

Out of Touch

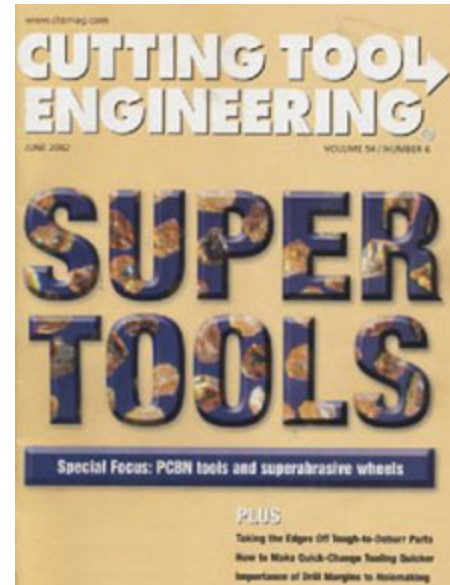
Tools and technologies for removing hard-to-reach burrs.

Removing hard-to-reach burrs, such as those that form at internal cross-hole intersections, can be a real pain.

Vibratory tumblers often are not an option because of the media these systems use. The media are either too large to reach the area in need of deburring or, if small enough to gain access, some of them become lodged in the part.

Attempting to remove these types of burrs manually can create problems, too. Rotary files often produce inconsistent results.

Presented here are some of the technologies and cutting tools that effectively and consistently deburr hard-to-reach burrs: electrochemical machining, thermal deburring, chemical deburring, abrasive-flow machining, waterjet deburring and spindle-driven carbide deburring tools.



The Cationic Method

Electrolytic cationic deburring is an effective method for removing hard-to-reach burrs. Also known as electrochemical machining (ECM), this sophisticated process involves pumping an electrolyte solution, such as sodium chloride or sodium nitride, through the space between the electrode tool (cathode) and the workpiece (anode).

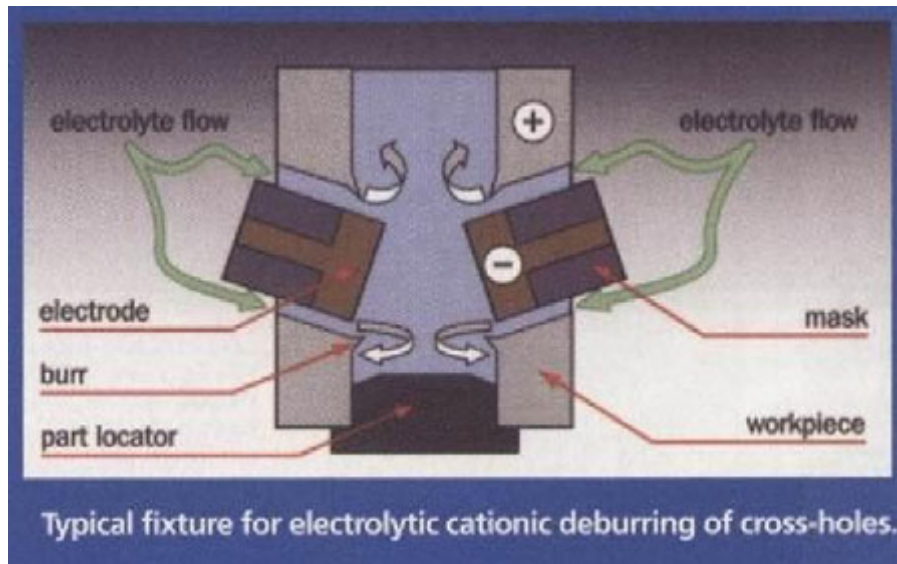
Workpieces receive a positive charge from anode contacts mounted on the fixture. Material is selectively removed from the positively charged workpiece when the electrolyte is flushed between it and a negatively charged electrode. There is no direct contact between the tool and workpiece, so there is no part or tool wear, distortion or mechanical stress.

ECM also doesn't produce a recast layer, said Joe Zmick, division manager for Cation, a Troy, Mich., ECM job shop.

Zmick said any workpiece that's conductive is suitable for the process. But he added that ECM is most appropriate for parts with internal intersections or slots, because other methods can damage the workpiece when deburring these types of features.

"Electrolytic deburring is not run-of-the-mill deburring," he said. "If you don't need a sophisticated deburring process, it's not recommended."

