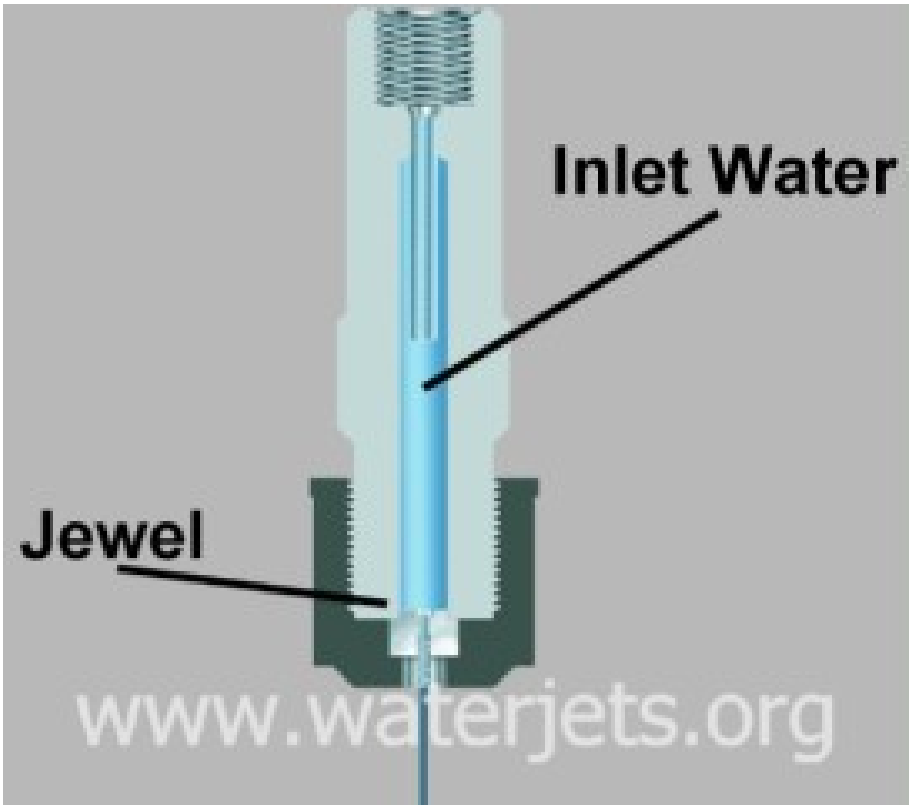
EML 2322L – MAE Design and Manufacturing Laboratory

Abrasive Water Jet Processes

Water Jet Machining (invented ~ 1970)

- A waterjet consists of a pressurized jet of water exiting a small orifice at extreme velocity. Used to cut soft materials such as foam, rubber, cloth, paper, food products, etc.



- Typically, the inlet water is supplied at ultra-high pressure -- between 20,000 psi and **60,000 psi**.

- The jewel is the orifice in which water exits to form the cutting stream. Typically jewels are made from sapphire, ruby, or diamond (thus the name).

Water Jet Machining (con't)

