Grinding help is on the way

By Susan Woods, Associate Editor

This month, CUTTING TOOL ENGINEERING covers technologies that can help manufacturers streamline wheel dressing and monitor grinding forces.

Dressed for success

One problem associated with metal-bonded superabrasive grinding wheels is the difficulty of dressing them. The low chip load of a metal-bonded wheel, the large contact area between the wheel and the workpiece and the reduced machine stiffness can diminish erosion of the wheel.

ELectrolytic In-process Dressing (ELID), available from Advanced Manufacturing Solutions Co. Ltd., Toledo, Ohio, uses electrochemical electrolysis to remove the metal bonds and worn particles and expose fresh grains on the wheel continuously while in-process.

Advanced Manufacturing Solutions

A model of an ELID grinding setup.

An ELID system consists of a metal-bonded superabrasive wheel, a copper electrode, an electric power source and electrolytic fluid. The wheel, connected to the positive terminal of the power supply with a smooth brush contact, is dressed by the electrode, connected to the negative terminal, in the presence of the electrolytic fluid.

A high pH grinding fluid diluted with water is used as the electrolytic fluid. This fluid is also the coolant, so there is no need for a separate coolant delivery system or special care to prevent contamination.

As a result of the electrolysis, a controlled insulating oxide layer forms on the outer surface of the wheel. This layer is more flexible than the bond material. As the grains wear during the grinding process, the oxide layer also wears. This leads to increased electroconductivity of the wheel, which facilitates an intensification of the electrolysis and generates a fresh insulating layer. Thus, the protrusion of the grains remains constant.

There are several benefits to using ELID. First, the grinding process is not interrupted to dress the wheel.

Second, wheel consumption is reduced. ELID eliminates mechanical dressing, which means the wheel volume lost during this conventional procedure is minimized.

Third, the wheel can have a small grit size, such as 5nm diamond. "This results in a mirror-like surface finish with roughness at a nano or subnanometer level," said Ioan D. Marinescu, Ph.D., CEO of Advanced Manufacturing, and professor and director of the University of Toledo's Precision Micro-Machining Center.

The ELID system works with conventional grinding machines and any metal-bonded superabrasive wheels.

Focus on force

Because the forces generated during ultraprecision grinding are so small, they present challenges for accurate and reliable process monitoring. A new grinding system overcomes these challenges to provide real-time force feedback.

The system, developed at Penn State University, uses an air-bearing spindle, powered by a frameless, brushless DC motor, and a rotary encoder for synchronized data acquisition. Two noncontact, high-resolution, capacitive-displacement sensors measure relative displacement between the rotor and stator of the workpiece spindle, without degrading machine stiffness.

The axial, radial and tilt stiffnesses are known for the spindle, so the grinding forces can be computed from the measured displacements and displayed in real-time. The real-time analysis software can log changes in grinding forces over time from wheel wear and be used to monitor transient events such as touchoff, sparkout and intermittent contact.

Monitoring grinding forces is also helpful in holding tolerances. "Typically, when you reach the final position, you hold there for a moment before you retract the wheel away from the workpiece," said Eric Marsh, associate professor of mechanical engineering at Penn State. "With this system, you can see when the forces have more or less dropped to zero and your part is the correct size."

The system can also be used to help maximize the material-removal rate. "It lets you know if you can go faster before you risk breaking down your wheel too fast," said Marsh.

Marsh and his team developed the real-time computer interface in partnership with Professional Instruments Co., Hopkins, Minn., a spindle manufacturer, and Lion Precision, St. Paul, Minn., a sensor manufacturer. The system can be obtained from Professional Instruments. △