BERTSCHE ENGINEERING CORPORATION
711 DARTMOUTH LANE, BUFFALO GROVE, IL 60089-6902 U.S.A. • Telephone (847)537-8757• FAX (847)537-1113

Hybrid Water Jet and Mechanical Deburring Machine

Increasingly manufacturers are expected to delivery burr free total clean parts to point of use. To meet this challenge, part manufacturers are turning to new technologies. 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 Electro-chemical Machining (ECM) deburring methods that are well known to industry. More recently High Pressure Water Deburring (HPW) has gained wider acceptance in the automotive industry and beyond as a particularly environment and part friendly technology for removing part contaminates, burrs, chips and at the same time cleaning the part.

High Pressure Water deburring has a number of advantages over other processes, first and foremost being that the part is totally clean and residue free after deburring. A brief comparison to other processes illustrates this point. When hand deburring is employed, 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 brush deburring internal features can not 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 then must 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) removing metal surface atoms without contact. The technology requires complex precision tooling with feature specific geometry to remove material only where needed. Afterwards parts must be washed to remove salt and prevent corrosion.

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

With CNC HPWD, a high pressure water jet typically between 5,000 and 10,000 psi is directed along edges and specific part features to selectively deburr surfaces. Parts are feature specific deburred and at the same time cleaned. Conditioned water (water with a rust inhibitor) is the deburring media.*

The basic operating principle of HPWD relies on the impact force of a high velocity water jet 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 HPW will remove material that is not solidly attached to the surface. The burr, in a sense, is qualified. Loosely attached burrs will come off and firmly attached burrs, burrs that cannot be removed with 10,000 psi do not. Feather edge burrs, often only visible through a microscope, are removed. In general HPD does not chamfer edges; in softer materials such as aluminum, edges are dulled. For harder materials, edges stay sharp.

The most suitable materials for HPWD are soft metals such as 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 machines 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 larger the pump power rating. Typically, it

will take 5-10 seconds per part feature and total cycle times between 30-60 seconds can be expected.

High-pressure water deburring is 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 can not be subjected to heat or corrosive chemicals. The media, 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.

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 configuration with one or more rotary axis (Cartesian orthogonal design) or some times a robot is used. In general, robots have less positioning accuracy, while X,Y,Z machine tool structures are used 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. The robot is also exposed to continual high pressure water spray within the deburr and wash chamber that, over time, will cut through pneumatic and hydraulic hoses and electrical cables, and compromise exposed motors, encoders and sensors.

For X,Y,Z movement machines there are a number of advantages when the part is moved to the nozzle instead of the nozzle to the part. Maintenance is considerably less, because with stationary deburr stations all high pressure lines are rigid piped and do not require high pressure flexing hoses, that have a short life at high pressure. Stationary Work stations allow for more complex tooling including same-time multiple feature deburring.

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The type of machine manufactured by Bertsche Engineering is an X,Y,Z and C 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 work stations in our equipment. The Part is moved and indexed to present the face to be deburred to the water jet nozzle. The Bertsche machine is a hybrid machine in that both mechanical-power deburring and HPW deburring are done in the same machine. Parts can first be carried deburred 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 as is robotic machine tending. 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 pre-wash station, a post deburr final part rinse station and an air blower drying station for complete part processing in one machine.

When greater cycle time reduction is needed a multiple parts can be picked up and moved to the water jet nozzle for simultaneous deburring.

Just as in machining, tool selection for HPWD is very important for reducing part cycle time. Nozzle materials include HSS, Carbide, Ceramics, Sapphire and more exotic

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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 diameter bores or cavities (down to 6 mm in diameter). The waterjet exits at or near the end of the nozzle typically at 90 or 45 degrees to axial direction of the nozzle. The nozzle is rotated as the part is fed, deburring the feature (feed/rev mode). Rotary manifolds work like a milling cutter. Typically 3 or more fan nozzles are rotated as the part is fed deburring across an area as wide as the cutter (analogous to a shell mill). For high-volume applications or when cycle time reduction is paramount a custom manifold is design that deburrs's all features in one shot.

The heart of any high pressure water jet deburring system is the pump. Typically electric motor driven 3 cylinder positive displacement plunger pumps are employed because of their better ability to create a constant (spike free) pressure. One or more high pressure shifting valves direct water from the pump to the deburring station. 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 is again filtered and supplies water for the high pressure pump. It's a closed-loop system. The pump power is dissipated as heat into the water and either a heat exchanger or water chiller is needed to keep the 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 or the fluid power industry, , should look to HPW deburring as a way for delivering a clean and burr free assembly ready part

* *High Pressure Water Jet Deburring (HPD) should not be confused with High Pressure Water Jet Machining. The latter employs higher operating pressures 60,000 psi (414 MPa) and higher and often relies on a garnet material to aid in machining. In contrast, HPWD operating pressures are typically in the range between 5000 and 7500 psi (34-52MPa) but can be as high as 15,000psi (103 MPa).*

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The waterjet deburring medium is a water based solution that contains a water conditioner that adds lubricity and prevents rust. High pressure washing systems operate at lower pressures (under 3000psi 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 milligram or less are becoming common place. For these applications, low pressure washing is insufficient, and high pressure water deburring is becoming the preferred technology.

