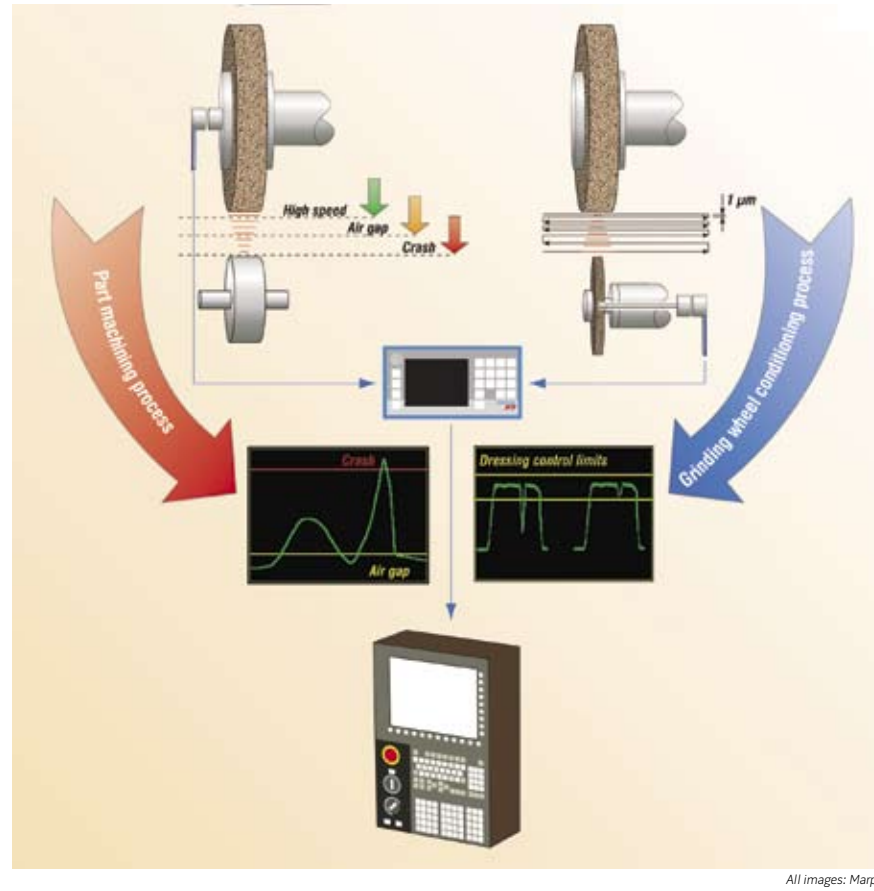
By Alan Rooks, Editorial Director

Now Hear This

New technologies have made acoustic emission monitoring systems more accurate, easier to use and suitable for other applications.



All images: Marposs

The three basic applications of AE sensors on grinding machines are gap elimination (contact detection), crash avoidance and grinding wheel conditioning.

If a tree falls in the forest and no one is there to hear it, did it really happen? If a grinding wheel crashes into a part and no one can hear it, does it cause a problem? The answer to the first question is debatable, but the second answer is a definite yes.

Crashes are a problem during grinding, but parts manufacturers are using acoustic emission (AE) sensor systems to detect and prevent them long before operators can hear them and react. AE systems are also used to reduce air grinding, control dressing operations and troubleshoot problems.

AE sensors detect ultrasonic sound waves emitted when the grinding wheel contacts a part or the dressing wheel and send that information to a process control unit. Monitoring the sound waves and comparing them with reference values allows operators to control the grinding and dressing processes. Variations in acoustic emissions indicate changes in cutting forces, which can then be modified. Some AE sensors are stationary while others rotate with the wheels. Electronic filters reduce or eliminate acoustic emissions from other nearby devices, such as bearings.

Today, most new cylindrical grinders for production machining come with AE sensors as standard equipment, and some parts manufacturers are retrofitting existing equipment with the technology. Other types of grinding machines are equipped with AE as well. According to one estimate, about 10 to 20 percent of all cylindrical grinders in the U.S. are equipped with AE sensors. These are much employed in auto parts production—particularly shafts. Use of AE is expanding into other areas, such as aerospace and medical parts production, as the technology has become easier to use and more accurate.

"We've used it for over 30 years," said Hans Ueltschi, national sales manager for United Grinding, Miamisburg, Ohio, a grinding machine builder. "It started out as a gap control and setup control tool. For example, on profile grinders it was very difficult to touch off the wheel to the part because some materials don't spark very much, and on ID grinding operations it was difficult to see if you were touching off or not."