The requirements for the electrode tooling are one reason the process deserves careful consideration before trying it. According to Eden Diver, vice president of SurfTran Mfg. Co. LLC, Madison Heights, Mich., the tooling can either be "simply or thoughtfully designed," but the former won't last long. SurfTran builds ECM systems ranging from single-station machines to automatic transfer lines.



Zmick noted that the main skill requirements for the end user involve developing the tooling, which Cation does in-house. The end user also has to determine the operating voltage, cycle time, gap size and electrolyte conditions, including type, temperature, pressure and velocity. "The process is very consistent once all that's engineered in."

Burr Meltdown

Excessive heat is undesirable at the cutting tool/workpiece interface. But a controlled burst of intense heat is an effective way to deburr hard-to-reach features.

The process is known as the thermal energy method. TEM systems, also available from SurfTran, oxidize burrs and flash without significantly changing parts metallurgically or dimensionally, said Diver.

He explained that the parts to be deburred are sealed in a chamber, which is pressurized with combustible gases such as natural gas or hydrogen and oxygen. When ignited by a 30,000v spark, the gas mixture produces a transient burst of heat (from 4,530° F to 6,330° F) that envelops and vaporizes the burr. Within a couple microseconds, the fuel burns off and the burrs continue to oxidize into a powder until there's nothing on the part's edge that can be removed. The method permits batch processing of similar or dissimilar parts.

While very thin or fragile parts are not suitable for TEM deburring, Diver said an otherwise robust part's thin and delicate features could be masked with a fixture detail or covered with a heat-absorbing block to protect them during ignition.

When thermally deburring internal cross-hole intersections, Jeff Hemphill, manufacturing engineer for Robert Bosch Corp., Charleston, S.C., said the depth-to-diameter ratio generally should be less than 5:1 and, for small-diameter holes, as low as 2:1. The reason is that the fuel needs adequate space to generate enough heat to vaporize the burr.

He said that Bosch, which makes fuel injectors and other automotive parts, employs electrolytic chemical machining to deburr internal cross-holes 95 percent of the time and TEM when the holes are big enough and not too deep. Hemphill added that TEM is primarily for removing external burrs.

However, Bob Douglas, general manager of ThermoBurr Illinois, a deburring job shop located in Huntley, disagreed that there's a diameter-to-depth limitation when thermal deburring cross-holes. He said that since the gas mixture permeates any and all part features, even the smallest cross-hole burr can be removed. According to Douglas, the burr's shape and physical characteristics dictate whether it can be removed with TEM. A burr with too large of a base, for example, would ball up rather than completely oxidize.

"If you can push or pick a burr off, it can be burned away," Douglas said.



A machine for deburring via the thermal energy method vaporizes burrs with a short burst of intense heat.

He added that a dull tool is more likely to generate burrs that can't be thermally removed, because it tends to "push" the metal rather than cut it. Machining parameters also impact burr dimensions. For that reason, Douglas said he'd recommend speed and feed changes, when appropriate, to help a customer produce burrs that can be burned away.

But when the part and burr dimensions are appropriate, Hemphill said TEM offers several advantages over electrochemical machining. TEMed parts do not need preparation before deburring, whereas it's critical to perform secondary work on workpiece variations in order to have consistent parts for ECM. Therefore, Bosch deburrs critical areas using tools and jigs produced in-house before the parts are ECMed.

In addition, the TEM fixturing is less complex. All that's required is a holder with a lid on top or a basket to contain the parts so they don't bang around during the process and get nicked or scratched.

Another advantage of TEM is its cost. A thermal-deburring machine and tooling costs about \$300,000, Hemphill said, while the machine, tanks and power supply for ECM deburring costs about \$200,000 and tooling adds \$500,000 or more to the price tag, depending on its complexity.

Even though it costs less than ECM, Douglas said his customers very rarely buy TEM equipment for in-house use. And although Hemphill said Bosch could outsource parts for thermal deburring, the same couldn't be said for ones that require electrochemical processing.

"Those parts have critical features, so we don't want the rest of the world seeing what we're doing," Hemphill said.

