Introduction to Waterjet Cutting Technology

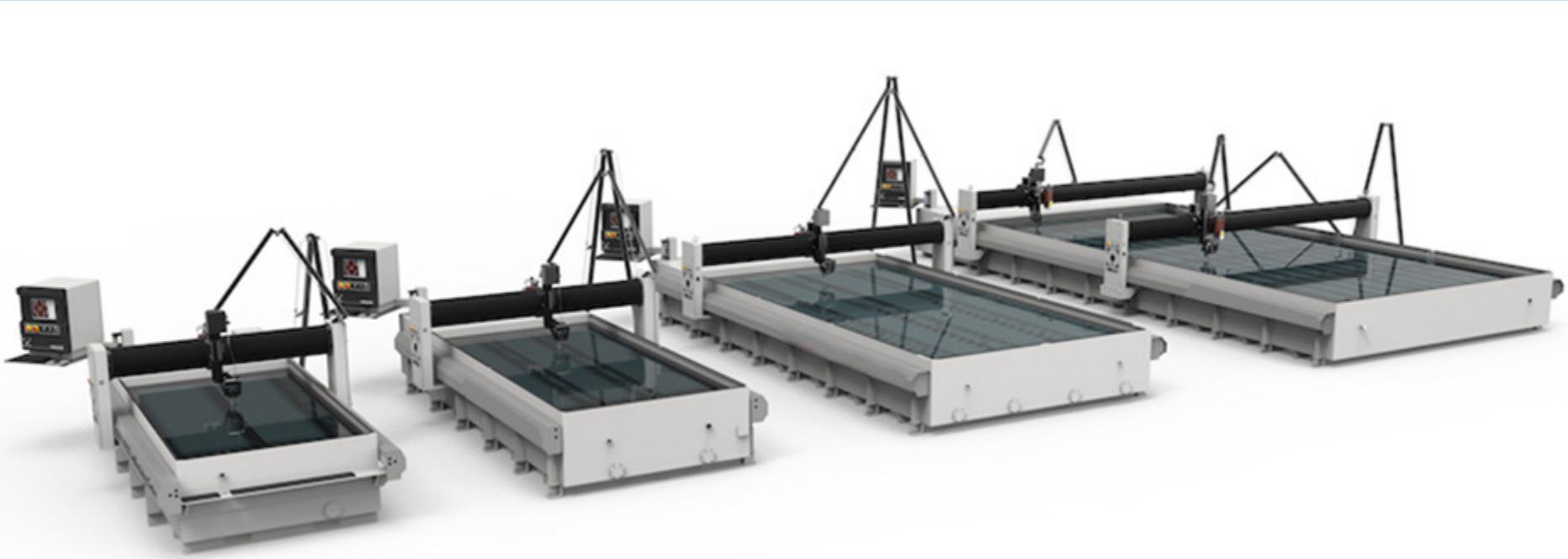
Last updated as 3/12/2020

Aims

- Understand the usage of waterjet Cutting machine
- operate the machine safely

5 Axis Waterjet cutter

Video 1.1



Waterjet Cutting Machine

1. History of Development
2. Working Principles
3. Control of Movement - G-code
4. Advantages & Disadvantages
5. Waterjet Main Components
6. Safety
7. Q&A

History of Development

The word “waterjet” is used to indicate a stream of water forced out through a small aperture and its meaning extends to all the equipment and processes that pertain to, or are operated by a waterjet (Random House, 1999).

1. Pure Water Jet (PWJ)
    - A first application of waterjet was in 1933 by the Paper Patents Company.
    - In 1950, a short burst of very high pressure able to cut wood were obtained, but no commercial application of the Technology was developed.
2. Abrasive Water Jet (AWJ)
    - A breakthrough in 1979, Dr. Mohamed Hashish developed a nozzle which was able to combine an abrasive material (garnet) into the high-pressure waterjet. (P.4)
    - By 1983, the first commercial abrasive waterjet cutting system were sold.

