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The Ultimate Guide to Waterjet

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The Modern Waterjet

Waterjet cutting technology is one of the fastest growing major machine tool processes in the world. There are virtually no limits to what waterjets can cut, which is why companies of all kinds and sizes are realizing greater efficiencies and productivity by implementing waterjets in their operations.

Waterjet Basics

The waterjet process provides many unique capabilities and advantages that can prove effective in your ongoing battle to reduce costs, increase efficiencies, and maintain quality in your shop. The more you know about waterjet technology, the better you'll be able to understand the benefits it can bring to your operation.

Waterjets entered the manufacturing scene in the early 1970's cutting soft materials like cardboard. In the mid 1980's, the abrasive waterjet was invented by a team led by Dr. Mohamed Hashish at Flow, expanding the capabilities of the tool to cut hard materials. The basic technology is simple, yet complicated at the same time.

At its most basic, water flows from a pump, through plumbing and out a cutting head. It's simple to explain, operate, and maintain. The process, however, incorporates extremely complex materials, technology, and design.

Waterjet pumps today are usually rated to pressures between 60,000 and 94,000 psi (~4100 to 6400 bar). To put it in perspective, your home water pressure is about 60 pounds per square inch (~4 bar) and a fire hose delivers about 200 psi (~14 bar). In the waterjet machine tool, the pressurized water safely runs to the cutting head through ultrahigh-pressure plumbing comprised of T's, elbows, swivels, and flexible stainless steel lines with diameters from ¼" OD to 9/16" OD (6.35 to 14.3 mm outside diameter). At the cutting head, a high speed air actuated On/Off Valve allows the water to pass through the jewel orifice creating a supersonic waterjet stream.

Despite the high psi, waterjets don't actually cut with pressure but instead rely on velocity. The water pressure is exchanged for velocity when the water passes out of the cutting head's orifice. The higher the pressure, the higher the stream velocity. At 60 psi, tap water out of a faucet is traveling 64 miles per hour (103 km/hr). At 94,000 psi, the waterjet is traveling nearly 2,500 miles per hour (4,000 km/hr) -- more than three times the speed of sound.

Pure Waterjet

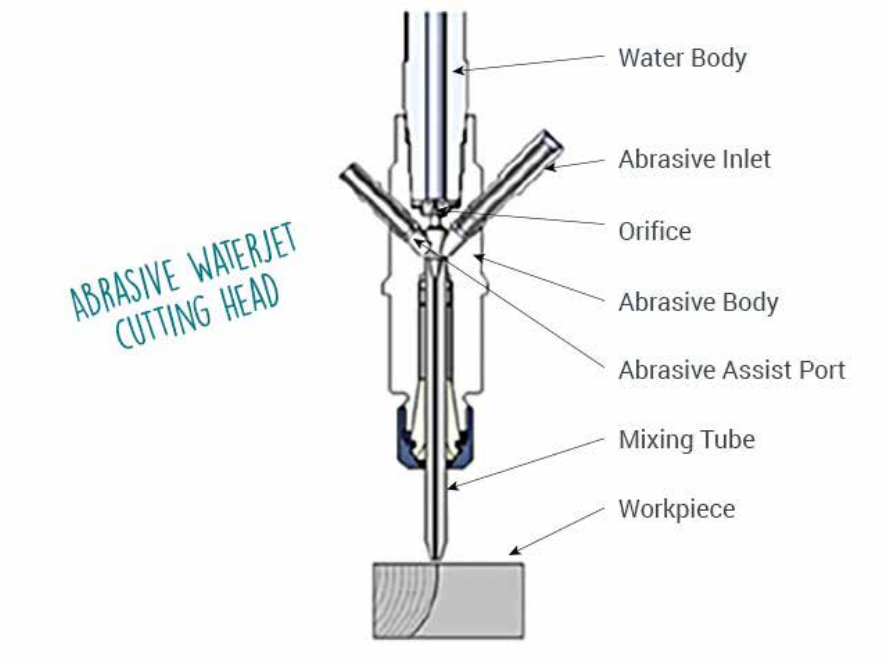
Pure waterjet is the original waterjet cutting method. It features a thin stream (.004 to .010 diameter), extremely detailed geometry, fast cutting speed, and is able to run 24 hours per day. The largest uses for pure waterjet cutting today involve soft materials like gasket, foam, disposable diapers, tissue paper, plastic, carpet, and food.

