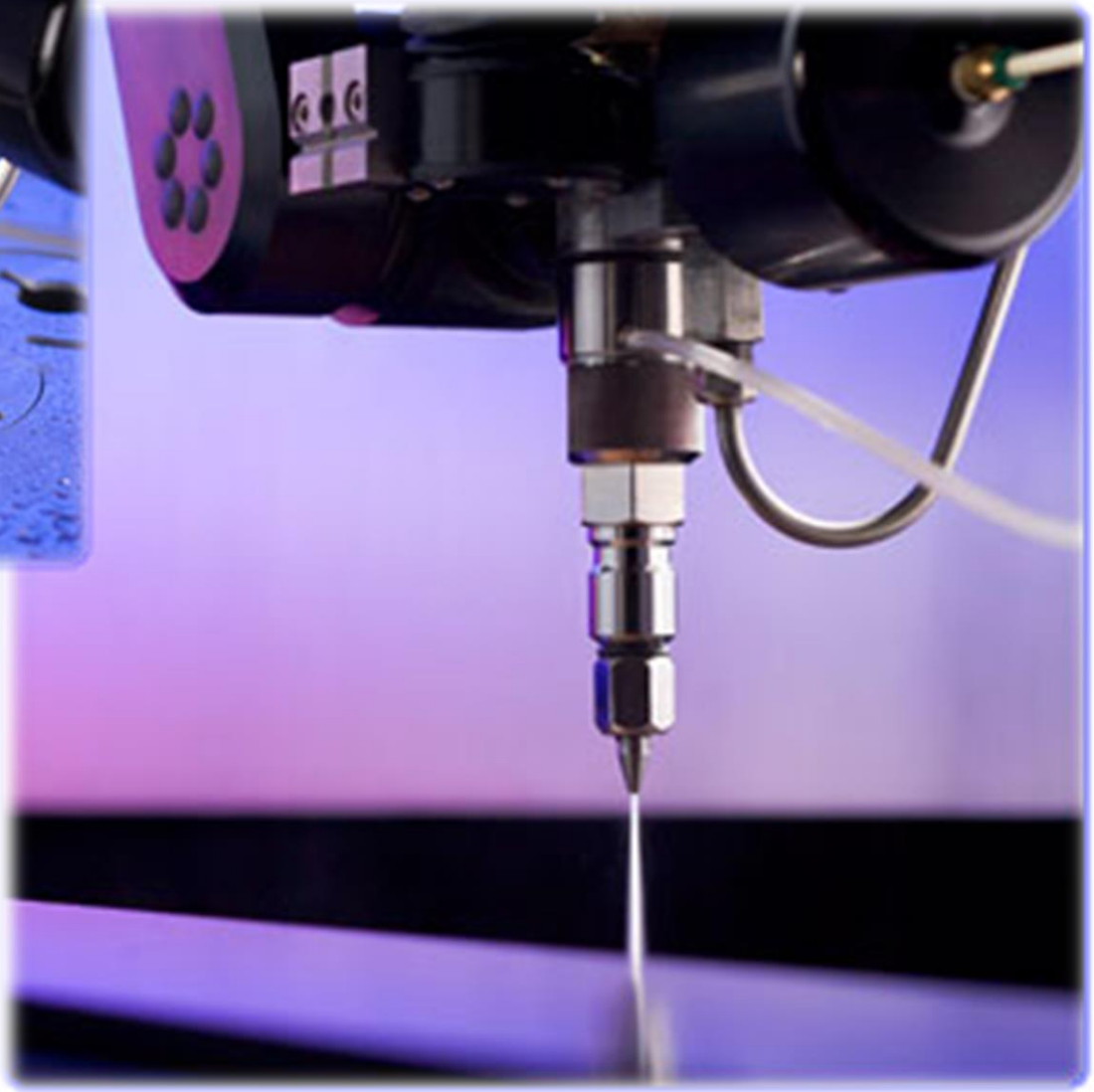
Abrasive Waterjet Machining



Introduction to Waterjet

- Fastest growing machining process
- One of the most versatile machining processes
- Compliments other technologies such as milling, laser, EDM, plasma and routers
- True cold cutting process – no HAZ, mechanical stresses or operator and environmental hazards
- Not limited to machining – food industry applications

