from a tool with count monitoring."

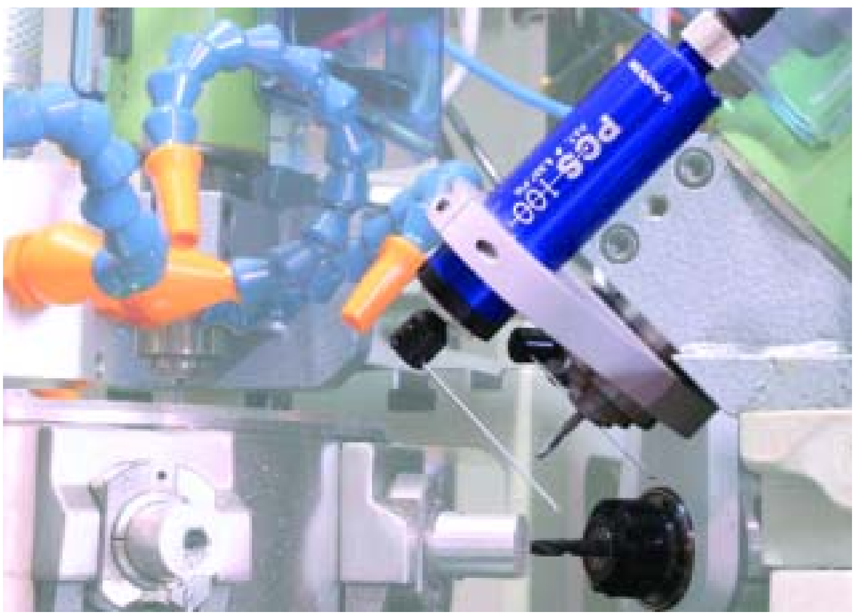
General Aluminum installed an ATAM-4000 on 10 of its Hardinge VT 100 machine tools, which produce 8"-dia. parts. In addition, there's an ATAM unit on a machine with two 6-spindle milling heads, allowing one system to monitor both heads simultaneously. "You don't have to buy two separate units to monitor two vibration levels," Maurer said.

Harry Kincaid, ATAM's president, said an accelerometer placed on a spindle, toolholder or other strategic location measures microscopic vibration patterns and plots the signature of a specific machine and tool. Limits are set for worn, missing and broken tools, and operation outside of the established parameter causes the system to send a "stop" command to the machine within 1 millisecond. The system also stops a machine immediately if it crashes, thereby preventing additional damage.

Maurer noted that knowing where to mount a sensor is critical to successful process monitoring. Using a magnetic device, various positions in the machine were tried until one was found that accurately measured the vibration for the operation. Once that position was located, the sensor was mounted securely in a way that protects it from chips and coolant.

"We drilled and tapped one hole in the sensor-mounting process, bolted it to the turret head and put the guards back on," he said.

With a typical cycle time of 30 seconds, Maurer said measuring horsepower is not an option for process monitoring at General Aluminum, Conneaut, Ohio. "We are ramping up at maximum rates, pushing the load systems rapidly," he said. "The ATAM system takes snapshots of the process when I want it to; it doesn't care about how fast you ramp up, so it's more accurate."



TPS International

Shown here on a rotary transfer machine, tool monitoring with a Positive Contact System is performed through light physical contact of the tool tip with the sensor's needle to determine if the cutting tool is broken or not.

Maurer added that by capturing the signatures and saving them on a laptop computer, he's able to determine the root cause of why a tool is breaking and further refine the machining process. "I want the cycle time to stay the same, but I can adjust the ATAM system based on the archived information that shows when a problem occurred."

The cost of the basic monitoring system is $3,995, Kincaid said, and another sensor can be added for $1,000. "You can increase performance in steps as the system pays for itself," he added. Kincaid estimated that the average payback time, through additional tool life and from fewer scrapped parts, is less than 4 months.

A primary motivation for Maurer's decision to buy the system was its ability to maximize life for PCD-tipped cutters. "I'm cheap," he said.

Even with the benefits of this type of in-process tool monitoring, Maurer said it's only for companies where there's an opportunity for a return on investment. "It's absolutely not for every shop," he said. "It's best for machining valuable workpieces or high-volume production."

Absence/Presence Monitoring

On the other hand, a monitoring approach wherein a tool tip makes *physical* contact with a sensor to determine whether a tool is broken or not has more universal use, said Jeff Gibbons, vice president of J.C. Gibbons Mfg. Inc. "There's an application in every shop for this monitor."