Abrasive Waterjet

An abrasive waterjet adds a garnet abrasive fed into the cutting head, mixed with the pure waterjet stream, and used to cut hard materials like metal, ceramic, stone, glass and composite. On a Flow waterjet, it takes only two minutes to switch from pure waterjet cutting of soft materials to abrasive waterjet cutting of nearly any hard material – whether thin or over 10 inches thick.

Adding abrasive to the supersonic waterjet stream increases the cutting power a thousand times. To avoid passing mud through the pump, the abrasive is kept clean and dry in a bulk transfer hopper and added to the cutting head at the last second. Once in the cutting head, the abrasive is accelerated by the water and shot out of the mixing tube like a bullet out of a rifle.

An abrasive waterjet, therefore, is a slurry of water, abrasive, and a little air. The process uses roughly one gallon per minute of water (3.8 l/min) and one pound per minute of abrasive (0.45 kg/min.). Abrasive grit sizes range from 50 to 220 mesh garnet, but the most common is 80 mesh.



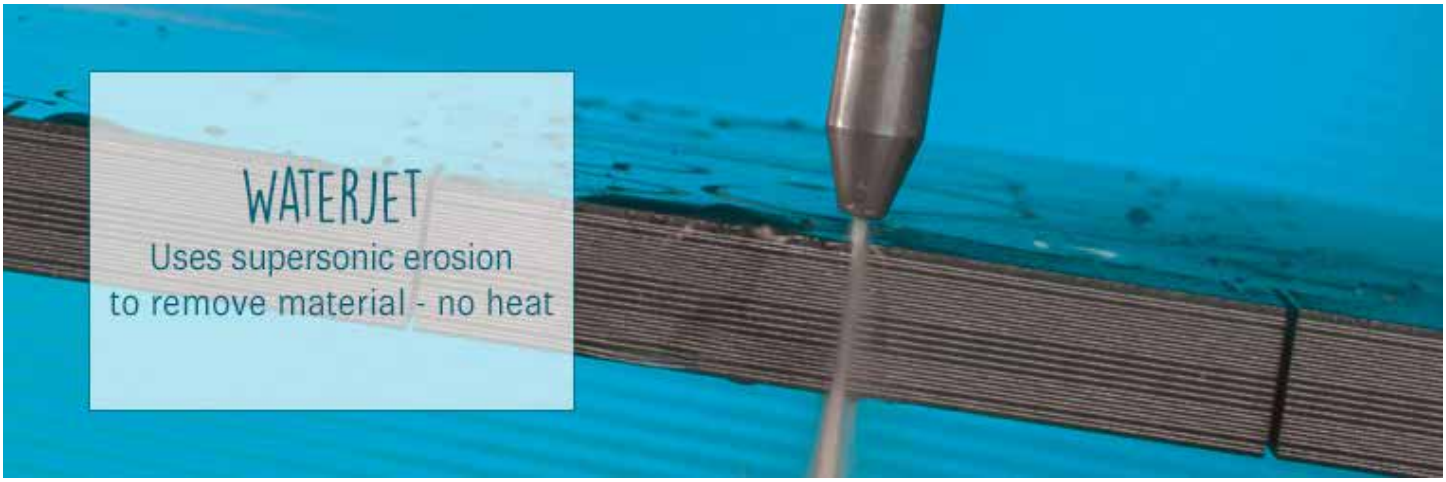
The Advantages of Waterjet Cutting

The waterjet process is recognized as one of the most versatile and fastest growing cutting processes used in production applications across the globe. Waterjet complements or replaces other technologies such as milling, laser, EDM, plasma and routers. No noxious gases or liquids are used in waterjet cutting, and waterjets do not create hazardous materials or vapors. No heat affected zones (HAZ) or mechanical stresses are left on a waterjet cut surface. It is truly a versatile, productive, cold cutting process.

Cold Cutting Process

Abrasive waterjet removes material in a different way than other processes in that it is a cold cutting process. A very small amount of material is removed with the tip of a grain of sand at extremely high speed using a supersonic erosion process. There is so little heat generated that even when cutting thermocouple heat detectors in half, not enough heat exists to change a material.