Electroless Steel Removal

If difficult-to-reach burrs need to be removed from a steel part, Robbinsville, N.J.-based Surface Technology Inc. has an electroless chemical deburring process for the job, said

Michael Feldstein, company president. Called Deburr 1000, the process is performed at room temperature (around 70° F) by bathing steel parts in a mildly acidic liquid, which is similar in color and viscosity to ice tea. He said that since it's electroless, there's less monitoring required and less expense involved.

Feldstein explained that the chemical solution etches, or dissolves, the part's surface in a controlled manner, severing the burr at its base. The burr then falls to the bottom of the polypropylene tank and continues to dissolve after the part is removed and rinsed.

The process works uniformly across complex geometric surfaces, making it ideal for deburring, say, two-stroke engine components with internal cross-holes. He added that the part experiences a negligible amount of deterioration, and that the surface has a peak-to-valley height of 0.1 μm .

In addition to the chemicals and a tank, a 300-series stainless steel or PTFE (polytetrafluoroethylene) cooling coil is needed. The coil connects to a chiller capable of removing the heat generated by the exothermic deburring reaction and maintaining a constant operating temperature ($\pm 1^\circ\text{C}$). Feldstein said a slightly warmer solution accelerates metal removal, while a colder bath is beneficial for delicate parts.

Typical cycle times are from 1 to 10 minutes, depending on the grade of steel, bath temperature, solution concentration and the amount of material to be removed. After deburring is performed, Feldstein said the solution is somewhat depleted and, based on an analysis, the appropriate amount of replenisher chemical needs to be added to the tank.

"It's a bleed-and-feed process of taking some out and putting some in," he said. "But the solution lasts forever."

In addition to making and marketing the chemicals, Surface Technology also provides a deburring service.

The electroless-chemical process is currently only for parts made of steel alloys—not stainless steel—but Feldstein said Surface Technology is looking at developing other chemicals for other metals. "We have a concept for aluminum and want to modify the current chemistry for stainless," he said.

Water Power

In nature, flowing water sculpts the shapes of rocks and riverbanks over time. In manufacturing facilities, high-pressure water can be applied to quickly deburr hard-to-reach features while simultaneously cleaning the parts.

David Becker, product manager for Sugino Corp., said the Schaumburg, Ill.-based company's 4-axis CNC Jet-Flex Center combines high-pressure waterjet deburring with drilling, tapping and milling. (Sugino's newest design just deburrs.)

The machine can be ordered with either a 5,000- or 10,000-psi pumping station and a 250-gal. water reservoir. The water pressure is controlled via a manual pressure regulator. In some cases, less pressure can definitely be more effective, because too much pressure can expose air pockets in a casting made from aluminum, for example.

Becker said high-pressure water is able to remove loose flat burrs and grinding burrs, but will not remove rollover burrs or burrs formed as a result of material being pushed instead of cut. Waterjets also can't radius a corner. He noted that Sugino tests a

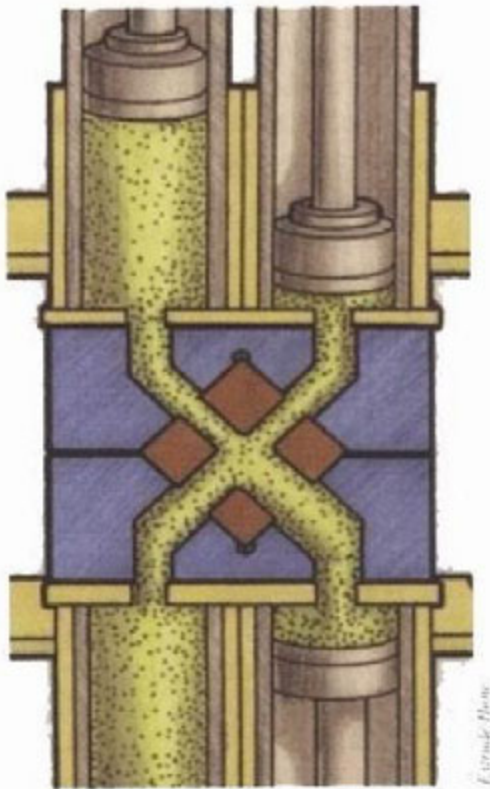
prospective client's production parts to determine if the burrs can be removed via waterjet. The waterjet nozzle sprays in a straight, fan or lance pattern, allowing water to be shot in any direction. And the nozzles can be programmed so they aim at specific locations inside a part and follow a linear, circular or helical-interpolation movement. (The deionized water contains a 3 to 4 percent solution of rust inhibitor.)