Working Principles

Two main steps:

1. Electric Servo Pump generally pressurized normal tap water at pressure levels above 50000 psi; to produce the energy required for cutting.
2. Water is then focused through a small precious stone orifice to form an intense cutting stream. The stream moves at a velocity of up to 3 times the speed of sound, depending on how the water pressure is exerted.

Control of Movement - G-code

G-code is a programming language for CNC that instructs machines where and how to move. G-code stands for “geometric code,” and follows some variation of the alpha numeric pattern:

N## G## X## Y## Z## F## S## T## M##

N: Line number

G: Motion

X: Horizontal position

Y: Vertical position

Z: Depth

F: Feed rate

S: Spindle speed

T: Tool selection

M: Miscellaneous functions

I and J: Incremental center of an arc

R: Radius of an arc

Application (1)

Pure Waterjet (PWJ)

- Rubber, leather, fabrics, paper, wood and some kinds of plastic
- Particularly good for food industry, since the absence of knives prevents the transmission of bacteria.
- Explosive industry

Video 1.2

Application (2)

Abrasive Waterjet (AWJ)

- Metal, stone, glass, ceramic, gasket and composite material
- Titanium, inconel alloys, kevlar
- Outdoor application: dismantling of offshore structure or nuclear plants

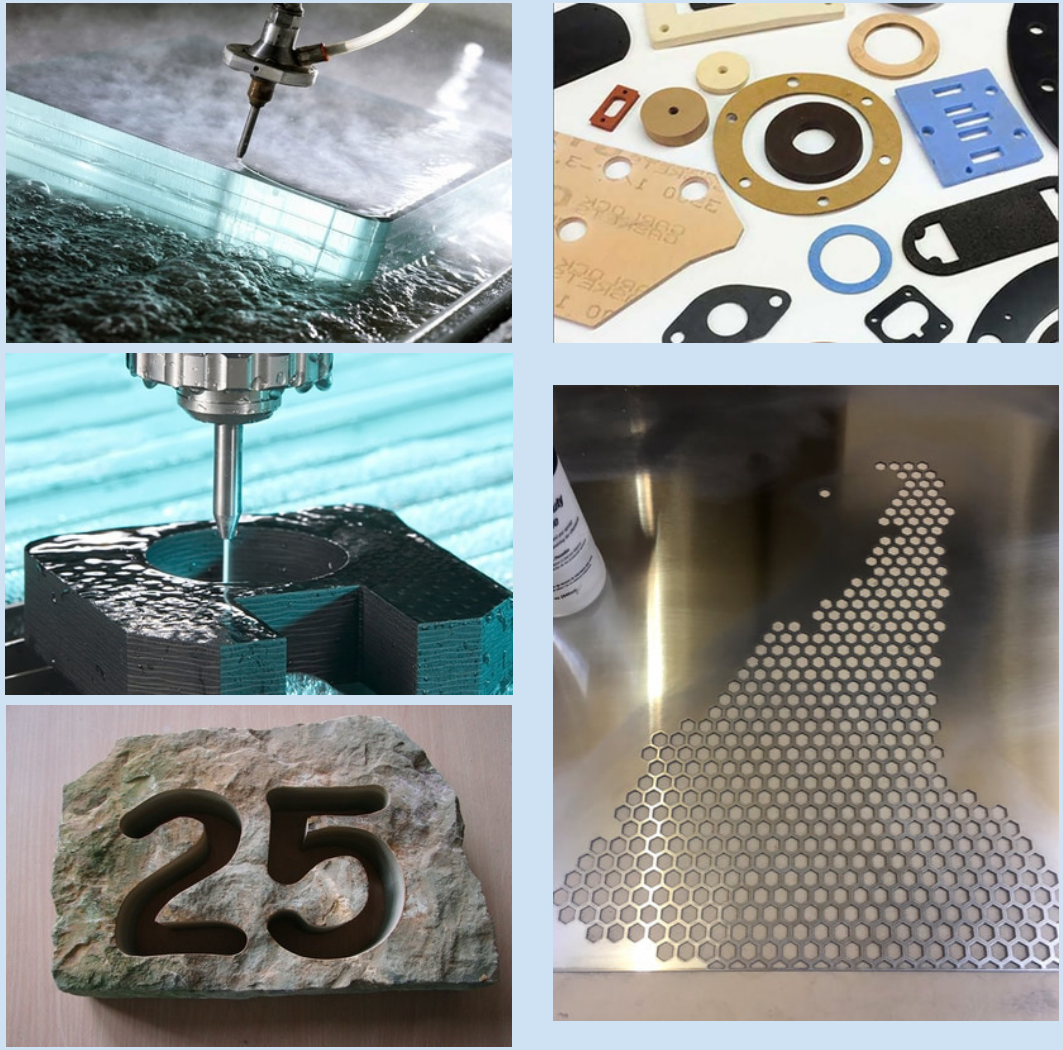


Image 1.3

Application (2)

Abrasive Waterjet (AWJ)

- Medical application: using sterile solution as cutting fluid and soluble substance as abrasive to perform surgeries.

Video 1.4

Advantages & Disadvantage

Advantages

1. Cold cutting – no heat affected zones, no hardening
2. Omni-directional cutting – ability to cut in any direction
3. Perforates most materials without starting holes
4. Cuts virtually any material
5. Net-shape or near-net-shape parts (no secondary processing required in many applications)
6. Environmentally friendly
   a. Normally, the process is clean and does not create grindings, chips, or hazardous gases.
   b. Cutting oils or emulsions are not needed.
   c. Reduces dust and hazardous gases
7. Does not workload material – stress-free cutting
8. Flexible machine integration
9. Saves raw materials (small cutting kerf width, nesting capabilities)
10. Faster than many conventional cutting tools