The material removed is so small and the grain of sand is moving so fast that there is no TIME for the heat to get into the material left behind. Heat needs time to transfer (move your finger through a candle flame fast and slow to understand how heat needs time to have an affect). The heat leaves with the tiny chip of material scooped away: cut material unaffected.



Dr. Hashish says, "In a PhD study conducted at Flow in conjunction with Michigan Tech, AWJ cutting through thermocouples imbedded in Aluminum samples was performed. Data showed that the local temperature rise is in the order of a few tens of degrees, not enough to cause any mechanical, metallurgical, or thermal effects."

The benefits of a cold cutting process can be seen immediately as you take your part off the machine. Since no heat is generated, there is no heat affected zone (HAZ) and the cut edge left behind is virgin material, retaining its original properties. This is a significant benefit for engineers since they can be sure the material will behave as predicted and intended. For example, critical aerospace components are often specified to be cut without heat, or if cut with heat, the edge must be "finished" where a thin layer of heat affected material is removed in a gentle way. HAZ also often hardens and makes surfaces brittle, making making it more difficult to complete secondary operations such as tapping or beveling.

Conversely, other cutting processes use heat or produce heat when cutting material. Lasers and plasmas both use heat to melt the target material causing the material to endure massive amounts of heat. Material is melted by the beam and blown away by an assist gas. Wire EDM (electro discharge machining) removes material by tiny lightning bolts. The lightning jumps from the wire to the target material to melt material and then is washed away with the flushing fluid. Even saws and machining (mills/lathes) produce heat and work hardening at the tool/chip interface due to the high shearing forces at play.

None of these heat and stress inducing changes occur during the supersonic erosion action of the waterjet process.

