New lathe tool offers direct in-process diagnosis of cutting process.

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Plugging In

▶ BY ALAN RICHTER, ASSOCIATE EDITOR

Large-volume machine shops and manufacturers of expensive parts continually strive to directly and reliably predict cutting tool failure, which is especially important for unattended machining.

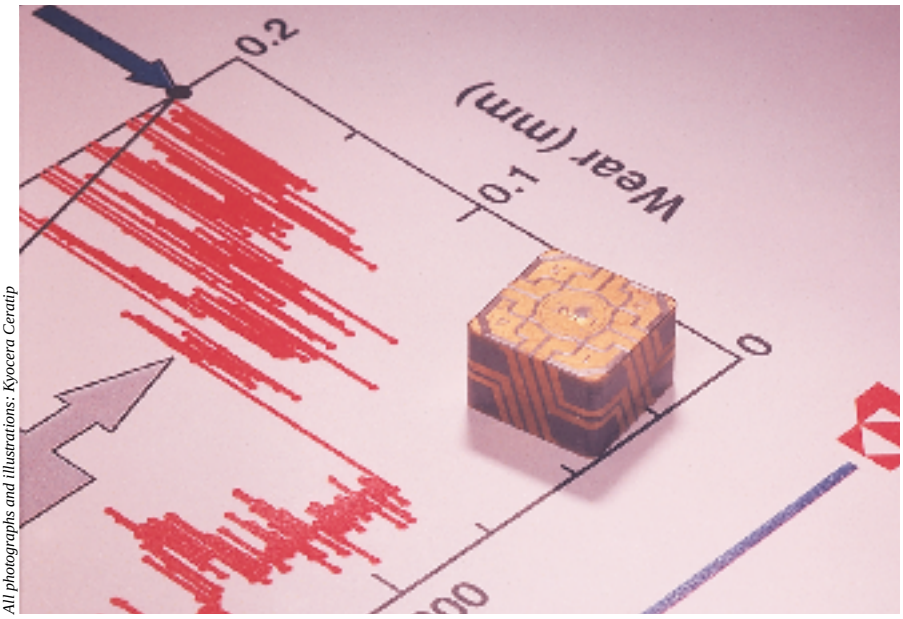
To determine the exact moment a cutting tool breaks while machining a part, Kyocera Industrial Ceramics Corp., Mountain Home, N.C., developed a patented tool-life diagnostic system with a wear-sensor-integrated indexable insert called Sensor Tool.

For some time, in-process tool diagnosis has been performed indirectly by acoustic emission and force diagnosis systems. But, says Kyocera, its patented Ceratip Sensor Tool is the only direct and reliable system that predicts cutting tool wear and breakage and, when a cutting edge fracture occurs, sends a signal that automatically stops the machine before a workpiece is damaged.

When it becomes commercially available in a year or two, the Sensor Tool will cost slightly more than other "non-sensor" tooling, said Chris McGraw, technical center manager for Kyocera Ceratip Cutting Tools. He also said that it will cost around $500 per lathe to have Kyocera set up the tool-life diagnostic system.

How It Works

Manufacturing the Sensor Tool involves ablating portions of the insert's single, 0.3µm-thick layer of TiN coating to reveal its ceramic (Al_2O_3) substrate, McGraw explained. Portions of the conductive coating are removed to create a unique electronic circuit pattern for each insert geometry.



All photographs and illustrations: Kyocera Ceratip

The Sensor Tool incorporates a TiN-coated ceramic insert. Areas of the coating are ablated with a laser to create an electronic circuit through which a signal is sent if the tool fractures.

In operation, an electrical current flows through the coating, which covers the insert's cutting edge. As the Sensor Tool wears, chips or cracks while in the cut, the circuit's resistance increases as the TiN coating wears away. This happens because there's less conductive material for the current to flow through. When the cutting edge breaks, the circuit breaks as well, causing infinite resistance. If this circuit pattern wasn't created out of the coating, a change in resistance couldn't be detected because the electrical current would continue to flow around the cutting edge after it became worn or broken.