History

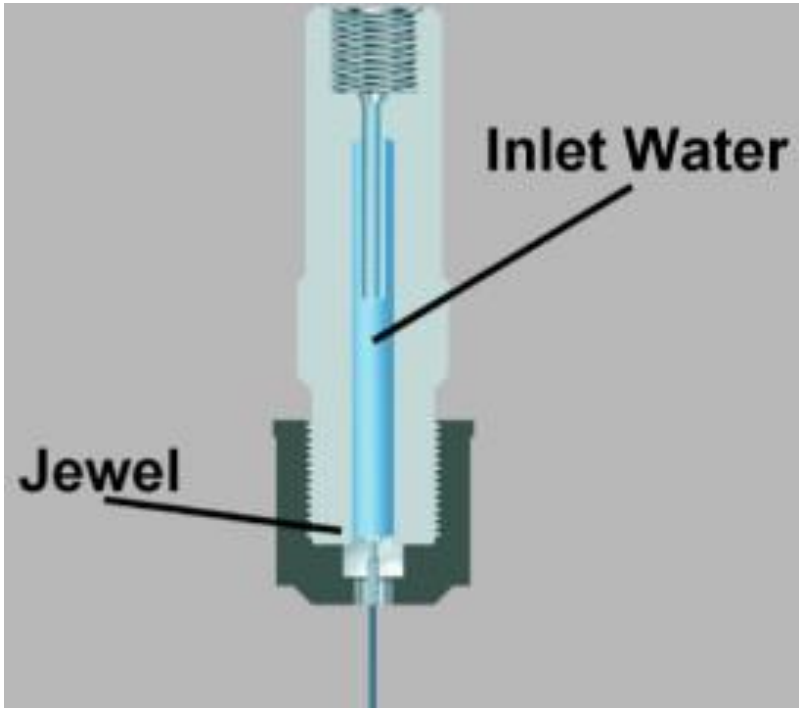
- Dr. Franz in 1950's first studied UHP water cutting for forestry and wood cutting (pure WJ)
- 1979 Dr. Mohamed Hashish added abrasive particles to increase cutting force and ability to cut hard materials including steel, glass and concrete (abrasive WJ)
- First commercial use was in automotive industry to cut glass in 1983
- Soon after, adopted by aerospace industry for cutting high-strength materials like Inconel, stainless steel and titanium as well as composites like carbon fiber

Pure WJ Cutting

- Pure cuts soft materials – corrugated cardboard, disposable diapers, tissue papers, automotive interiors
- Very thin stream (0.004-0.010 dia)
- Extremely detailed geometry
- Very little material loss due to cutting
- Can cut thick, soft, light materials like fiberglass insulation up to 24" thick or thin, fragile materials
- Very low cutting forces and simple fixturing
- Water jet erodes work at kerf line into small particles

Pure WJ Cutting cont.

- Water inlet pressure between 20k-60k psi
- Forced through hole in jewel 0.007-0.020" dia
- Sapphires, Rubies with 50-100 hour life
- Diamond with 800-2,000 hour life, but they are pricey

