Water Jet Machining & Abrasive Water Jet Machining

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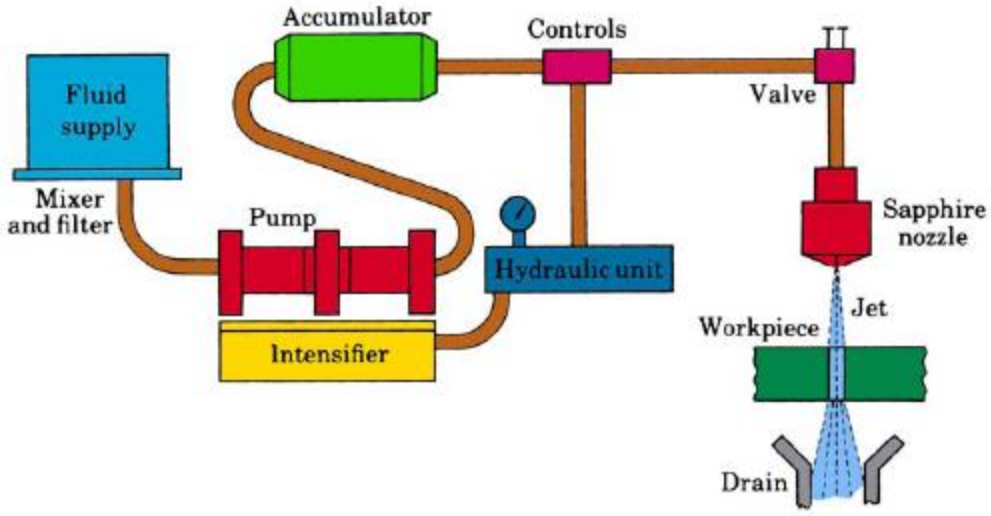
تعریف ماشینکاری با جت آب :

در این روش، آب به عنوان ابزار برش از مسیر پیوسته و کنترل شده ای از نازل با مجرای باریک و با فشار 2000 – 4000 بار خارج میشود و به قطعه کار برخورد میکند. ابزار برش، آب خالص یا آب به همراه مواد ساینده است. فرآیند برش با آب خالص معمولا برای مواد با استحکام کم مانند کاغذ، فایبر گلاس و مقوا و فرآیند برش با آب به همراه مواد ساینده، برای مواد مستحکم مانند فلزات و آلیاژها مورد استفاده قرار میگیرد. هنگامی که نیروی موضعی ضربه سیال از مقاومت پیوندهای زیر ساختار ماده بیشتر باشد، موجب جدایی توده ای از اتم ها یا مولکول ها از ماده گردیده و ساییدگی یا برش اتفاق می افتد.

Water Jet Machining (Cutting)

- Uses a fine, high pressure, high velocity stream of water directed at work surface for cutting

- When cutting metals, includes abrasive particles in stream
- Water pressure from 2000 to 4000 bar
- Water velocity is around 900 m/s
- Feed rate: 10 to 6000 mm/min