The Livonia, Mich., shop installed Positive Contact tool monitors, from Sussex, Wis.-based TPS International Inc., on two Davenport screw machines. "We would like to have it on all 30 machines," Gibbons said.

He noted that the system was initially purchased for one part requiring tapped holes. Since then, its use has been expanded to determine when there's a broken tap for any appropriate job.

Gibbons said the system's sensing needle is applied to primarily 4-40, 8-32 and 10-24 taps. If a tap is broken, the needle will swing past the tool, interpreting the condition as a broken tap. The unit will then send the appropriate stop command to the machine control.

"It shuts down the machine before parts are sent out without threaded holes," Gibbons said. "It's a proactive move that keeps customers happy." He added that having the tool monitors has allowed the shop to generate additional tapping business, because customers know the company is better able to ensure that it ships nondefective parts.

According to TPS, the Positive Contact system consists of two main components: a sensor and a sensor-control unit. The control unit is mounted in the machine-control cabinet and the sensor is bracket-mounted close to the cutting tool. Generally, the sensing needle is kept straight, but it can be bent to suit an application.

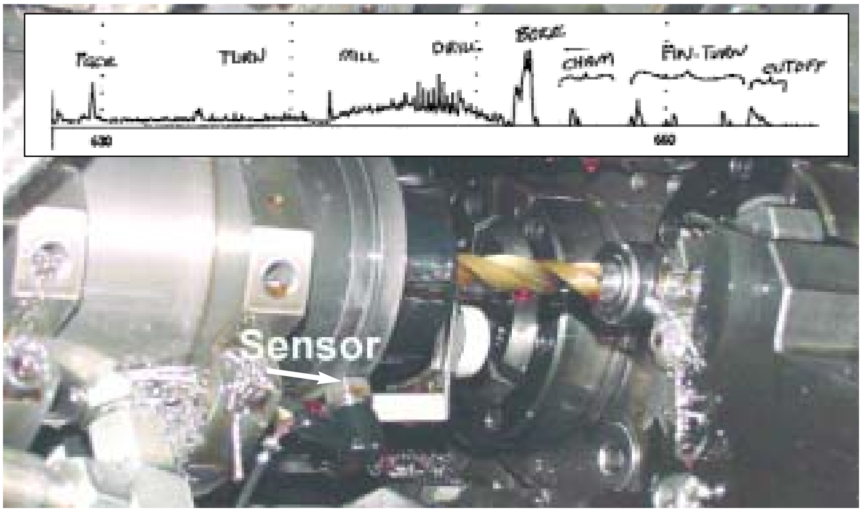
In addition to the system, which costs about $800, Gibbons said the company needed to buy limit switches—for determining when to activate each cam-driven machine—make a few brackets out of angle iron and hire an electrician to wire the unit into the control. "It's priced low enough so you don't need a big job to pay for it."

The price isn't the only thing that's small. Gibbons noted that the unit's compact size allows it to monitor tools in a Davenport's limited cutting area.

Tool Down the Barrel

Another method for monitoring tools is by measuring and displaying true motor horsepower. With such a system, a horsepower transducer is connected in-line with any motor being monitored, typically the spindle motor, said Rob Caron, president of Caron Engineering Inc., Wells, Maine. As a part is cut, the system "learns" the peak horsepower output for each tool as it's cutting and saves the information. "The CNC tells the monitoring system what tool is cutting, so the system can bring up the tool's data," Caron said.

He explained that as the tool wears, spindle-motor horsepower increases. If



ATAM Systems

A sensor, or accelerometer, needs to be strategically placed in a machine to measure an operation's microscopic vibrations accurately. Inset: The signature produced when monitoring various operations for producing a 0.209"-dia., 0.054"-wide part on a Citizen M20 machine.

The following companies contributed to this report:

ATAM Systems Inc.
(614) 939-2266
www.atam.com

Caron Engineering Inc.
(207) 646-6071
www.caron-eng.com

General Aluminum Mfg. Co.
(440) 593-6225
www.generalaluminum.com

J.C. Gibbons Mfg. Inc.
(734) 266-5544

Smith & Wesson
(800) 331-0852
www.smith-wesson.com

TPS International Inc.
(800) 423-4031
www.tpsintl.com

the measured horsepower exceeds a preset limit, the machine responds by issuing a feed hold, which stops the cutting program, and then calls up a subprogram to retract the tool or perform an other action, based on a customer's requirements.

Rich Picard, project engineer for Spingfield, Mass.-based Smith & Wesson, said the firearms manufacturer incorporated Caron's tool-monitor system on four 7-axis, bar-fed, Tsugami TMA8 machines for making 410 stainless steel pistol barrels.