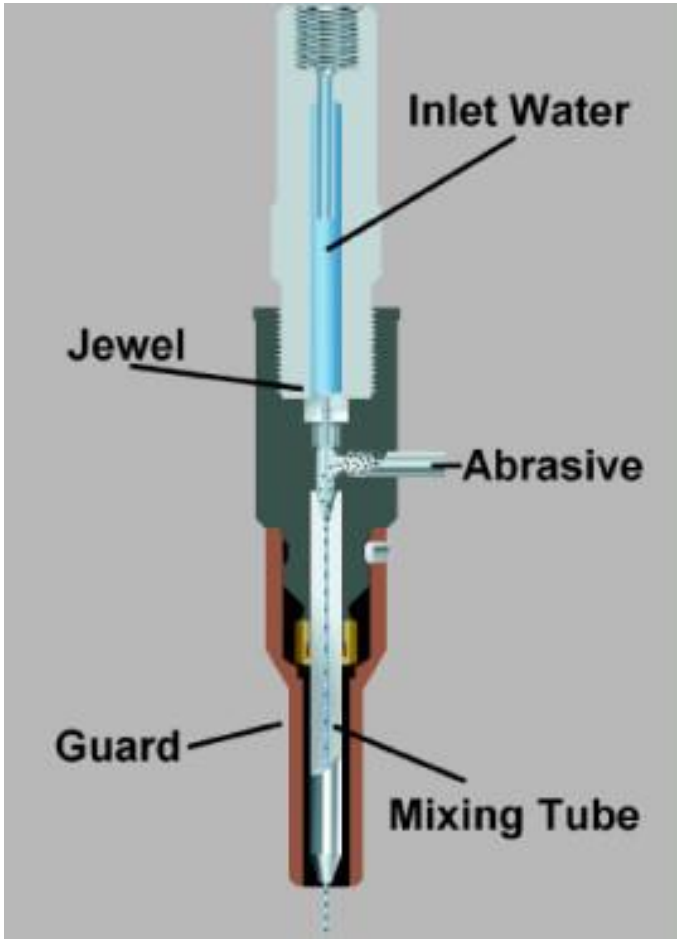


Abrasive WJ Cutting

- Used to cut much harder materials
- Water is not used directly to cut material as in Pure, instead water is used to accelerate abrasive particles which do the cutting
- 80-mesh garnet (sandpaper) is typically used though 50 and 120-mesh is also used
- Standoff distance between mixing tube and workpart is typically 0.010-0.200 – important to keep to a minimum to keep a good surface finish

Abrasive WJ Cutting cont.

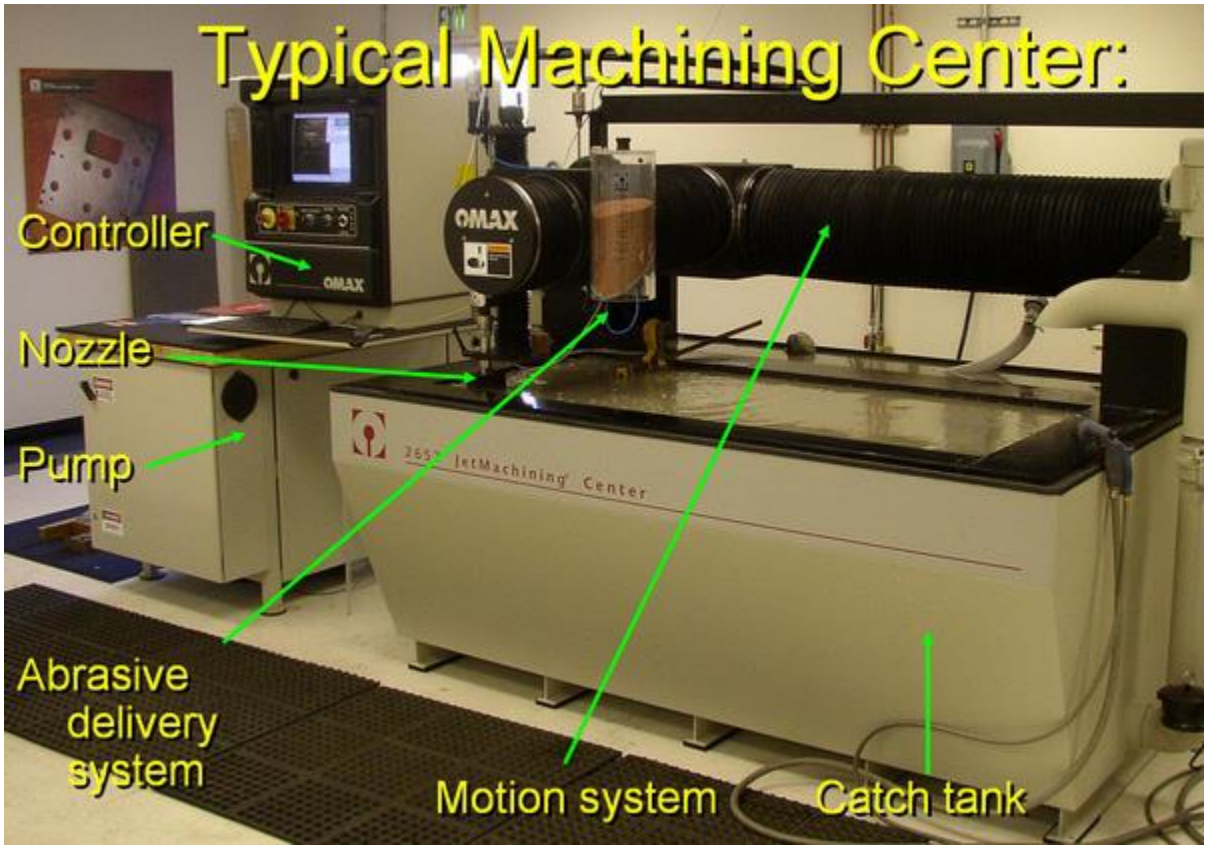
- Evolution of mixing tube technology
- Standard Tungsten Carbide lasts 4-6 hours (not used much anymore)
- Premium Composite Carbide lasts 100-150 hours
- Consumables include water, abrasive, orifice and mixing tube



