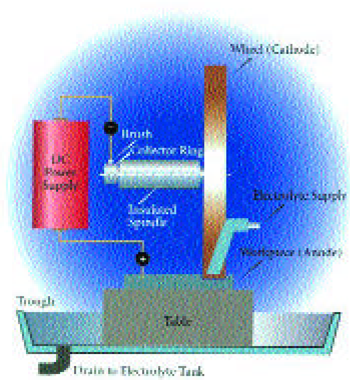
AMERICAN MACHINIST
STRATEGIES AND INNOVATIONS FOR COMPETITIVE MANUFACTURING

May 1, 2003

Charged-up grinding

Electrochemical grinding tackles the tough stuff and leaves a fine finish.



Electrochemical grinding removes metal through the chemical action resulting from the passage od DC current in the presence of an electroytic fluid.

Pumping electricity through the workzone of a surface grinder transforms it into a machine that operates at low cutting forces and one that generates no heat in the workpiece. Yet this same machine tackles tough materials with surface hardnesses of over 65 Rc, leaving no burrs, workhardening effects, or recast layers -- even on fragile, thin-walled, and thermosensitive parts.

Electricity, or more specifically an electrochemical reaction, is the principle behind electrochemical grinding (ECG). This nonconventional machining process involves a machine similar to a surface grinder, an abrasive wheel, and an electrolytic fluid.

The conductive grinding wheel connected to a negative terminal of dc power is the cathode, and the workpiece, which is conductive and connected to a positive dc terminal, is the anode. As electrical current flows between the cathode and anode, the electrolyte fluid dissolves workpiece material, forming soft metal oxides. The abrasive in the grinding wheel then rapidly removes this oxidized material. Since workpiece material dissolves and is removed simultaneously, the process creates no part stress or burrs.

ECG uses extremely low dc voltages (usually between 3 and 15 V) that minimize spark discharge. This generates little or no heat in the cut -- unlike EDM, which can create small surface distortions and heat-affected zones.

According to Dan Stern, CEO of Everite Machine Products, a manufacturer of electrochemical grinders in Philadelphia, ECG does not require a machine that's extremely rigid or powerful. The main reason is that an ECG wheel works much less than a conventional one. This is another reason why the process produces burr-free parts.

What makes ECG wheels different from their conventional counterparts is that they are conductive, usually solid disks, and their abrasives aren't as rough. Metal or resin-bond wheels with silicon carbide, aluminum oxide, diamond, or Borazon abrasives work in the process.

Wheels wipe away the oxide formed on the workpiece to expose new material. Shops control how quickly the wheel does this by adjusting speeds and feeds. Typically, wheels run a little faster than the electrochemical process, so there is some abrasive grinding, but very little, says Stern.

Wheel wear is thus minimal and usually balanced with the level of productivity a shop wants. "In some applications, ECG wheels may last as much as 103 longer than those in a conventional-grinding process," he comments. There is also no wheel loading because an ECG wheel is simply wiping away decomposed part material. In fact, Everite has cut stainless steel with a diamond wheel and had no loading problems.

"The process is as abrasive as a user wants it to be," says Tom Travia, a manager at Everite, "and there is a limit as to how much electrochemical dissolution happens in a given timeframe. Metal removal is proportional to the amount of current flowing. Increasing the flow from 3 to 15 V, for instance, decreases abrasive activity, while upping the machine feedrate increases it.

The key is to come as close to a perfect balance between electrochemical oxidation and abrasive removal of the oxides. The application and the user's desired part finish and accuracies dictate a proper balance, which, says Travia, is not always a 50/50 split.

While the mechanical aspect (the machine) of the process is accurate, the chemical part can affect tolerances. For instance, on a fairly light cut, an ECG machine easily holds tolerances within 0.001 in. But when removing large amounts of material, such as in roughing cuts, those tolerances are closer to 0.005 in.

The amount of electrolytic fluid at the workpiece/wheel interface determines the amount of electrochemical oxidation. The fluid flows through a coolant nozzle similar to one on a conventional grinder. However, unlike the coolant flow of a conventional grinder in which more is generally better, excess electrolyte in ECG removes metal beyond the shape of the wheel. Shops doing ECG use just enough, and no more, electrolyte to accomplish a particular job. According to Travia, electrolyte is not there to wash away the by-products of the process. That's what the wheel is for.

