Deburring & Finishing

True Grit Smooths Surfaces, Knocks Down Burrs

Machining imperfections targeted, functional surfaces produced

Jim Lorincz
Senior Editor

The best way to handle a burr, of course, is to “not create” it in the first place. The best way to finish a surface is to understand the quality of finish that is required for both function and appearance. That said, the reality too often is that burrs and other imperfections like nicks, scratches, and generally function-robbing surface conditions are created and must be removed. The material and the process responsible for burr formation or other surface condition should be identified and the part matched to the appropriate finishing process—whether manual or automated. In some cases, especially of high value and extremely delicate and small components for the aerospace or semiconductor industries, manual or automated processes may be available. For larger components where ID and OD treatment is required, more traditional processes like honing have proven to be the most effective way to achieve a highly targeted technical result.

Piston pump bodies used in hydraulic flight control systems have clearances of 0.005 mm between moving parts requiring ultraprecise bore size, roundness, straightness etc. The multispindle Sunnen honing machine with air gaging stations between spindles is honing pump bodies controlling bore size to within 0.00025 mm.
New Materials Challenge Honing with Multiple Parameters

The granddaddy of precision surface finishing for large tubular products, honing, traces its development back more than 70 years to the need to de-glaze cylinder bores of early automobile engines. Advances in honing technology include computer controls, new tool designs, new abrasives, integrated air-gage part measurement and servo-driven tool feed systems and spindles enable new honing machines to produce part bores with 0.000010" (0.0003-mm) accuracy and crosshatched surface finishes within a very narrow range for oil bearing purposes. Also, honing can efficiently correct bore geometry distortion from upstream machining processes, welding, or heat treating.

“Today, most of the work we’re involved in is highly technical finishing where surface finishes may be described with as many as five or six parameters to meet manufacturing requirements,” said Dennis Westhoff, business development manager, Sunnen Products Co. (St. Louis, MO). “A lot of it has to do with the evolution in materials. On a daily basis, we’re presented with new materials that feature little adjustments here and there in material composition, often creating parameters that may even work against each other. When you’re trying to adjust the process, there’s a sweet...
Spot you have to hit which basically involves finding the right combination of pressure, grit size, and speeds and feeds,” said Westhoff. “As you might guess these customer formulations are more often than not proprietary.”

The aerospace and energy industries offer some of the most challenging and difficult-to-machine materials, like superalloys, Inconels, and stainless steel with HVL and twin plasma arc spray coatings. “These are all materials that typically produce long stringy chips, are pretty low on the machinability chart, and are not easily cut. As a result we’re always looking at other types of abrasives, different types of diamond, CBN, and adjustments to our bond formulations, as well as adjusting the feed of the machines to give us more finesse, more ability to sense load, and perhaps more stages of feed pressure capabilities. Most of our machines for these types of applications have servo-driven feed systems, so sometimes you can program as many as five or six feed parameters, what I
call pressure profiles into the machine. The operator has the ability to make a lot of little adjustments to keep the honing operation right in the middle of the tolerance,” said Westhoff.

With tolerances continuing to shrink, Westhoff said the only process that can make a cylinder to closer tolerance than a hone is a skilled operator who can lap a bore. “The challenge for us to hold tolerances closer depends on providing the operator with better tooling and better control of feed systems.”

Deburring Cross-Hole Potato Chip Burrs

“One of the most nagging problems in manufacturing is deburring of cross-drilled holes,” said Stan Kroll of J.W. Done (Hayward, CA). “Our Orbitool deburring cutter is capable of in-process deburring of cross-drilled holes and is used just like any cutting tool found on a lathe turret or tool magazine of a CNC milling machine. It removes burrs specifically from the intersection of the crossholes, and can be tailored to leave a minimally broken edge or a blended radius.”

“Cross-hole deburring has always been a challenging application, specifically because you’re working inside the part with blind holes and intersections. Typically the intersections where the burrs are formed takes the shape of a potato chip. Adding to the complexity is drilling holes at angles or off center which can create partial breakout and irregular edges. It has always been a challenge to selectively deburr those edges without damaging or scratching the wall.”

Getting at the burrs, let alone removing them, can be very troublesome. A handful of methods are commonly employed for dealing with these burrs. “While effective to varying degrees, these methods have their drawbacks and generally are off-line processes, involving a separate secondary operation. Parts need to be handled and/or moved from machining to deburring. The extra handling, movement, queue, and transport represent non-value-added operations. Sandblasting, extruding...
abrasive pastes and similar techniques involve capital investment, often substantial, or require outsourcing. Manual deburring with knives, abrasive stones, brushes, and burrs, as everyone knows, is very labor intensive, as well as craft sensitive,” said Kroll.

“Elbows, in particular, have always been a big challenge to deburr. You are getting an edge that is blending out into the wall, so that a cutting tool that is going to cut at the intersection edge is going to jam and break against the wall or it’s going to scratch up that wall.