Disadvantages

1. Get wet
2. Depth of cutting

Waterjet Main Structure

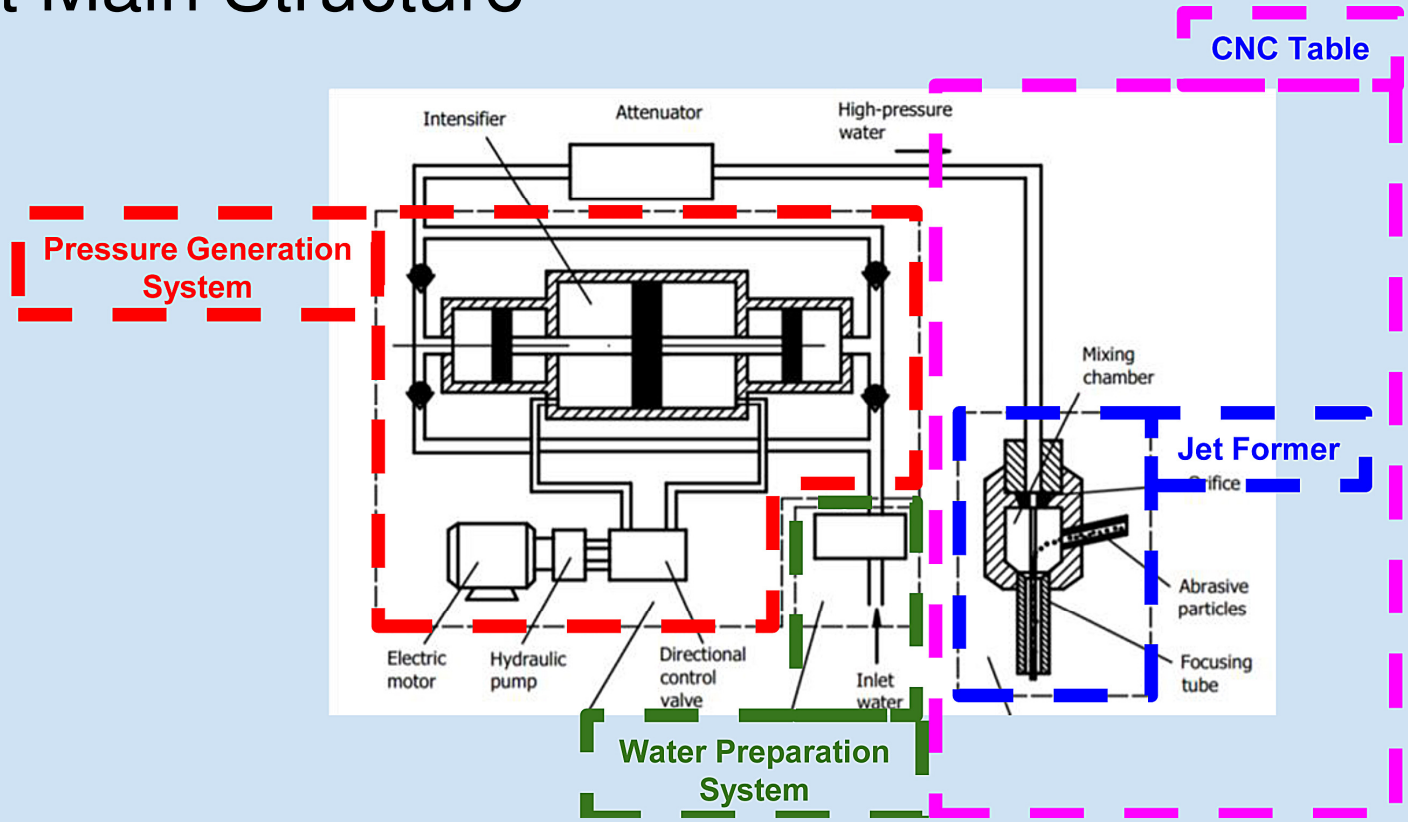
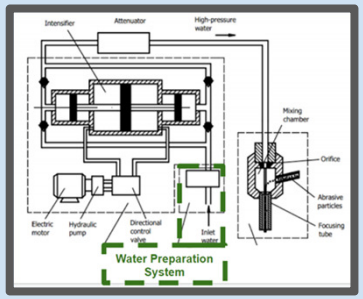


Image 1.5

Waterjet Main Systems (1)

1. Water Preparation System
   - Water must be clean and filtered, sometimes needed to remove harmful minerals.
   - Filtering suspended solids can impact the orifice to prevent **premature wear.**
   - Water softening is a process in which the ions of calcium, magnesium and sometimes iron are removed.
   - Water temperature, since water warms up when it is pressurized, chiller system is required.