Tolerances

- Typically +/- 0.005 inch
- Machines usually have repeatability of 0.001 inch
- Comparatively traditional machining centers can hold tolerances of 0.0001 inch with similar repeatability
- WJ tolerance range is good for many applications where critical tolerances are not crucial to workpart design

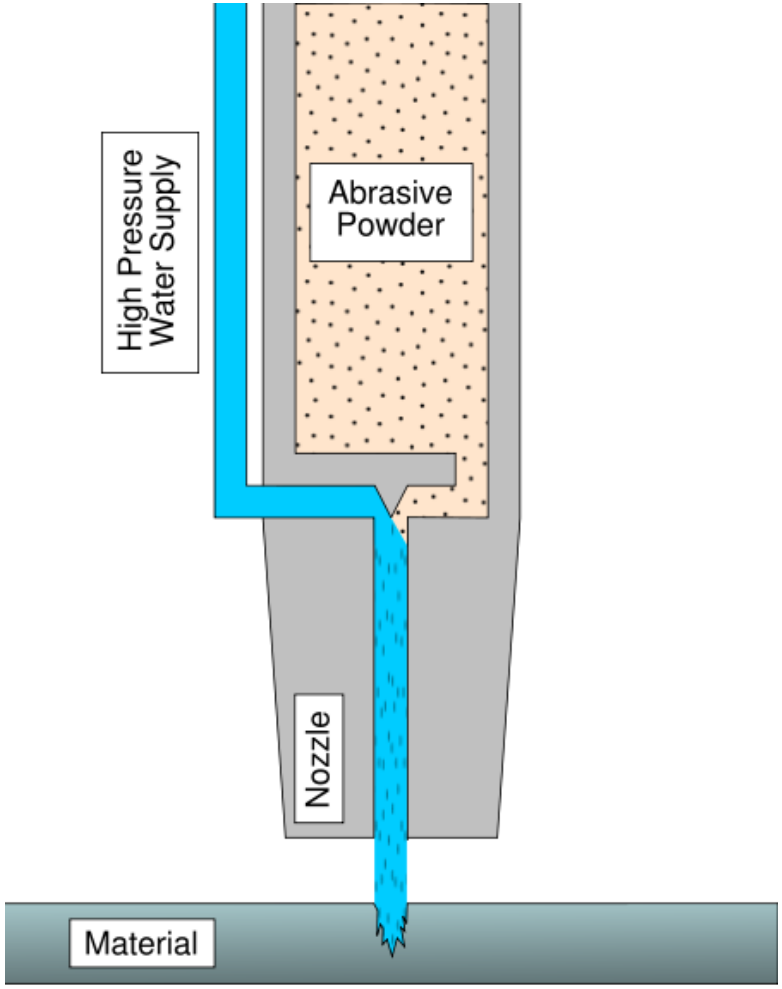
Setup


Typical Machining Center:
Controller
Nozzle
Pump
Abrasive delivery system
Motion system
Catch tank
OMAX
OMAX
JetMachining Center

When is it Practical?