Intensifier

توان ورودی = توان خروجی

$P2 * Q2 = P1 * Q1$

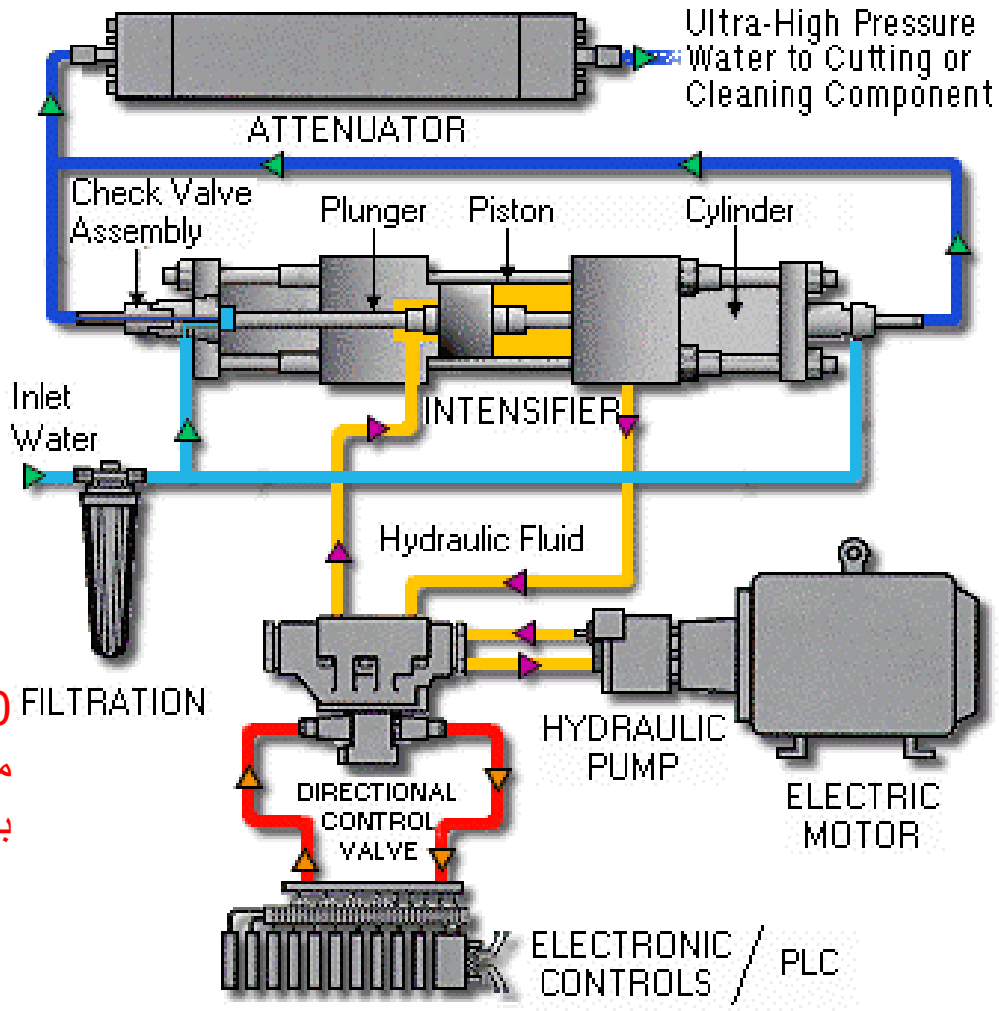
$P2 = (Q1/Q2) * P1$

$P2 = ((V1*A1)/(V2*A2)) * P1$

$V1 = V2$

$P2 = (A1/A2) * P1$

با توجه به رابطه اخیر اگر فشار روغن 400مگاپاسکال باشد، جهت ایجاد فشار 20 مگاپاسکال برای آب، باید سطح پیستون روغن برابر سطح پیستون آب باشد



History

- Dr. Norman 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)

www.flowwaterjet.com

- 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 WJM

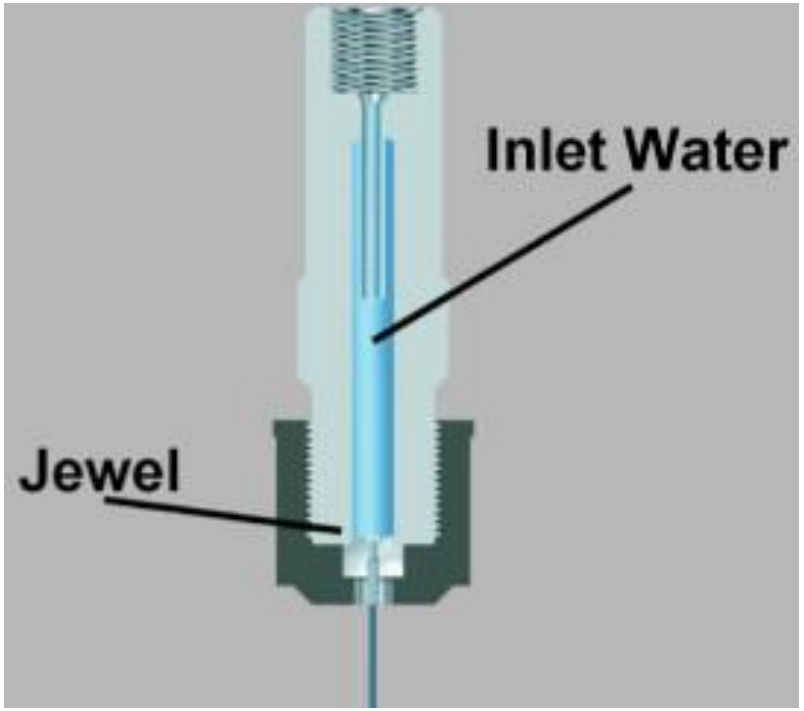
- Fastest growing machining process
- One of the most versatile machining processes
- Compliments other technologies such as milling, laser, EDM, and plasma
- True cold cutting process – no HAZ (heat affected zone), mechanical stresses or operator and environmental hazards
- Not limited to machining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