Unlike conventional grinding techniques, ECG machines materials independent of their hardness or strength. Workpieces just have to be conductive and electrochemically reactive, and almost all metals are, says Travia. In fact, he adds, a high-temperature Inconel or Hastelloy is more reactive and cuts better on an ECG grinder than do some mild steels.

For example, materials used for body implants, such as cobalt-chrome alloys, are well suited for ECG, which produces an excellent finish on those materials, says Stern. "In one application, EDM took 45 min to burn a slot in a femoral hip component, and ECG did it in 2 min. The finished part was cool, had no burrs, and needed no secondary operations, and the inside of the cut had an 8-Ra finish.

Also for the medical industry, shops grind billions of hypodermic needles yearly measuring from 0.012 to 0.125 in. in diameter on Everite ECG machines. "Ten years ago," says Travia, "electrochemically grinding hypodermic needles was considered impossible." What makes it a reality is that the parameters of the process are adjustable to produce a sharp edge.

Needles typically have three angles: a large bevel and two small relief angles, called lancet points. Shops using ECG grind the large bevel angles without generating burrs and with minimal wheel wear. These shops then adjust the process voltage and feedrate for a more abrasive cut that produces sharp edges on the remaining angles. By incorporating ECG, these shops also eliminate a secondary bead-blasting operation.

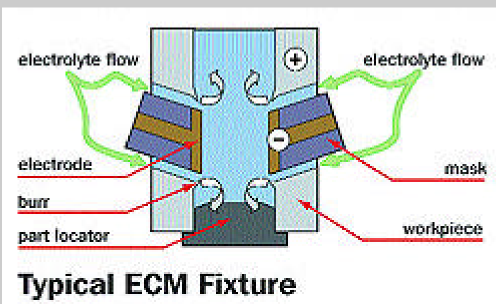
A machine for the process

Everite's most popular electrochemical surface grinder is the Ultracut Model EG618S.

Everite makes electrochemical cutoff machines and grinders. One of its most popular machines is the Ultracut Model EG618S. This electrochemical surface grinder features Smart Axis table power feed and touchscreen programmable operator interface. Smart Axis provides both conventional and climb-grind capabilities along with an infinitely variable feedrate range of 0.25 to 60 ipm. There are multiple settings for rapid traverse and feed positions with no limit switches to set. Users control all machine functions with the touchscreen, which features on-screen instructions and error checking. With the touchscreen interface, operators can also preset table positions for multiple fixtures, wheel dressing, or part loading.

The EG618S's work surface measures 6318 in. with an X table travel of 21 in. Crossfeed travel is 61/2 in., and height under an 8-in.-diameter wheel is 15 in.

Electrochemical machining



Extrude Hone manufactures machines for electrochemical machining, a process related to electrochemical grinding.

In the same family with electrochemical grinding (ECG) is electrochemical machining (ECM). Like ECG, ECM removes metal using a dc current flowing through an electrolytic fluid. However, in ECM, the tool never touches the workpiece.

There is always a gap of 0.010 to 0.020 in. between the tool, or electrode as it is referred to, and the electrically conductive workpiece. As the electrolytic fluid flows through this gap, it dislodges metal atom by atom. Dislodged metal comes off the workpiece as a positive ion, forming neutral metal hydroxides that are filtered from the recirculating electrolyte.

Typical applications for the process include edge finishing (deburring or radiusing), surface-improvement finishing, and feature machining. On stainless steel, generated surface finishes are as good as 16 uin.

As with ECG, the workpiece in ECM is the anode, and the electrode is the cathode. Electrodes are typically brass, stainless, or copper tungsten, and their shapes match the profiles to be machined in the part. Electrodes do not wear or dissolve in the process. "In fact," says Don Risko, director of ECM technology at Extrude Hone Corp. in Irwin, Pa., "ECM tooling lasts for millions of parts."

ECM electrolyte solution is typically table salt and water. Temperatures of the solution range from 600 to 1,000* F, and the current flowing through it is between 0 and 30 V.

ECM equipment is generally built to suit specific machining tasks. A complete installation consists of a machine/base, power supply, electrolyte system, and tooling. Workpiece dimensions, production rate, and material removal all dictate whether a single-station, dual-station, or special fully automatic machine is required.