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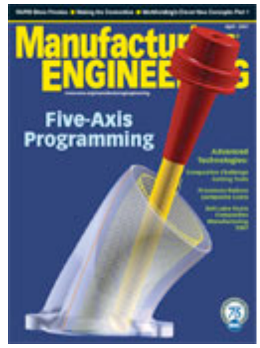

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Why Use Waterjet Deburring?

High-pressure water can simultaneously clean and deburr a workpiece, and hybrid systems can include mechanical deburring in the process

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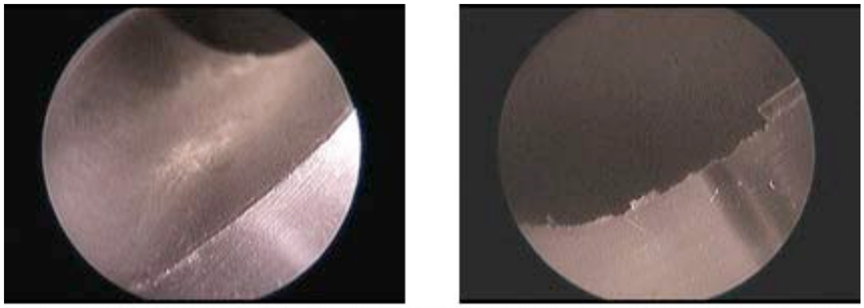


In waterjet deburring, water at up to 10,000 psi (69 MPa) is directed at one or more part features to remove chip burrs, while simultaneously cleaning the part. The process doesn't cut the part; feather-edge burrs are removed.

Increasingly, manufacturers are expected to deliver burr-free totally clean parts to the point of use. To meet this challenge, part manufacturers are turning to new technology. Traditional mechanical and abrasive-deburring methods include hand and/or robotic mechanical deburring with deburring tools and rotary brushes or vibratory finishing. Abrasive Flow Machining (AFM), Thermal Energy Method (TEM) and to a lesser extent Electrochemical Machining (ECM) are deburring methods that are well-known to industry. More recently, High Pressure Water (HPW) deburring has gained wider acceptance in the automotive industry and beyond as a particularly environment and part-friendly technology for removing part contaminates, burrs, and chips, and at the same time cleaning the part.

High-pressure water deburring has a number of advantages over other processes, the first and foremost being that the part is clean and residue-free after deburring. A brief comparison to other processes illustrates this point. When you employ hand deburring, quality is not always consistent, the work is often labor intensive, and internal features are very often difficult to reach. Even when deburred, the part still needs to be cleaned. With robotic deburring, internal features cannot always be reached, very small, loosely attached chips cannot be removed with total certainty, and, again, parts still need to be cleaned.

With AFM, the abrasive material is forced through the part, and must then be flushed free from the part. ECM is employed primarily for edge and surface finishing. Parts are submersed in a salt solution, and an electrical current is pulsed, flowing from tool (cathode) to tool (anode), and removing metal surface atoms without contact. The technology requires complex precision tooling with feature-specific geometry to remove material only where needed. Afterward, parts must be washed to remove salt and prevent corrosion.

TEM removes material by means of combustion. Burrs are actually burned off. Parts are put into a chamber; gas is injected and then ignited. Parts must be properly cleaned and dried before TEM, and cleaned afterward to remove combustion residue. Because many parts are deburred in a single cycle, tooling for TEM is simple and cycle times are short.

The Bertsche iJet CNC hybrid high-pressure waterjet deburring and washing center handles parts as large as 300 x 300 x 200 mm. It moves the part to the waterjet nozzle -- not the nozzle to the part, and generates water pressure to 10,000 psi (69 MPa).

With CNC high-pressure water deburring (HPWD), a high-pressure waterjet, typically operating at between 5000 and 10,000 psi (34–69 MPa), is directed along edges and specific part features to selectively deburr surfaces. Parts are feature-specific deburred and cleaned at the same time. Conditioned water (water with a rust inhibitor) is the deburring medium.

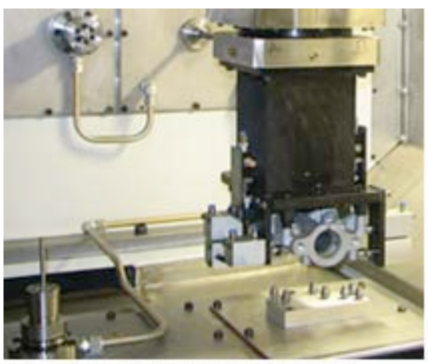
The basic operating principle of HPWD relies on the *impact force* of a high-velocity waterjet exiting from a small-diameter orifice to knock away chips, debris, and burrs from the surface. The process does not cut or compromise the basic part features, nor is it intended to. It removes material that is an unintended consequence of the machining process. The high-pressure water removes material that is not solidly attached to the surface. The burr, in a sense, is qualified. Loosely attached burrs come off, and firmly attached burrs, burrs that cannot be removed with 10,000 psi water, do not. Feather-edge burrs seen only with a microscope are removed.

In general, HPWD does not chamfer edges; in softer materials, such as aluminum, edges can be dulled. In harder materials, edges stay sharp.

The most suitable materials for waterjet deburring are soft metals like aluminum, cast iron, and materials of lower tensile strength. Harder materials require higher pressures, softer materials lower pressure. The time it takes to deburr a part is a function of the type of machine, the power of the machine's pump, the sophistication of the nozzle tooling and—most importantly—the number of features that need to be deburred. With generic tooling, cycle times are generally longer, but fewer stations are needed.