The cutter is commonly connected to a high-pressure water pump, where the water is then ejected from the nozzle, cutting through the material by spraying it with the jet of high-speed water.

It's practical to use it to cut any kind of material. In waterjet cutting, there is no heat generated. This is especially useful for cutting tool steel and other metals where excessive heat may change the properties of the material. Waterjet cutting does not leave a burr or a rough edge, and eliminates other machining operations such as finish sanding and grinding. It can be easily automated for production use.



Advantages

- Cheaper than other processes.
- Cut virtually any material. (pre hardened steel, mild steel, copper, brass, aluminum; brittle materials like glass, ceramic, quartz, stone)
- Cut thin stuff, or thick stuff.
- Make all sorts of shapes with only one tool.
- No heat generated.
- Leaves a satin smooth finish, thus reducing secondary operations.
- Clean cutting process without gasses or oils.
- Modern systems are now very easy to learn.
- Are very safe.
- Machine stacks of thin parts all at once.

This part is shaped with waterjet using one tool. Slots, radii, holes, and profile in one 2 minute setup.

Advantages (continued)

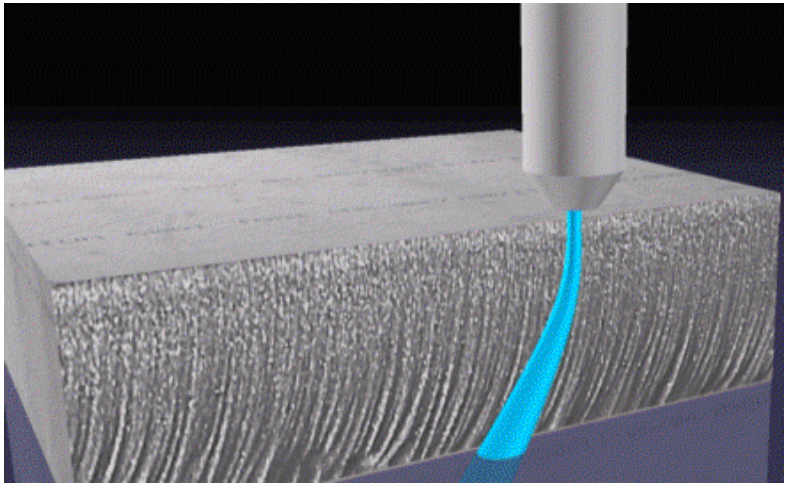
• Unlike machining or grinding, waterjet cutting does not produce any dust or particles that are harmful if inhaled.
• The kerf width in waterjet cutting is very small, and very little material is wasted.
• Waterjet cutting can be easily used to produce prototype parts very efficiently. An operator can program the dimensions of the part into the control station, and the waterjet will cut the part out exactly as programmed. This is much faster and cheaper than drawing detailed prints of a part and then having a machinist cut the part out.
• Waterjets are much lighter than equivalent laser cutters, and when mounted on an automated robot. This reduces the problems of accelerating and decelerating the robot head, as well as taking less energy.

Get nice edge quality from different materials.

Disadvantages

• One of the main disadvantages of waterjet cutting is that a limited number of materials can be cut economically. While it is possible to cut tool steels, and other hard materials, the cutting rate has to be greatly reduced, and the time to cut a part can be very long. Because of this, waterjet cutting can be very costly and outweigh the advantages.

• Another disadvantage is that very thick parts can not be cut with waterjet cutting and still hold dimensional accuracy. If the part is too thick, the jet may dissipate some, and cause it to cut on a diagonal, or to have a wider cut at the bottom of the part than the top. It can also cause a rough wave pattern on the cut surface.