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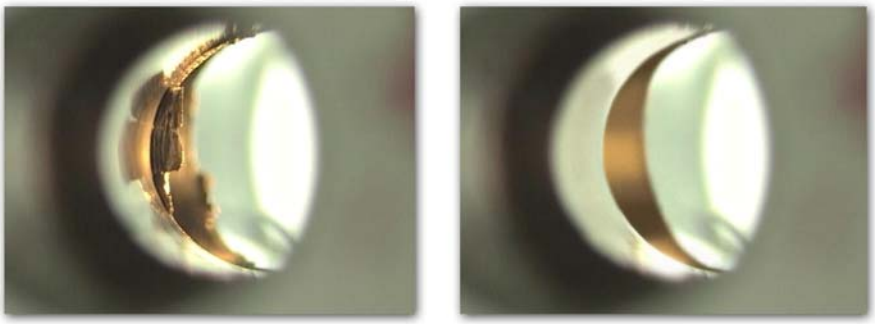
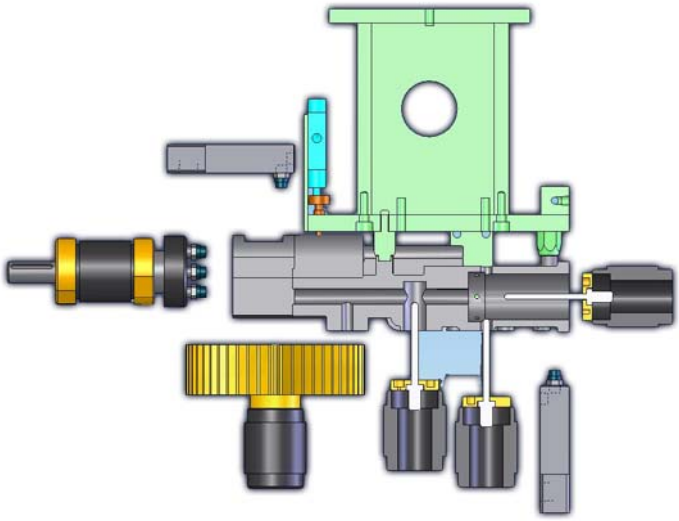


A typical burr formed when crossing drilling and the hole intersection shown after deburring



Tooling Graphic; Part is held by end-effecter with part detection feature.
Typical part processing is shown using a combination of straight and 90 degree direct nozzles, rotary lance nozzles, and rotary fan nozzles, and rotary brush tool to deburr the part on all six sides.

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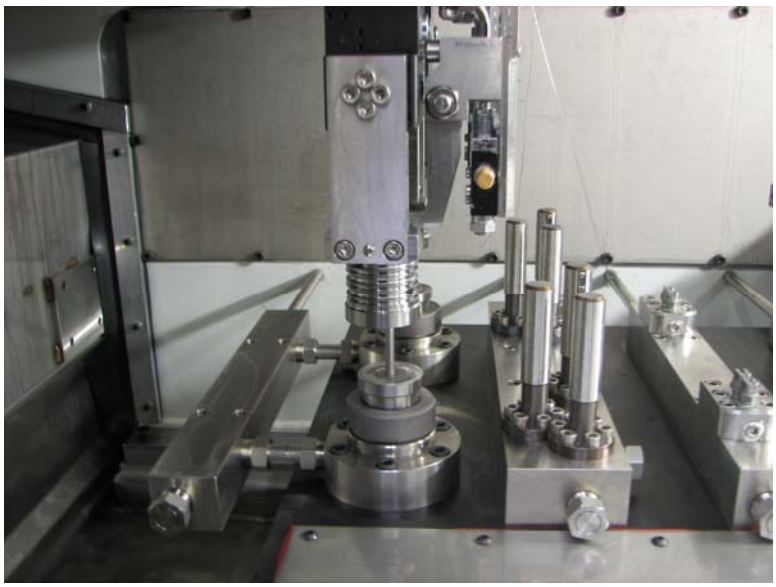
Bertsche 4 axis (X,Y,Z and C axis) i-Jet with integral drying station and post deburr part rinse station



Internal part feature being deburring with a rotary lance nozzle (shown without water for clarity).

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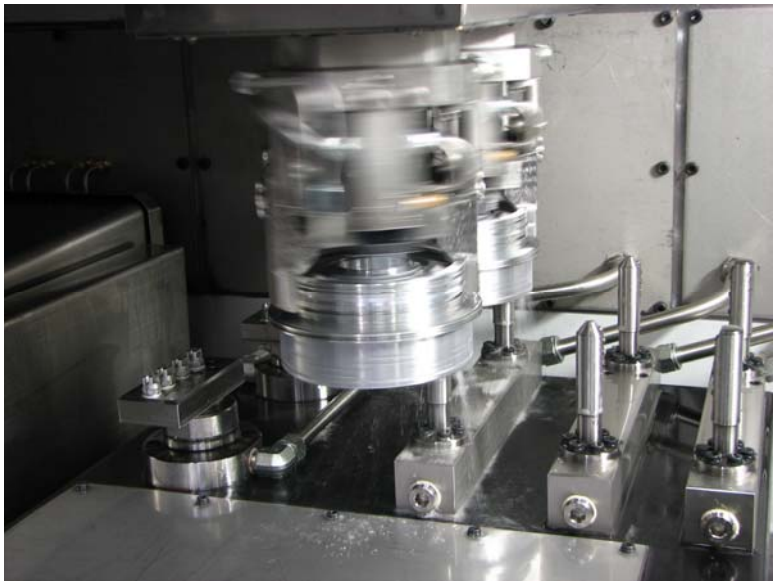
Internal part feature being deburred.
Cross section illustrates how internal features are reached.



With twin C axis used as spindle, parts can be rotated at high speed to quickly deburring and clean.