Pure WJM

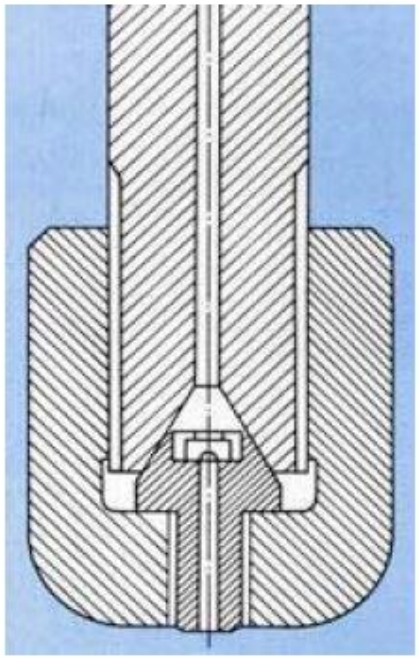
- Pure WJ cuts soft materials , disposable diapers, tissue papers, automotive interiors
- Very thin stream (0.004-0.010” in dia.)
- Extremely detailed geometry
- Very little material loss due to cutting
- Can cut thick, soft, light materials like fiberglass insulation up to 24” thick or thin, fragile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

Pure WJ Cutting cont.

- Forced through hole in jewel (precious stone)0.07-0.5 mm in dia
- Sapphires, Rubies with 50-100 hour life
- Diamond with 800-2,000 hour life, but they are pricey



WJC Nozzle

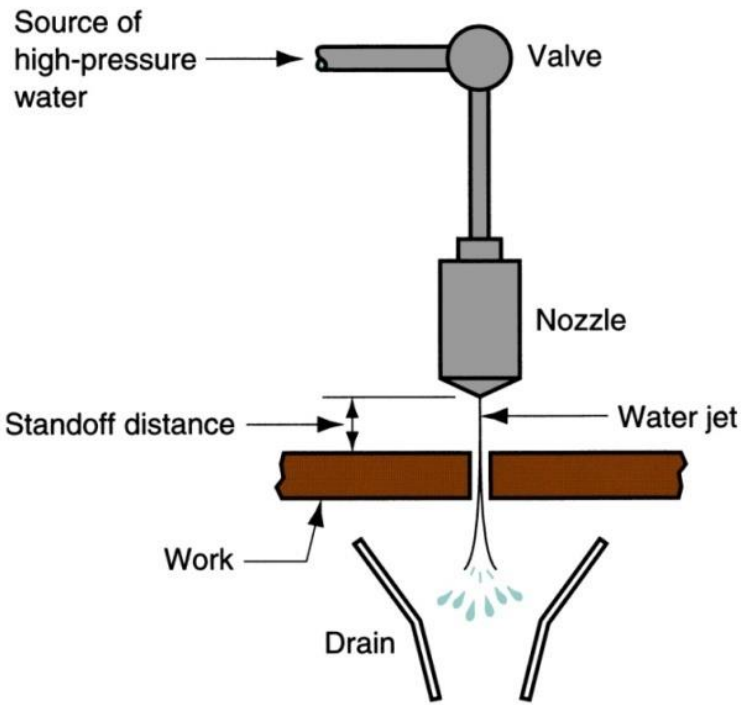


nozzle

orifices

WJC

- WJC advantages: no crushing or burning of work surface, minimum material loss, no environmental pollution, and ease of automation, no heat affected zone
- WJC disadvantages: Not suitable for brittle materials (e.g., glass), high capital investment, safety, not suitable for metals and hard material