Waterjet lag

Disadvantages (continued)

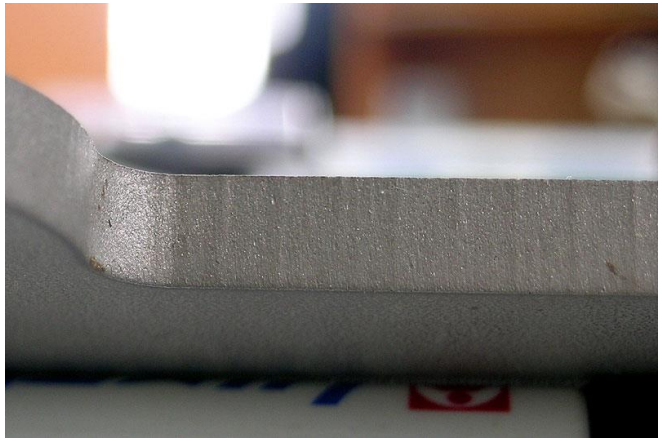
• Taper is also a problem with waterjet cutting in very thick materials. Taper is when the jet exits the part at a different angle than it enters the part, and can cause dimensional inaccuracy. Decreasing the speed of the head may reduce this, although it can still be a problem.

Stream lag caused inside corner damage to this 1-in.-thick stainless steel part. The exit point of the stream lags behind the entrance point, causing irregularities on the inside corners of the part. The thicker the material is or the faster an operator tries to cut it, the greater the stream lag and the more pronounced the damage.

Waterjets vs. Lasers

- Abrasive waterjets can machine many materials that lasers cannot. (Reflective materials in particular, such as Aluminum and Copper.
- Uniformity of material is not very important to a waterjet.
- Waterjets do not heat your part. Thus there is no thermal distortion or hardening of the material.
- Precision abrasive jet machines can obtain about the same or higher tolerances than lasers (especially as thickness increases).
- Waterjets are safer.
- Maintenance on the abrasive jet nozzle is simpler than that of a laser, though probably just as frequent.

After laser cutting



After waterjet cutting

Waterjets vs. EDM

- Waterjets are much faster than EDM.
- Waterjets machine a wider variety of materials (virtually any material).
- Uniformity of material is not very important to a waterjet.
- Waterjets make their own pierce holes.
- Waterjets are capable of ignoring material aberrations that would cause wire EDM to lose flushing.
- Waterjets do not heat the surface of what they machine.
- Waterjets require less setup.
- Many EDM shops are also buying waterjets. Waterjets can be considered to be like super-fast EDM machines with less precision.

Waterjets are much faster than EDM.

Waterjets vs. Plasma

- Waterjets provide a nicer edge finish.
- Waterjets don't heat the part.
- Waterjets can cut virtually any material.
- Waterjets are more precise.
- Plasma is typically faster.
- Waterjets would make a great compliment to a plasma shop where more precision or higher quality is required, or for parts where heating is not good, or where there is a need to cut a wider range of materials.

After plasma cutting

After waterjet cutting

Waterjets vs. Other Processes

Flame Cutting:
Waterjets would make a great compliment to a flame cutting where more precision or higher quality is required, or for parts where heating is not good, or where there is a need to cut a wider range of materials.

Milling:
Waterjets are used a lot for complimenting or replacing milling operations. They are used for roughing out parts prior to milling, for replacing milling entirely, or for providing secondary machining on parts that just came off the mill. For this reason, many traditional machine shops are adding waterjet capability to provide a competitive edge.

Punch Press:
Some stamping houses are using waterjets for fast turn-around, or for low quantity or prototyping work. Waterjets make a great complimentary tool for punch presses and the like because they offer a wider range of capability for similar parts.

Future of Waterjet

- Drilling wells
- Drilling for oil
- Radial tunnels

Practical Applications

- Edge finishing
- Radiusing
- De-burring
- Polishing

Conclusion

- Relatively new technology has caught on quickly and is replacing century-old methods for manufacturing
- Used not only in typical machining applications, but food and soft-goods industries
- As material and pump technology advances faster cutting rates, longer component life and tighter tolerances will be achievable
- Paves the way for new machining processes that embrace simplicity and have a small environmental impact

References

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