

HIGH PRESSURE WATER DEBURRING

Friendly both to parts and the environment, this process is gaining momentum in the gear-manufacturing industry as its many benefits are discovered.

By Richard Bertsche

Increasingly, gear manufacturers and others are expected to deliver burr-free clean parts to the 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 are well known to industry. More recently, High Pressure Water Deburring (HPW) has gained wider acceptance in the automotive industry and elsewhere as a particularly environmental and part friendly technology for removing contaminants, 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. 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 cleaned at the same time. Conditioned water—water with a rust inhibitor—is the typical 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 compromise the basic part features. It removes material that is an unintended consequence of the machining process.

* 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). 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 commonplace. For these applications, low-pressure washing is insufficient, and high-pressure water deburring is becoming the preferred technology.

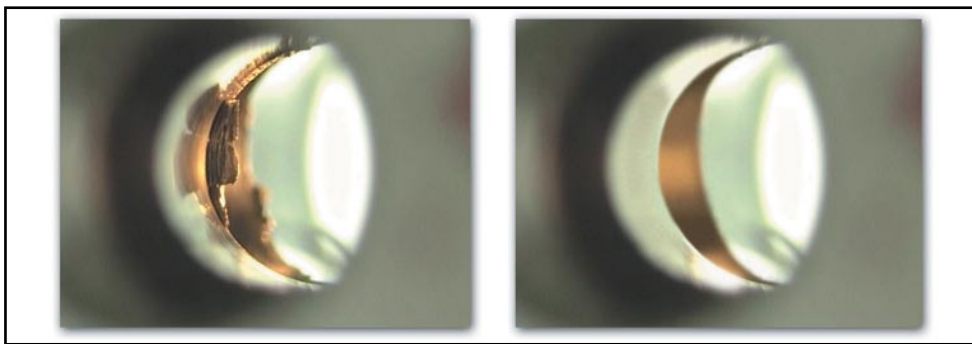


Fig. 1: A typical burr formed when cross drilling and the hole intersection shown after deburring.

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 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, and

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

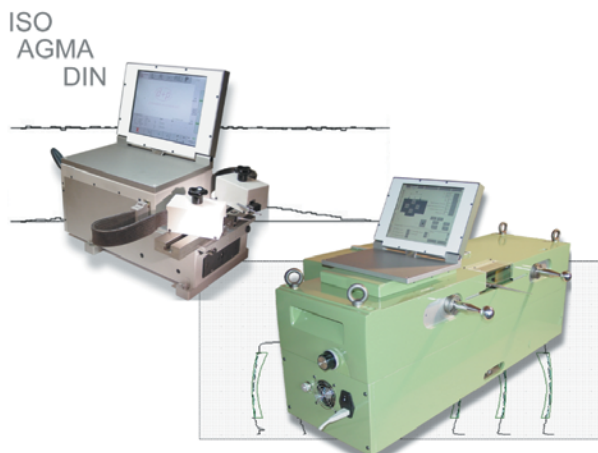
High-pressure water deburring is well

sued 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 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.

HPW deburring is a process well suited for manufactures that need to deliver a microscopic clean part to "point of assembly." The process is sometimes used for edge deburring and cleaning of alloy steel and brass/worm gearing. The process will remove loosely attached metal shavings and feather edge burrs. With high tensile strength materials a distinction must be made between deburring and cleaning. In many cases the burr cannot be removed with high pressure water alone, but HPW will do a very good job of cleaning the part; much better than a typical parts washer that operates between 200-2,000 psi.

Because gears are usually manufactured of high strength steels, HPW is often used as a cleaning process. Deburring and wash-

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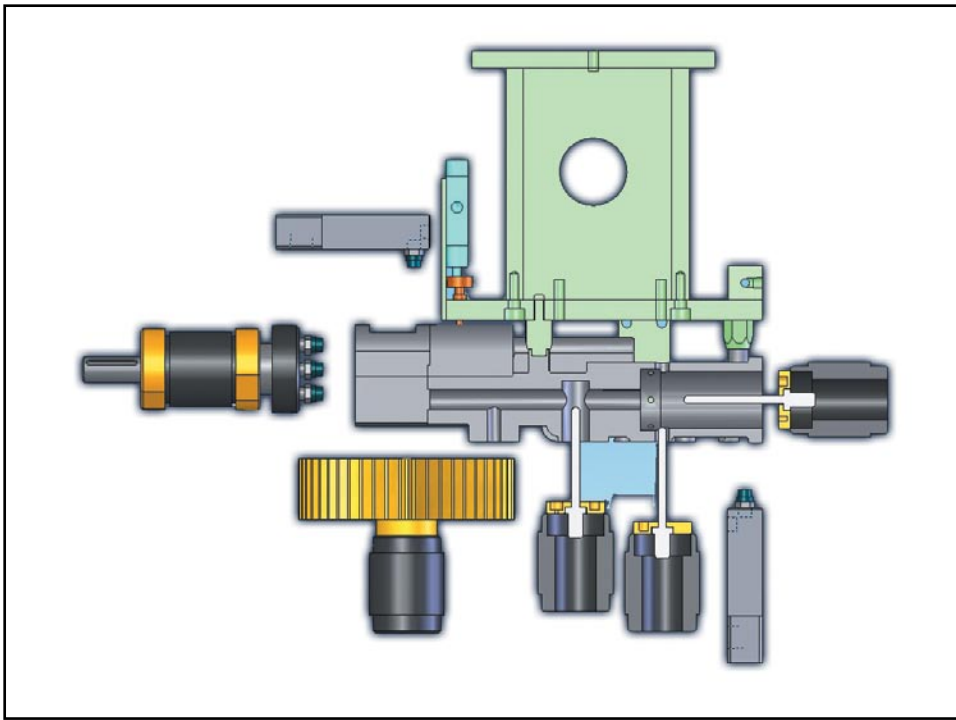