The technology evolved into a process monitoring system integrated with a grinding machine's control, allowing operators to visualize—and manufacturing engineers to better control—the grinding process. In addition to the applications noted earlier, this capability helps operators confirm if the process is meeting specifications, determine whether the wheel is sparking out properly and

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Now Hear This *(continued)*

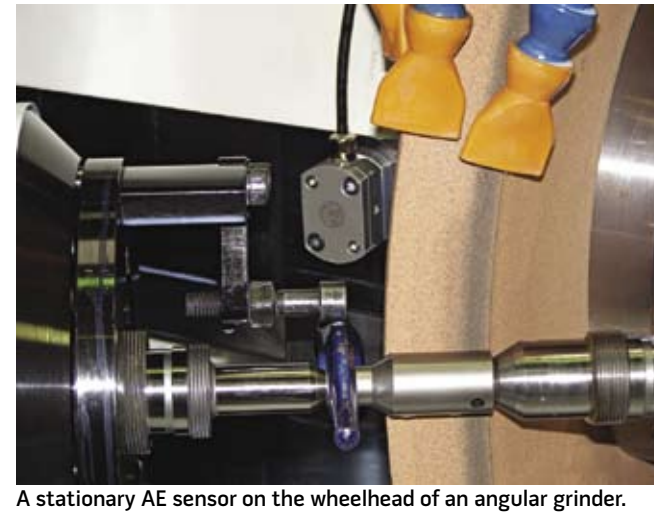
fine-tune the process. These particular AE tools are used mainly during setup for production machining, Ueltschi noted.

Locating the Part

Contact detection gained a foothold in production grinding during the mid-1970s. Contact detection's main goal was and is to minimize air grinding, according to Randy Masters, who handles machine tool accessories sales for GTI Spindle Technology Inc., Bloomington, Ill. In addition to manufacturing and repairing spindles, GTI is the North American representative for Walter Dittel GmbH, Landsberg am Lach, Germany, a manufacturer of AE sensors and other components.

Air grinding happens as the operator tries to locate the part. Without AE, the approach speed has to be slow to avoid crashing into the part. With AE, the wheel can approach the part rapidly, and when the first grain touches the part it produces a sound that is instantly detected by the AE sensor. The machine can then automatically change its slide speed from rapid infeed to grinding speed.

"The most successful contact detection application I've seen produced a 40 percent cycle time reduction on a part that previously took a minute to grind," said Masters. He added that cycle time reductions from AE range from 10 to 40 percent compared with other detection systems.



A stationary AE sensor on the wheelhead of an angular grinder.

Ueltschi agreed, adding that AE is particularly useful when grinding premachined parts, which may vary in size. He said using AE is, on average, up to 10 times faster than other detection technologies, such as power load monitoring, which measures load variations in the drive as a grinding machine moves from air grinding to workpiece engagement and back. An older technology, power load monitoring still provides contact detection in many grinding operations, but AE offers much faster contact recognition, sources said.

"A customer and I were able to directly compare AE to power load contact detection," said Masters. "I hooked up an AE sensor to his grinder, and the sensor detected contact before the power load meter showed any movement. He likened the AE sensor to 'tickling his beard'—it would tickle his beard and warn him before the wheel would hit his chin."

The second major AE application, crash prevention, is a version of contact detection. "If you are about to hit the part too hard, the AE sensor picks up that frequency and provides a crash output," said Masters. "The machine can be programmed to do an emergency stop or to retract the slide."

Well-Dressed Plan

The third major application for AE in grinding applications is dressing control—an application growing in importance as costly CBN wheels are used more frequently. AE-based dressing systems aided in the acceptance and use of CBN wheels.

"AE is an enabling technology for the economic use of CBN grinding wheels," said Tim Hykes, chief engineer, Cinetic Landis Corp., a grinding machine builder based in Waynesboro, Pa. Cinetic Landis uses both Marposs and Dittel sensors in its AE systems.

Hykes said: "The initial AE sensors were not designed for our applications, but the market has evolved. Both Dittel and Marposs have adapted the technology so it can be effectively used in our environment. The sensors are reliable and robust, and there are few 'touchy-feely' issues in setup; we can set gains, thresholds and decibel levels for different applications right out of the box, so AE systems are easier to use."

Grinding machines need the "eyes" provided by AE sensors in dressing operations, said Giordano Falchieri, product manager, Marposs Corp., Auburn Hills, Mich., a metrology equipment builder. "A grinder is a beautiful machine, but it's kind of blind. Without AE sensors, you have to make a somewhat indeterminate guess of the wheel's position when it is engaged with the dresser and when the dressing is complete. With AE sensors, that's not a guess, it's reality."

Operators should dress CBN wheels as little as possible to minimize grit loss. AE contact detection allows the machine to set its axis and begin to dress from that point. The operator creates upper and lower decibel limits to establish a band across the monitor. The grinding machine's AE output crosses into the band while dressing, the signal moves across the monitor for a certain length of time and then drops down when dressing is completed. The critical value is how long it should take to fully dress specific wheel types. If the signal drops too early in the process, it could indicate a gouge, chip or nick in the wheel, and the need to continue dressing.