WJC Applications

Usually automated by CNC or industrial robots to manipulate nozzle along desired trajectory

cake

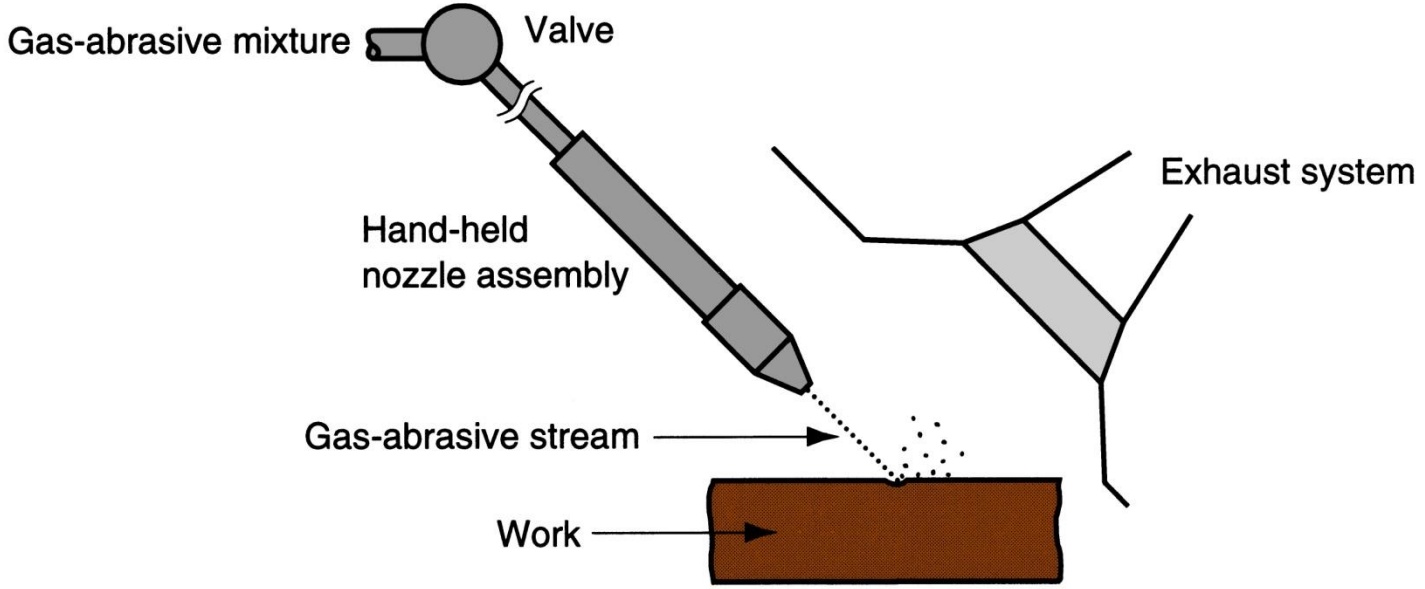
fish

Printed wiring board

pwb

Abrasive Jet Machining (AJM)

- High velocity stream of gas containing small abrasive particles



- (aka Sandblasting)