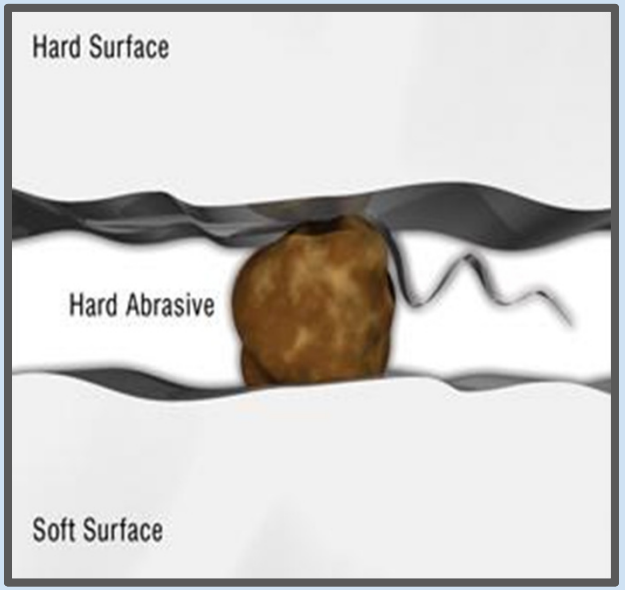
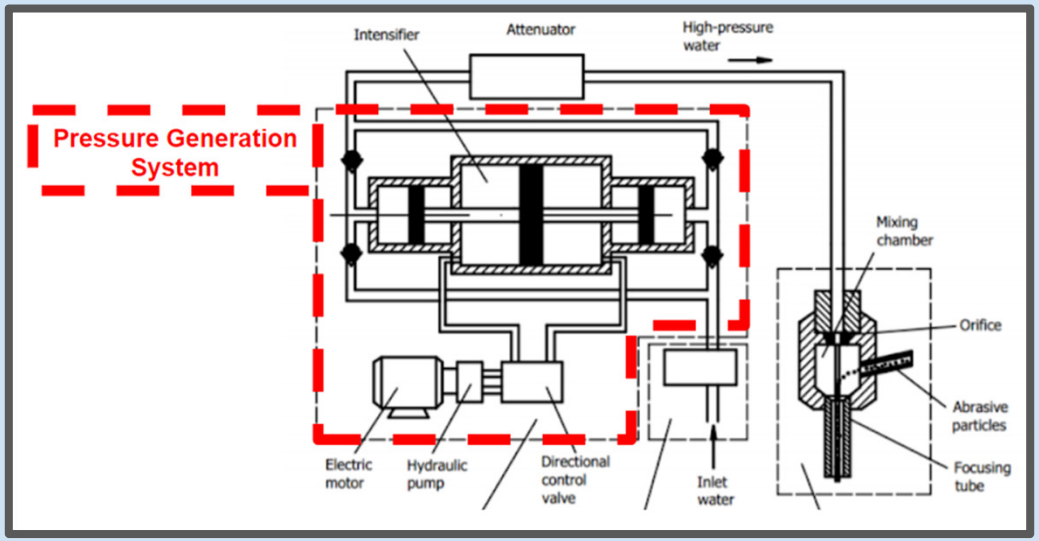


Image 1.6

Waterjet Main Systems (2)