Fig. 2: Tooling Graphic; Part is held by end-effector with part detection feature. Typical part processing is shown, using a combination of straight and 90° direct nozzles, rotary lance nozzles, rotary fan nozzles and a rotary brush tool to deburr the part on all six sides.

ing with pressures from 7,500 to 15,000 psi will remove particles that otherwise cannot be removed with conventional parts washing. Gears that require honing and or broached keyways will benefit from HPW deburring by removing loosely attached metal shavings.

A simple test can be performed to determine if the process will work for the parts being considered for HPW deburring. The impact force of high-pressure water is between five-10 lbs. force. A 0.5 mm lead pencil can be used to mimic the pressure that a 0.9mm (0.036") water jet orifice operating at 7,000 psi exerts on a part feature. If the burr in question can be pushed with the pencil, then the burr can be removed with HP water. If the lead breaks the burr in all likelihood will not be removed.

By combining mechanical deburr (rotary brush or filament brush tooling) into the high-pressure water deburring process, a gear maker is able to use the same machine to remove burrs that otherwise would not come off with HPW alone. The part is first mechanically deburred and then is high-pressure water cleaned to produce a part that is ready for use in critical assemblies.

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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 axes (Cartesian orthogonal design) or sometimes 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 numerous 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 rigidly piped and do not require high-pressure flexing hoses that have a short life at high pressure. Stationary workstations also allow for more complex tooling, including same-time multiple feature deburring.

The type of machine manufactured by Bertsche Engineering is an X, Y, Z and C-axis 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 on such 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 on 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 a part drop-off point. A quick change end-effector 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, multiple parts can be picked up and moved to the water jet



Fig. 3: Bertsche 4-axis (X, Y, Z, and C axis) i-Jet with integral drying station and post deburr/part rinse station.

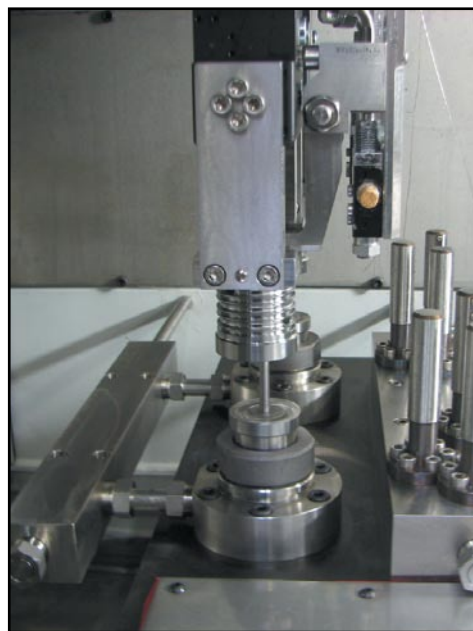


Fig. 4: Internal part feature being deburred with a rotary lance nozzle (shown without water for clarity).




Fig. 5: Internal part feature being deburred. Cross section illustrates how internal features are reached.

nozzle for simultaneous deburring.

HPW deburring tooling 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 diameter bores or cavities (down to 6 mm in diameter). Rotary manifolds work like a milling cutter. Typically, three 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 designed that deburrs all features in one shot.

The heart of any high-pressure water jet deburring system is the pump. Typically, electric motor driven three-cylinder positive displacement plunger pumps are employed because of their greater 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 or fluid power industries—should look to HPW deburring as a way to deliver a clean, burr-free, assembly-ready part. 