AJM Applications

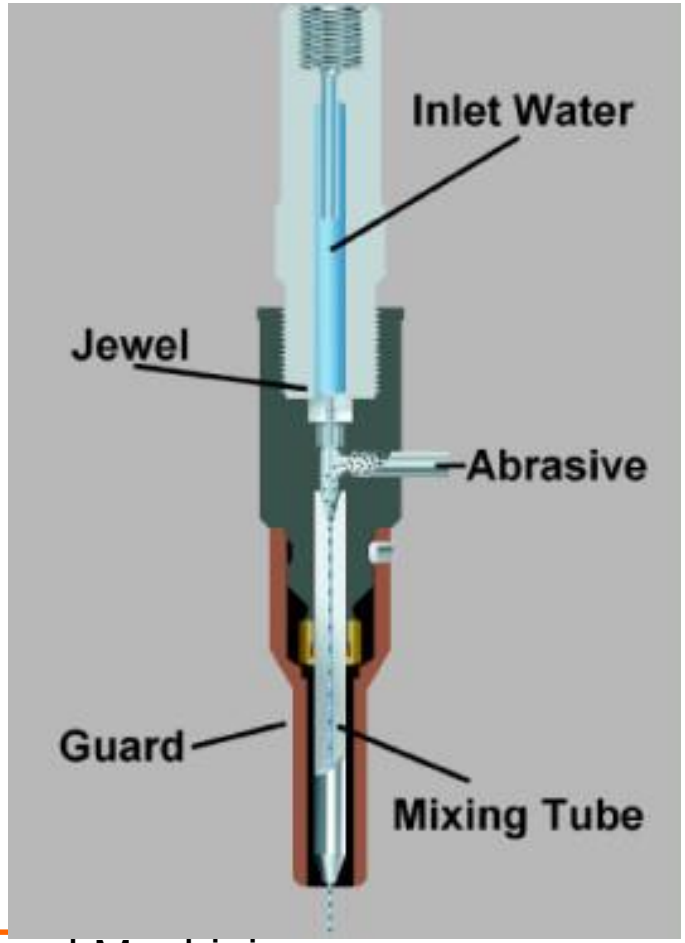
Abrasive WJ Machining (AWJM)

این فرایند ترکیبی از اصول WJM و AJM که از یک جت اب به همراه مواد ساینده تشکیل شده است.
به عبارت دیگر در فرآیند AWJM از ترکیب یک جت آب با سرعت زیاد همراه ذرات ساینده برای ایجاد یک جت دوغابی شکل و برنده استفاده میشود.

- 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 Machining cont.

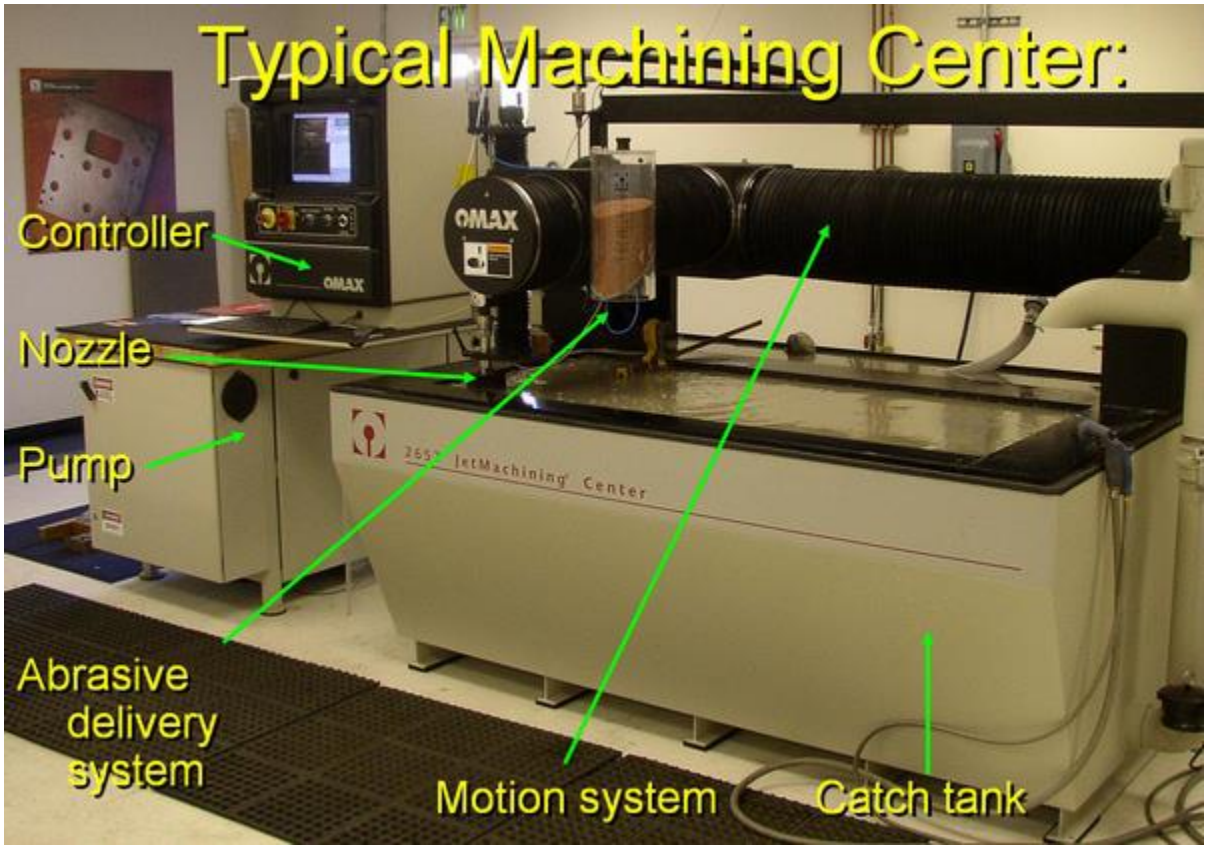
- Evolution of mixing tube technology
- Standard Tungsten Carbide lasts 4-6 hours (not used much anymore)
- Premium Composite Carbide lasts 100-150 hours
- Consumables include water, abrasive, orifice and mixing tube