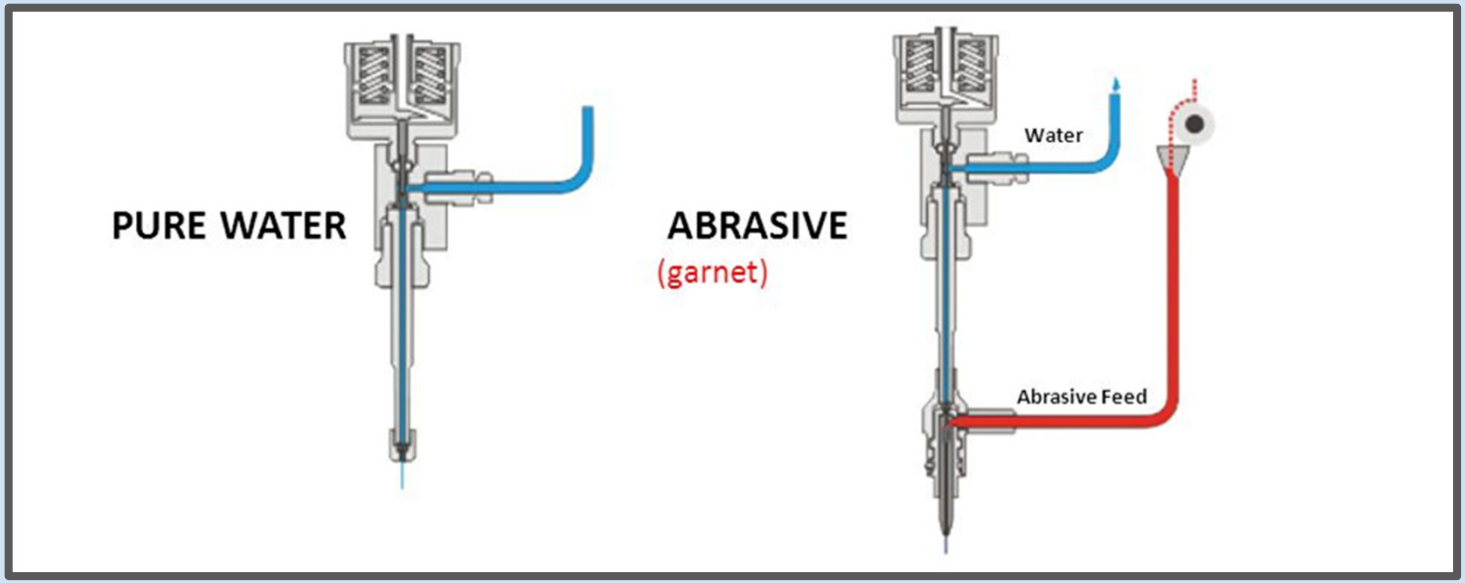
2. Pressure Generation System

The pressure generation system includes an **electric motor** with an output power that lies in the range between 20 kW to 200 kW driving a **pump** that increase the pressure in a separate hydraulic system. This pressure moves a cylinder (named intensifier) that raises the water pressure up to the required level, usually in the range between 300 and 600 MPa (43500 psi and 87000 psi).



Waterjet Main Components

1. Jet Former
   - High-pressure water is forced through an orifice, producing a high-speed jet of water.
   - orifices can be made of sapphire, ruby or diamond



Video 1.7

Waterjet Main Components

2. CNC Table

For machining operations, the cutting head is mounted on a CNC system that allows to control in details all the different parameters.

e.g

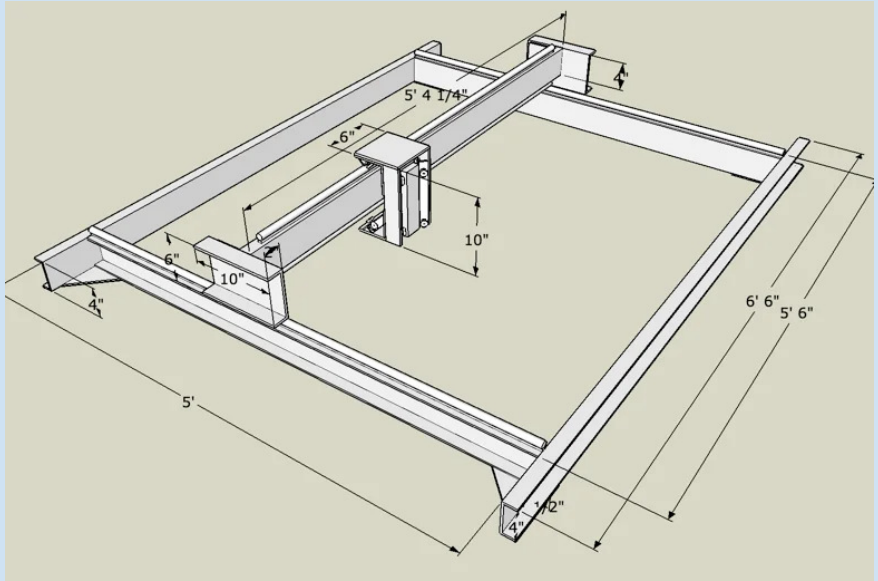


Image 1.8

Waterjet Main Components

3. Catcher

The catcher is a container that has the purpose of collecting the water and abrasive jet after it passes through the workpiece: since the jet still retains much of its initial energy, the catcher must contain some kind of absorbent material in order to slow down the jet without damage.

4. Abrasive Supply Systems

Abrasive supply system is designed to provide the right amount of abrasive in the mixing chamber and it is usually computer-controlled to provide an optimal value of the abrasive mass flow.

Safety

PERSONAL PROTECTIVE EQUIPMENT

- Always wear safety glasses and non-slip footwear during setup, operation, and maintenance of the machine. This includes non-operators within a 10-foot vicinity of the machine.
- Hearing protection is required when operating the machine for long periods of time.
- Wear gloves when handling material. Materials may have sharp edges immediately after cutting.