He said the system allows two alarms—"wear" and "extreme"—to be set. The wear alarm signals that a tool's cutting edges are starting to deteriorate, and the extreme alarm indicates the tool needs to be retracted before it chips or breaks.

In addition to preventing workpiece damage, Picard said retracting a tool, such as a $150 solid-carbide, deep-hole drill, before it snaps allows the cutter to be reground rather than scrapped. "With tool monitoring, we can get the most regrinds possible out of a tool."

When setting limits, the programmer decides how high the horsepower goes before an alarm is registered. "Everything is defined on our end and we can micromanage it," Picard said.

Caron's PC-based system, which costs $7,500 to $12,000, also allows an end user to monitor a particular tool with different horsepower limits during a cut. This optional Automatic Time Incremented Limits feature is valuable, for instance, when milling a contoured surface, where it's desirable to have lower limits on radius cuts.

Caron said another option is an adaptive control, which allows the system to regulate a machine's feed override. This maintains constant spindle-motor horsepower during cutting.

Picard said the adaptive control option is particularly beneficial when the peak horsepower for a tool exceeds the spindle's rated horsepower. For example, if a roughing tool peaks at 8 hp and the machine has a 7½-hp spindle, the cutter's maximum limit can be set at 7 or 7¼ hp. This helps extend spindle life. "When the machine starts to cut, the adaptive control will drop the feed rate down so the horsepower doesn't exceed the spindle's rating," he said.

Measuring tools in the spindle

Users of offline tool presetters often assume that variation between the preset tool and the tool in the spindle is negligible—if not nonexistant. However, this assumption is frequently incorrect, said Paul Meinhardt, general manager for Blum Laser Measuring Technology Inc.

The Fort Mitchell, Ky.-based company's LaserControl system is for tool setting by measuring the length and diameter of rotating tools, as well as detecting breakage and wear—within a machining center. Using a visible red laser with a wavelength of 670nm, multiple-insert tools can be measured at full nominal rpm and the correct position of all cutters in multicutter tools can be checked radially and axially. This allows any setting and clamping errors to be identified in a few seconds.

Meinhardt noted that measuring tool wear with a laser is especially beneficial for monitoring ballnose endmills used to produce complex curves in large molds. The tool can be run through the beam after every 15 to 20 minutes of cutting, for example, and when the system detects that a wear threshold for a cutting edge has been exceeded, the tool is automatically changed.

Maximizing part precision on low-cost machines that experience spindle growth and thermal drift of the axis and tool is another application. "You can't change machine design, but if the machine shifts you can control the inaccuracy by compensating for it," Meinhardt said.

—*A. Richter*

For more information, call (859) 344-6789, visit www.blumlmt.com.

Although Picard said it took only about an hour to get the "self-explanatory" system up and running, and the system's "learn" button monitors horsepower and sets limits automatically, fine tuning this initial setting can be time consuming because of lengthy part programs. "For example, a part program may consist of 20 to 30 different tools with a total cycle time of an hour or more," he said. "In the course of an 8-hour day, a given tool may only experience a few minutes of cut time. So it may be days before the tool's life begins to expire."

With that in mind, Picard noted that true-horsepower monitoring works well for production runs, but a higher level of commitment is required for smaller runs. "In a job shop, the programmer needs to get intimate with the machine and find out how it works with each tool," Picard said.

This may be why, according to a recent survey conducted on www.ctemag.com, a majority of the respondents indicated that they do not have a tool-monitoring system.

Avoiding Presetting

In addition to the horsepower monitor, Picard said the four machines also integrate with Blum laser tool-setting systems and builder-installed touch pads. However, for Smith & Wesson's needs, the laser systems don't detect broken rotating tools. "We utilize the laser for checking the initial tool length and diameter so the operator doesn't have to enter the data manually," he said (see sidebar, page 32).

The company's tool-life-management system tracks each tool's cut time and alerts the operator to change the tool when a predetermined length of time is reached. If a tool consistently lasts longer than predetermined, Picard said an operator may recommend bumping up the time the tool cuts before it's changed. "The power monitor will protect us from premature tool wear or failure."

Picard said the horsepower monitor also allows Smith & Wesson to evaluate similar cutters from different suppliers. Although the company makes most of its tools in-house, he noted that drills are an exception. "We're always trying new ones," he said. "We compare drills with the power monitor by watching the horsepower change over the life of the drills, and store the data to show vendors that we're not playing favorites."