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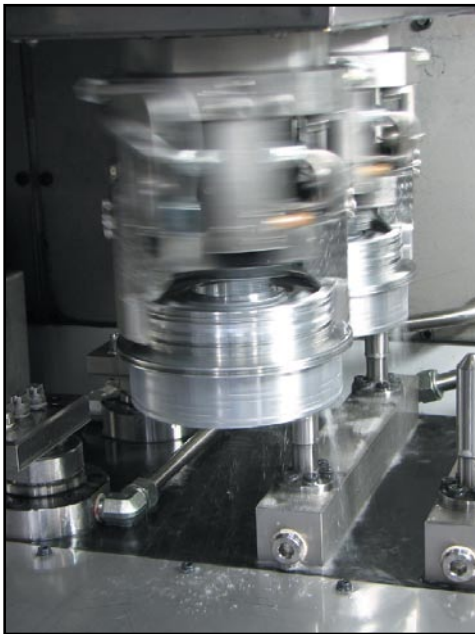
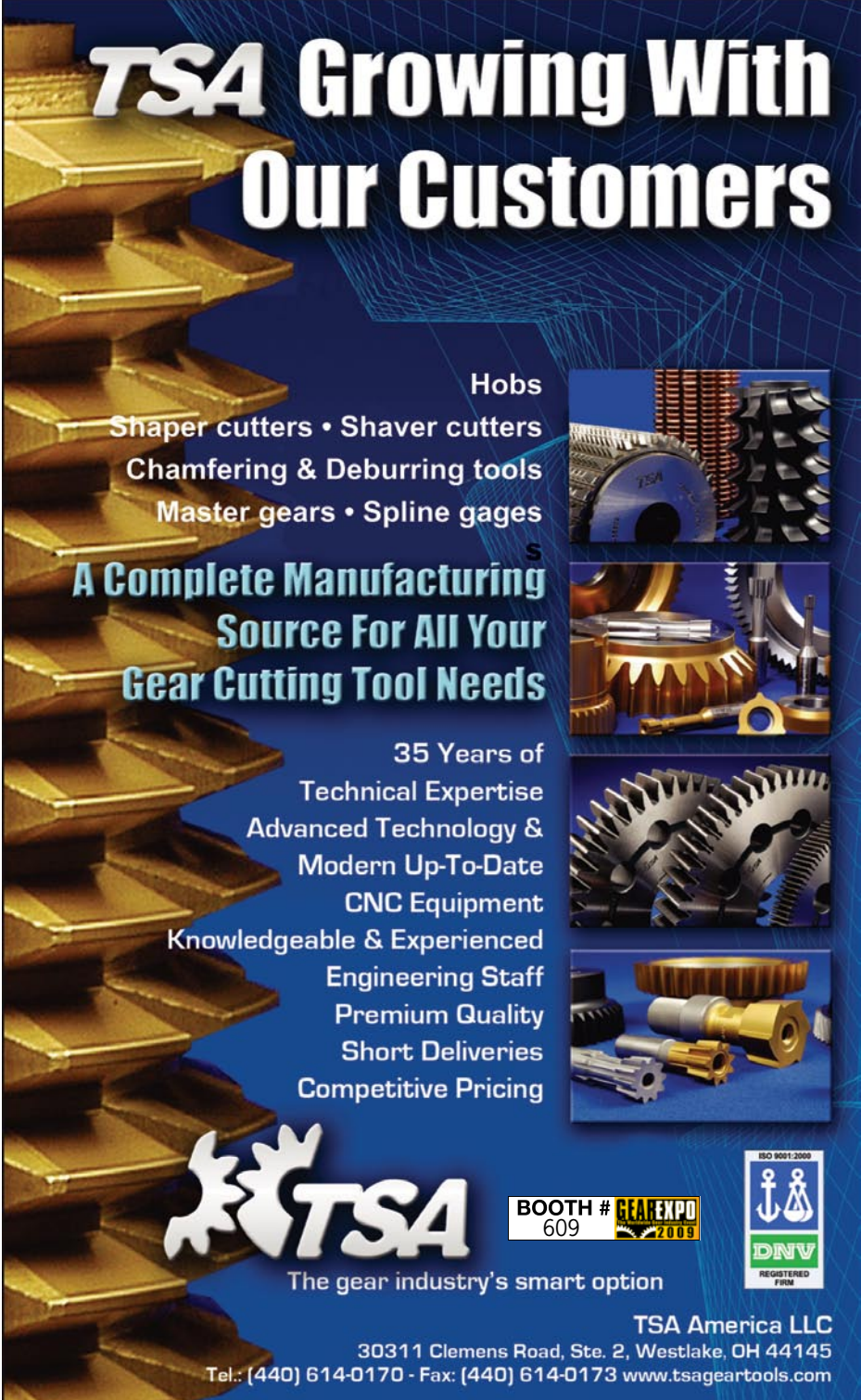


Fig. 6: With twin C axis used as spindle, parts can be rotated at high speed to quickly deburr and clean.



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