ENVIRONMENT AND MACHINE LOCATION

- Make sure the floor surface around the machine's location is water resistant and slip resistant. The machine operates with abrasive and water. While it is an enclosed system, water is likely to spill during routine use, setup, or maintenance. Ideally, a floor drain should be located near your waterjet.
- The waterjet operators should ensure anyone within 10 feet of the waterjet follows the proper safety precautions.
- Waterjet should be installed in an area that allows the machine to be monitored while cutting.

Safety

USAGE

- WAZER can cause serious injury and should be accessible only to those that have read this User Manual and are capable of understanding the risks associated with this tool. Ensure the WAZER location will never result in an untrained individual using the machine.
- Never leave WAZER unattended while in operation.
- Do not modify WAZER or its components.
- Use of non-WAZER approved Abrasive can result in equipment or property damage as well as personal injury.

Q&A

1. **How accurate is a waterjet cutter?**

   Accuracy. Flow waterjets can make parts to very tight tolerances, some systems can create parts with a tolerance as close as 0.001" (0.025 mm). For waterjet cutting, typical part tolerances range from between 0.003" and 0.005" of an inch.

2. **How much water does a waterjet cutter use?**

   Waterjets use between one half and five gallons (2 to 19 liters) of water per minute when cutting. Some of that water is used to cut and some of it is used to cool the pump. Systems using intensifier pumps use much more water for cooling than do systems with direct drive pumps.

Q&A

3. Are waterjets dangerous?

A common danger associated with waterjet cutting is eye damage. ... Waterjet cutting is also associated with a high volume of noise, which can damage hearing at sustained levels. Ear protection should be worn at all times when operating a waterjet, and the user should try to remain aware of the decibel level.

4. What is the function of a waterjet Cutter?

The **waterjet** separates the material particles near the surface and causes a stress-free cutting process without heat ingression into the material. Depending on the nature of the **waterjet** and the hardness and thickness of the material, different cutting depths and speeds can be achieved.

Q&A

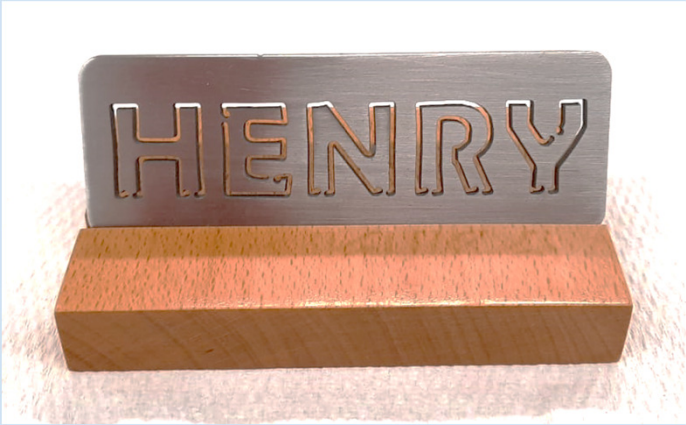
5. **How much PSI can cut skin?**

100 PSI, Anything over **100 PSI**. This is because a pressure washer shoots air and water at an extremely high velocity that penetrates deep into and past your skin causing air bubbles. It is even worse if its not water (ex: cleaning solvent), which leads to an increased risk of infection, which can lead to amputation.

6. **How much PSI of water is dangerous?**

Residential water pressure tends to range between 45 and **80 psi** (pounds per square inch). Anything below 40 psi is considered low and anything below 30 psi is considered too low; the minimum pressure required by most codes is 20 psi. Pressures above **80 psi** are too high.

Project sample : Stainless Name Tag



Source and Acknowledgements

Image / Video	Source
Video 1.1	https://www.youtube.com/watch?v=PCsoC3i7JYc
Video 1.2	https://www.youtube.com/watch?v=UyxjXCqmPIY
Image 1.3	https://www.oremwaterjet.com/
Video 1.4	https://www.youtube.com/watch?v=szkUpaO3R0I
Image 1.5	https://cwww.intechopen.com/media/chapter/61201/media/F1.png
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Thank you