AE can reduce wheel wear during dressing, according to Masters. "Without AE, an operator dressing a wheel might take 20 microns across the wheel when he might only have to take 5 microns," he said. "Operators tell me the cardinal sin is to underdress a wheel, so many of them arbitrarily overdress to ensure they don't degrade part quality. But if operators can dress wheels objectively using data, they can reduce tooling costs. In one AE application, CBN wheel wear was reduced by 80 percent."

During dressing of CBN wheels, machine moves are much smaller than the uncertainty of axis positions due to thermal variations, acording to Hykes of Cinetic Landis. "We can make small, very accurate, incremental moves," he said. "Using AE, we'll know within 3 to 4 microns where the wheel is. We will back off the wheel 50 or more microns before starting the dressing operation, then dress until we see

the AE signal that indicates dressing is completed."

Technical Advances

According to Hykes, the most important improvements in AE have been in coupling the signal data—sending it from a remote sensor to a transceiver. Sensor manufacturers initially attempted to couple AE signals through a coolant interface, which attenuated the signal and made setup more difficult. The next step was using rotating sensors with embedded microphones that send a wireless signal to the transceiver. "The latest evolution has been embedding the sensor in a dressing wheel spindle or a grinding wheel spindle, again with wireless coupling of an amplified signal back to the transceiver and then the control panel," said Hykes. "It provides an accurate, sensitive signal and eliminates setup variables."

Masters agreed that advances in sensor technology and placement have led to improved AE operations. "A stationary sensor placed on a spindle housing depends on sound transmission through layers of machinery, including bearings that emit interfering noise. While some of this sound can be filtered, it is preferable to locate a sensor away from noise sources to eliminate the interference."

Rotating sensors, such as Dittel's M sensor and Marposs's contactless AE sensor, can be embedded in the center of a rotating wheel, with the receiver mounted on a wheel cover or other spot. Both Dittel and Marposs also manufacture ring sensors that can be mounted around the grinding machine's shaft, providing a larger sensing area.

"For high-speed ID grinding, Dittel integrated a sensor through the shaft," said Masters. "We modified some spindles by boring right through the center of the shaft and placing a sensor at the back of the quill."

Changes in how sensors "listen" have also helped improve AE operations. For example, Marposs developed AE technology that, just before a grinding cycle, listens for 250 milliseconds to establish the background noise level for operations in which background noise changes continuously. The sound threshold for detecting the start of the grinding cycle resets each time a new background noise level is detected.

"For example, you have 20 decibels of background noise, and the threshold for detecting the grinding wheel contacting the part is 40 decibels," said Falchieri. "If the next time the cycle starts and the

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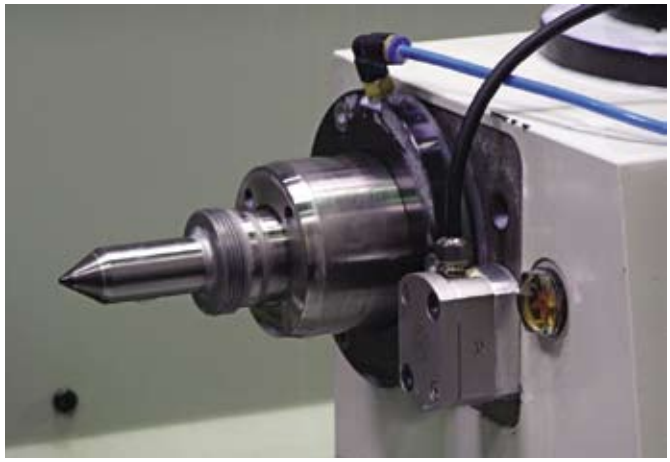

A stationary AE sensor is mounted adjacent to a grinder foot stock.

background noise is 30 decibels, the threshold goes up to 50 decibels. It is a feature you can activate or deactivate depending on the circumstances."

Dittel has introduced an option for its AE systems called envelope monitoring. It allows operators to use more dynamic limits around the signals. For example, as the signal goes across the screen, the operator can snap a profile envelope with upper and lower limits around the signal, allowing him to automate subsequent dressing using that envelope.

Other Uses

While AE is standard on new cylindrical grinding machines, some parts manufacturers are retrofitting grinding machines with AE. The technology can also be used as a troubleshooting tool. "I was running a simulation for one company in a conference room, after which we picked up my portable system and put it on the grinding machine to get a sample dress," said Masters. "The engineer looked at the display for a while and then called in two other engineers, and they talked about it for a while. He then said, 'If this is true, then we have a taper on our wheel that is not supposed to be there.' "

A side benefit of using AE is reduced maintenance downtime. "If you're not crashing your spindle, you don't have to change spindles and reset machine references," said Masters. "One AE retrofit project produced a 50 percent reduction in downtime, which was the biggest savings item in the entire project." CTE

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