Pump sizing is a function of the size and number of orifices that are designed into a nozzle or the manifold. The greater the flow rate for a given pressure, the greater the pump power rating. Typically, it will take 5–10 sec/part feature, and total cycle times between 20 and 60 sec can be expected.

High-pressure water deburring is very well suited for applications that require inaccessible features to be deburred, when parts must be very clean, when consistent quality is required, or when parts cannot be subjected to heat or corrosive chemicals. The deburring medium, conditioned water, is very good in a number of respects. It's friendly to the environment, and the process occurs at room temperature and does not use abrasives or corrosive chemicals.


Rotary lance nozzles on the iJet deburring machine can enter bores or cavities as small as 5-mm diam.

Specific to the equipment itself, a CNC HPW deburring machine either moves the nozzle to the part feature or (better yet) the machine moves the part to the nozzle. Machines are either of *X, Y, Z* (plus rotary or Cartesian orthogonal design) configuration, or (sometimes) a robot is used. In general, robots are used when less positioning accuracy is needed, while X, Y, Z machine-tool structures are employed when greater accuracy is needed.

Part programming is also easier and simpler with an *X, Y, Z*-type machine. Parts dimensioned in *X, Y, Z* coordinates translate easily to CNC *X, Y, Z* coordinates for part-program execution. Because the robot must be placed inside the work zone, machines that rely on a robot to move the part require more floor space. This location also exposes the robot to continual high-pressure water spray that, over time, will cut through pneumatic and hydraulic hoses and electric cables, and compromise exposed motors, encoders, and sensors.

For *X, Y, Z*-movement machines, there are a number of advantages when the part moves to the nozzle instead of the nozzle moving to the part. Maintenance is considerably less, because with stationary deburr stations all highpressure lines are rigid-piped and don't require flexible hoses, which have a short life at high pressure. Stationary workstations allow for more complex tooling, including parallel-feature deburring.


Horizontal stations on the iJet deburring system include a horizontal direct nozzle, rotary lance nozzle, rotary manifold, and 90° direct nozzle.

The machine manufactured by our company is an example of the type of waterjet deburring system that moves the part (or multiple parts) to the nozzle. Only the overhead ram holding the part is in the wash chamber. Parts are linearly processed from station to station.

Horizontal and vertical part-face operations can be performed in any of six workstations in our equipment. The part is moved and indexed to present the face to be deburred to the waterjet nozzle. Ours is a hybrid machine in that both mechanical-power deburring and HPW deburring are done in the same machine. Parts can first be carried to a mechanical deburr station for a chamfering or brush operation, then moved to water-deburring stations.

All axes are ballscrew-driven to give the machine the accuracy and rigidity required for mechanical deburring. Integration to a part in-feed and out-feed material delivery system is straightforward. The machine becomes the handling device, moving the part from conveyor (or part pickup point) station-to-station to part-drop-off point. A quick-change end effecter allows the same machine to handle a wide variety of parts.

Other features can be incorporated, including a first-operation prewash station and a final-operation part blowoff station to near-dry state, for complete part processing in one machine.

When greater cycle-time reduction is needed, multiple parts can be picked up and moved to the waterjet nozzle for simultaneous deburring.


Hybrid design enables the iJet to do mechanical brush deburring and hole chamfering, as well as high-pressure water deburring.

Just as in machining, part-tool selection for HPWD nozzle selection is very important for reducing part cycle time. Nozzle materials include HSS, carbide, ceramics, sapphire, and more-exotic materials. Harder materials result in longer nozzle life. Direct nozzles create a solid stream or jet that is pointed at the feature to be deburred. Rotary-lance nozzles are used for entering small bores or cavities (down to 5 mm in diam). The waterjet exits at or near the end of the nozzle, typically at 90 or 45° to the axial direction of the nozzle. The nozzle rotates as the part is fed, deburring the feature (feed/rev mode).

Rotary manifolds work like a milling cutter. Typically, three or more fan nozzles rotate as the part is fed, removing burrs across an area as wide as the cutter (the action is analogous to that of a shell mill). For high-volume applications, or when cycle-time reduction is paramount, a custom manifold is designed that deburrs all features in one shot.

The heart of any high-pressure waterjet deburring system is the pump. Typically, electric-motor-driven three or five-cylinder positive-displacement (plunger) pumps are employed, because of their superior ability to create a constant (spike-free) pressure. One or more high-pressure shifting valves direct water from the pump to the nozzle(s). Water returns from the wash chamber to the recovery water tank. The recovery water is strained and filtered, then pumped back to the clean-water tank, where it's again filtered and supplies water for the high-pressure pump. It's a closed-loop system. Pump power is dissipated as heat into the water, and either a heat exchanger or water chiller is needed to keep water temperature reasonably constant.

As the benefits of HPW deburring and cleaning become more widely recognized, users from fields beyond automotive, such as the medical industry, should look to HPW deburring as a way to deliver an assembly or part that's both clean and burr-free.

It's Not Machining

High Pressure Waterjet Deburring (HPWD) should not be confused with High Pressure Waterjet Machining. The latter employs operating pressures of 60,000 psi (414 MPa) and higher, and often relies on an abrasive material such as garnet to aid in machining. In contrast, HPWD operating pressures are typically in the range between 5000 and 7500 psi (34–52 MPa), but can be as high as 15,000 psi or 103 MPa (referred to simply as high pressure).

The waterjet deburring medium is a waterbased solution that contains water conditioners and additives to prevent rust. High-pressure washing systems operate at lower pressures (under 3000 psi or 2.1 MPa), and will clean a part, but will not deburr the part. Customer part requirements for cleanliness of residual debris of 3 mg or less are becoming commonplace. For these applications, low-pressure washing is insufficient, and highpressure water deburring is becoming the preferred technology.