Tolerances

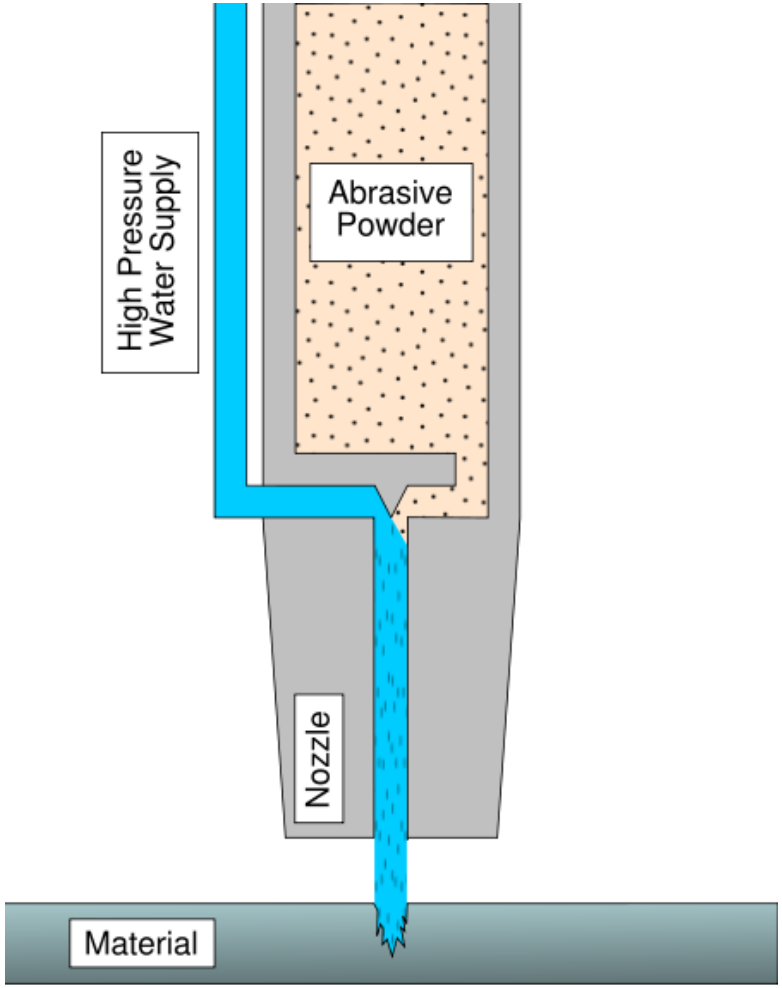
- Typically +/- 0.005 inch
- Machines usually have repeatability of 0.001 inch
- WJ tolerance range is good for many applications where critical tolerances are not crucial to workpart design

Setup


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

When is AWJM Practical?

It's practical to use it to cut any kind of material. In abrasive 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 smooth finish, thus reducing secondary operations.
- Clean cutting process without gasses or oils.
- Modern systems are now very easy to learn.