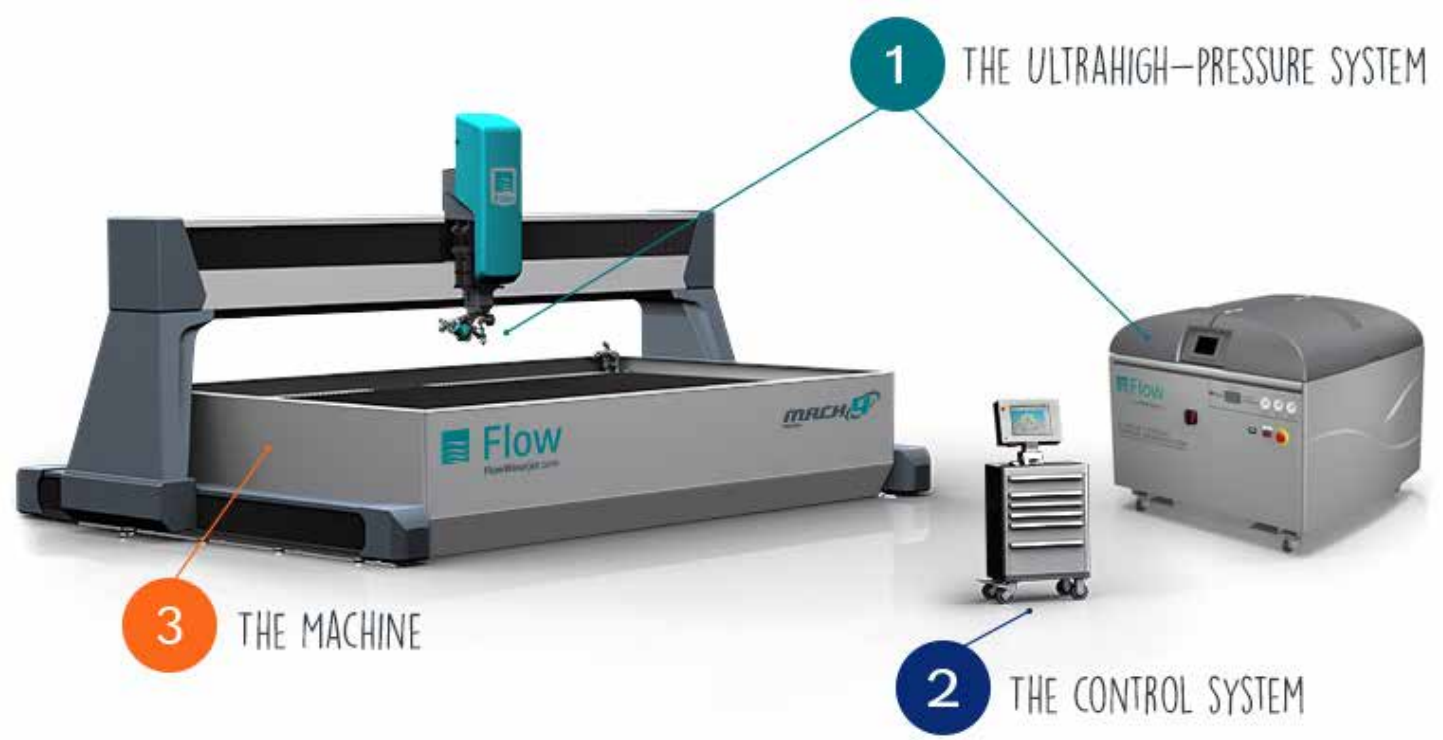
Versatility

The waterjet has shown that it can do things that other technologies simply cannot. From cutting whisper thin details in stone, glass, and metals to rapid hole drilling and cutting of thick titanium to cutting food, the waterjet has proven to be uniquely flexible.

A waterjet can be attached to a variety of machines:

- Hand-held waterblasting wands with rotating tips used to remove paint
- Stationary jets used for high-speed tissue paper slitting
- Single axis systems used for cutting baked goods, fiber cement board, or other product moving off of a roll and others attached to 7-axis pedestal robots used for trimming automotive interiors.

The most common machine used to hold or move a pure or abrasive waterjet is the shapecutting machine tool -- similar to machines that cut with plasma, laser, or router.



With the shapecutting machine tool, the material is placed (or fixtured) on a work table and the cutting head is moved in an XY plane over the top. Sometimes the head has five axes of motion for bevel or 3D cutting.

The shapecutting system is comprised of:

1. The ultrahigh-pressure system with pump, cutting head, and plumbing.
2. The control system with operator interface, motors, feedback system (to ensure you know where the head is at all times), and the software used to program and run the machine (the HMI – human machine interface).
3. The machine with X, Y, Z axes, optional wrist axes, and material support catcher.

Another significant benefit of cutting with a waterjet is that it doesn't induce warp on the target material. If your material is stress free when you start, it will be stress free after you've finished cutting with a waterjet.

However, there are some materials you might work with that already contain stresses when you lay them on your waterjet worktable. For example, tempered glass has, by design, high stress in it so that if it breaks it will shatter into thousands of small pieces. You should never cut tempered glass, not even with a waterjet.

Another example is inducing stress relief by cutting from the outside the edge of a piece of cold formed metal. Stainless steel sheet metal commonly contains stresses caused during cold roll sequences. In such cases the material might be already full of stress and when the waterjet cuts through this outer edge, the material could warp. The abrasive waterjet didn't induce the stress, it relieved it, but that is what caused the warp. For this reason many users simply start the cut just inside the edge of the stressed material, never cutting the picture frame edge and minimizing the warping caused by stress relief.

In addition, today's waterjet machines are often equipped with contour following devices that will ride up and down a warped piece of plate material. This can help, but keep in mind that cutting a precise part from a warped plate is not possible without flattening the plate during cutting and ensuring it is also flat in its final application. If your material is seriously warped, your part can never be truly accurate.

Versatile Solution

There are many reasons for the growing adoption of waterjet cutting technology. Its versatility, quick set up, easy operation, and high quality part production make it an ideal choice for any manufacturing orgainzation looking to reduce costs and improve efficiency.

As the world-leading waterjet machine tool supplier, Flow International Corporation offers the widest range of products to meet your waterjet cutting needs. We make small, entry level machines for simple, low end production, higher end waterjets for intricate five axis cutting in high production running companies, and specialized equipment for companies such as Boeing and Kimberly-Clark.

Our application engineers are available to answer any questions or review your current manufacturing issues to see if waterjet might be right for you. Please visit our website to learn more or to contact us for a test cut: www.FlowWaterjet.com.

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