The turret-type machine is available with six or eight spindles and either a horizontal or vertical design. Typically, companies use the hard-tooling portion of the machine—as opposed to the waterjet portion—for other deburring tools, such as brushes, Becker said.

He said the cost of the system, which can be supplied as a turnkey package, ranges from about \$200,000 to \$400,000.

Abrasive Putty

Imagine grinding and having the wheel change its shape to match the internal features of a workpiece. That's sort of what happens with abrasive-flow machining. But, instead of a wheel, a plastic, abrasive-laden polymer selectively and controllably abrades the surfaces that it flows across. This makes AFM another effective method for deburring difficult-to-reach features, as well as radiusing cross-hole intersections to remove stress risers.



Abrasive flow machining, such as the Multiflow process, is able to effectively and selectively deburr internal part features.

The putty-like polymer substance contains an abrasive, such as boron carbide, diamond, aluminum oxide or silicon carbide, with grain sizes from 1,000 grit to 8 grit, said Thomas Kohut, vice president of sales at Extrude Hone Corp., Irwin, Pa. "The grit size varies from flour to fine pebbles." He added that the polymer can penetrate holes as small as 50µm.

Typically, an AFM system has two vertically opposed cylinders that press an abrasive back and forth through the workpiece's passages. Using hydraulics, the extrusion pressure ranges from 100 to 3,000 psi. In addition, Extrude Hone, which purchased SurfTran about 1 year ago, offers patented oneway and Multiflow abrasive-flow machinery. The Multiflow process uses multiple media cylinders that can be selectively actuated to provide controlled AFM to each edge and passage in a complex part.

According to Kohut, the diesel industry has the most applications for AFM. For example, diesel injector bodies, valves and nozzle holders are abrasive-flowed to produce radii from 0.004" to 0.016" on the intersections of the high-pressure holes.

This improves the high-cycle-fatigue strength of the parts.

The Tool after Drilling

Mechanically applied cutting tools produce difficult-to-reach features, so why not deburr these features, such as drilled cross-holes, in-line with spindle-driven tools?

Such a procedure is possible with J.W. Done Co.'s Orbitool deburring tool, said Rick Kosarchuk, vice president of the Foster City, Calif. -based company.

"If the part is already on the machine, you can deburr it in that machine with the tool," he said. "And there's no cleaning required prior to deburring."

The tool consists of an uncoated carbide cutter and a slightly larger, polished-steel disk fixed on the end of a tool-steel shaft, which is mounted on a flexible elastomer coupling. The deburring tool also has a drive shaft that fits into a toolholder.



An in-line tool allows drilled cross-holes to be deburred without moving parts to another area of the shop.

After the tool is partially inserted into a hole and is properly positioned against the smooth bore wall, it rotates and advances while sweeping the wall. The disk prevents any cutting until the tool reaches the intersection; burr removal begins when the disk enters the second bore, allowing an interface between the cutter and burr.

The operation can be tailored to leave a minimally broken edge or a blended radius. Kosarchuk said that compared to other mechanical deburring methods, J.W.

Done's in-line process doesn't generate any hazardous material, require the purchase of an additional machine, consume electrolytes or need fixed tooling. The tool costs about \$300, he noted.

Steve Huette, shop manager for Morton (111.) Welding Co. Inc., said the biggest benefit of the tool is that it eliminates parts handling between workstations. "Material movement is costly, so there's a tremendous savings when you don't have to move parts from one area to another," he said.

In addition, Huette said cycle time was reduced from 5 minutes to less than 2 minutes after switching from manual deburring to the in-line method.

For one application, he said the tool rotates at 2,000 rpm and the helically interpolated feed is 12 ipm.

"The tool is easy to cost-justify," he said. "And it's more consistent than if humans are involved, which creates a potential for errors." ThermoBurr's Douglas concurred that manually deburred parts are prone to suffer from human error. "Half of the manually debarred parts I've seen still have burrs," he said.

Douglas added that after a company automates its deburring operation, not only are there fewer human errors, there are fewer people on the payroll as well. In one instance, the number of manual deburrers at one shop dropped from 27 to 4, he said.