“With ‘tee’ type intersections (fittings, tubing, manifolds, etc), if you have a much smaller hole that is drilling into a much larger hole you’re creating a flatter circle which may be possible to deburr with a 45° chamfer tool. However, when you have two holes that are very close in size, you generate the potato chip-shaped edge. Similar to elbows, this is where you get into trouble with expanding blade-type tools. They’re going to want to jam and break,” said Kroll.

Orbitool was designed to overcome this problem. The Orbitool cutter has a flexible shaft and a protective disk around the equator of a standard spherical burr. Any time that the tool is inside the hole, it can’t scratch the wall of the bore. Feeding the Orbitool further into the bore moves it past the edge into open space, where the carbide burr begins deburring the edge. Deburring can be done manually like hand-grinding or automated in an NC mill or lathe.

“In an NC mill, the tool makes a spiral motion where the edge of intersection is located, using the helical interpolation function basically like a thread milling program. The cutter head is positioned adjacent to the edge to be deburred and preloaded against the wall of the bore by positioning the shaft very close to, or even touching, the wall of the bore. The tool is fed down the hole over the edge of intersection. The ‘spring-loading’ of the deflected shaft provides cutting pressure. The operator doesn’t have to program the tool to find the edge or know what the contour is. The only thing that the operator needs to know is what diameter is being interpolated for the Orbitool to deburr the edges,” said Kroll. Orbitool cutters are available in diameters
from 1.2 mm to 3/8" (9.5 mm) and are capable of deburring hole diameters from 1.3 to 51 mm. Typical applications include hydraulic manifolds, fittings, elbows, camshafts, crankshafts, and connecting rods, as well as large oil field parts.

Sandblasting Small Parts Where Nanometers Matter

As today’s manufacturing processes enable the fabrication of smaller and more intricate parts, traditional deburring methods, using hand tools to carefully remove burrs, may no longer be adequate. Micro-abrasive blasting, or MicroBlasting, which is a subset of the larger grit blasting industry, effectively removes fine burrs on complex geometries without causing dimensional changes to the part. The process can be used on a wide range of applications including precision deburring, controlled erosion, surface texturing, selective cleaning, and shot peening.

“We do a lot of work with aerospace, medical, electronics, semiconductor, artisan/museums, and industrial controls for applications that are smaller, more fragile, and higher value and more susceptible to damage,” said Colin Weightman, president, Comco Inc. (Burbank, CA). “We take some of the attributes of the sandblasting process and shrink it down to the point where we are focusing a fine stream of abrasives at very high velocities in the 100–200 m/sec range, almost two-thirds the speed of sound to strike the surface. The abrasive fractures on impact, changing size and physical properties so rather than using a shotgun approach we use a machine gun approach of delivering a very accurate abrasive stream,” said Weightman.

Selecting the right type of abrasive, nozzle size, and air pressure to quickly cut off fine burrs for the application is critical. “We work with everything from very hard cutting abrasives to very soft cleaning abrasives—from the harshest to the most gentle—from silicon carbide, aluminum oxide, crushed glass, glass beads to walnut shells, plastic media, and sodium bicarbonate. The
average size for the finest material is about 10 µm. The coarsest material would have particle size of 250–300 µm; while the majority of what we work with is in the 25–50 µm range,” said Weightman.

A pressurized system, MicroBlasting uses a modulated feed mechanism to feed the abrasive into a mixing chamber where a small amount of abrasives is mixed with compressed air and then propelled out of a precision nozzle. The typical abrasive feed rate is 1 gram per minute to 50 grams per minute. “We work with both manual and automated equipment. Our manual systems typically incorporate one of our AccuFlow micro-abrasive blasters with a ProCenter Plus. The ProCenter combines a workstation, air dryer and downdraft dust collector into a single free-standing unit. This all-in-one provides good ergonomics for working on small to mid-size parts while extracting the consumed abrasive.

Some of the most challenging applications MicroBlasting can handle include removing the oxide layer from medical devices, for example, without affecting the base material underneath. “Titanium alloys have a certain amount of ductility. Aluminum oxide hits the surface, quickly shattering and removing any of the more brittle areas that are caused by laser cutting without damaging any of the material underneath. One of the unique properties of MicroBlasting is that being similar to an erosion process all of the features are going to be slightly rounded which is especially effective for fluid flow where sharp edges and corners could generate turbulence,” said Weightman. “In aerospace, we work quite a bit with turbine blades, removing coating material that needs to be selectively removed without damaging the overall part and without masking. In semiconductor production, MicroBlasting can selectively remove layers of materials, eroding down into a wafer to a specific depth or removing an epoxy material from the surface of a wafer to expose given features.”

Microabrasive blasting textures the thread surfaces of this titanium dental implant for improved osseointegration.

Plus combines a workstation, air dryer and downdraft dust collector into a single free-standing unit. This all-in-one provides good ergonomics for working on small to mid-size parts while extracting the consumed abrasive.

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