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

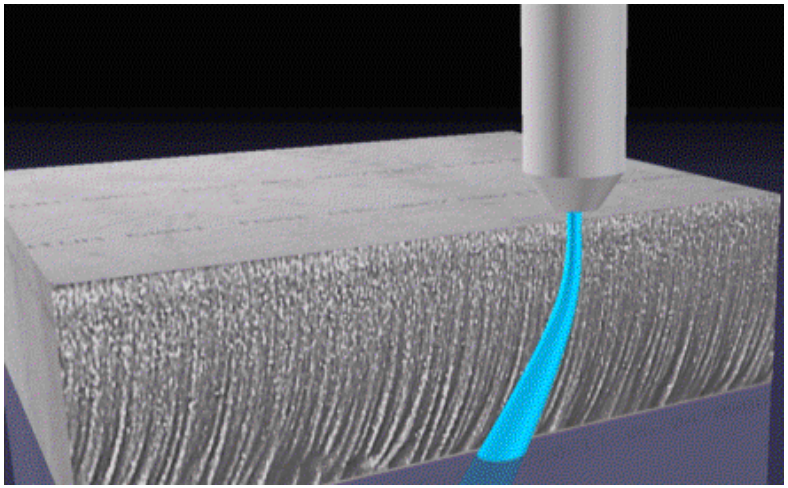
Advantages (continued)

- 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.

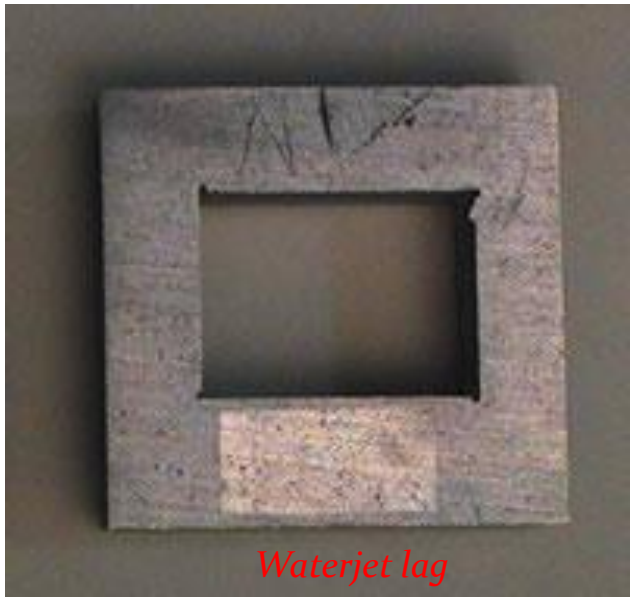
Disadvantages

• 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.



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.



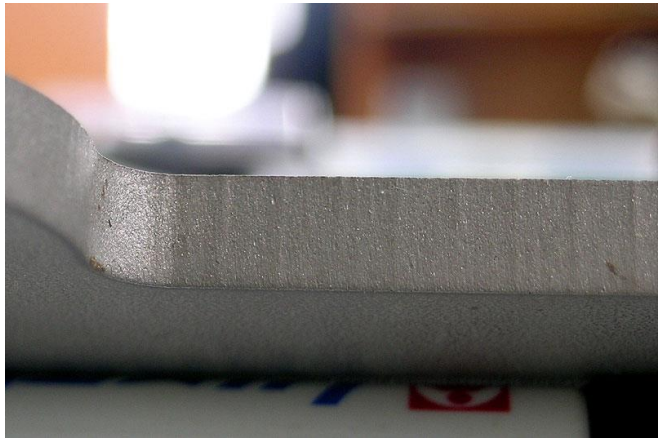
Waterjet lag

در قطعات ضخیم ، جت اب از بالا تا پایین ضخامت قطعه منحرف میشود و در پایین قطعه عقب تر از بلای ان است. به همین خاطر وقتی جت به کنج قطعه میرسد به خاطر تفاوت در بالا و پایین قطعه در کف قطعه این مشکل بوجود می اید و کنج های قطعه خراب میشود.

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.
- Waterjets can be considered to be like super-fast EDM machines with less precision.

Waterjets are much faster than EDM.

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.

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

Advanced Technology

https://www.flowwaterjet.com/Resources.aspx#videos

References

- www.flowcorp.com
- www.waterjets.org
- www.aqua-dynamics.co.uk

با تشکر از توجه شما