A digital ohmmeter measures the circuit's level of resistance via two probes in the insert pocket of the Sensor Tool toolholder that are hard-wired to the ohmmeter (Figure 1). McGraw said that although this wiring configuration will not allow a machine's turret to index, the company is working on a wireless prototype that will send signals via a transmitter.

Once the cutting tool experiences excessive wear or breakage, McGraw said the ohmmeter sends a signal to the lathe's CNC. The control then directs the machine to follow preprogrammed instructions, such as stopping the machining operation, pulling the tool out of the cut or changing the cutting tool then resetting the machine to continue producing parts.

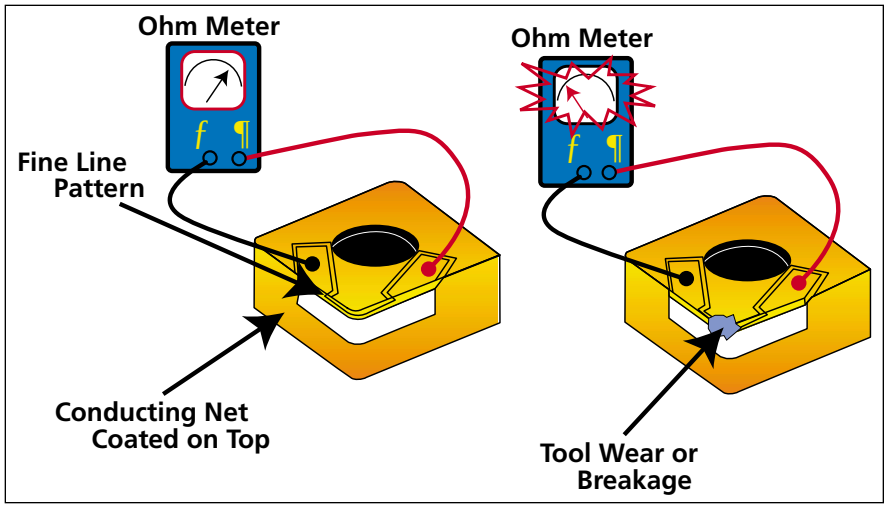
For a facing cut, for example, the CNC would be programmed to move an

excessively worn insert off of the part in the Z-axis direction, followed by a movement in the X-axis direction. If a groove were being cut, the control would direct the machine to pull a broken insert straight out of the cut, thereby preventing damage to the sides of the groove.

Future Possibilities

Kyocera initially developed the Sensor Tool system to incorporate ceramic inserts. However, the company plans to develop cermet inserts next, followed by ones made from carbide. McGraw said that the wear-sensor technology could even be applied to diamond cutting tools.

Although the first Sensor Tool insert is square and has eight cutting edges, the technology would work with any tool geometry except a round insert, according to McGraw. As round inserts were indexed within the toolholder, the insert's circuitry could not be positioned so that precise contact would be made with the holder's two probes, he said. He added that the sensor technology could be applied to non-round inserts with chipbreaker geometries.



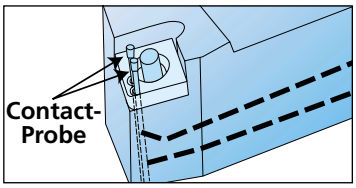


Figure 1 (top): When the cutting edge breaks, the circuit formed by the coating breaks, too, creating infinite resistance. 1a (right): A digital ohm meter measures the circuit's level of resistance via two probes in the insert pocket of the Sensor Tool toolholder that are hard-wired to the ohm meter.

Kyocera developed Sensor Tool to be a direct and reliable method for detecting tool wear and breakage during high-volume and high-risk jobs. And while Sensor Tools will carry a higher price tag and require some modifications to be made to the user's lathe, McGraw said the payback would be reduced scrap and machine tool downtime.