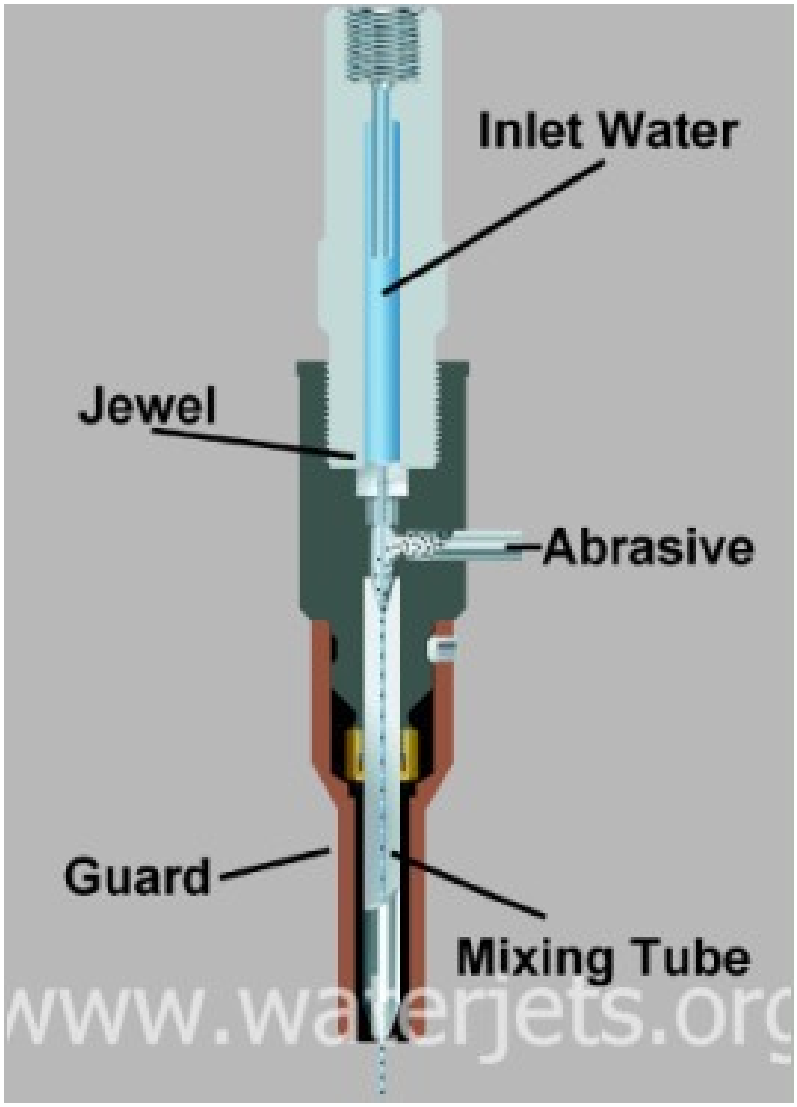
- Below is a jewel mounted in a steel insert. The orifice size of the jewel is typically 0.002″ to 0.020″ diameter.

- Basic fluid momentum analysis applied to the jet will show the water exiting the jet is approaching Mach 3 (approx. 2200 mph!)

- This nozzle is part of a 2 axis CNC machine that controls nozzle positioning and feedrate with respect to the workpiece. It works like the CNC milling machine except there is no rotating tool.

Abrasive Water Jet (AWJ) Machining (invented ~ 1980)

- An abrasive waterjet consists of a regular waterjet with an abrasive added into the fluid (or mixing) nozzle. It is used to cut or machine nearly any hard material such as metal, stone, glass, etc.

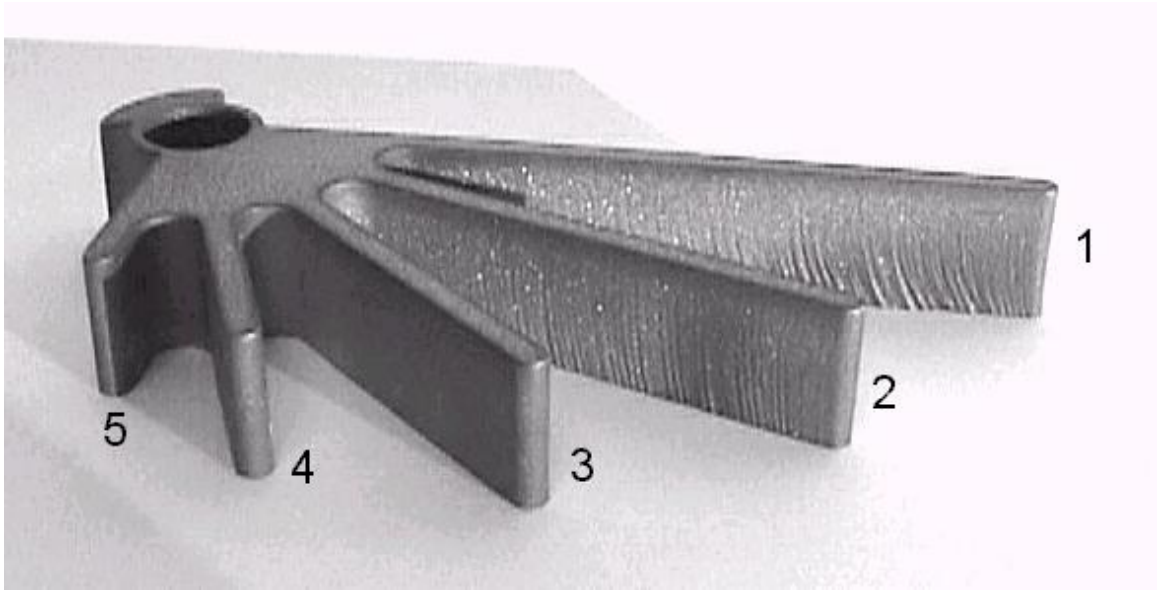


Advantages of Abrasive Water Jets

- **Virtually ALL materials can be cut with an AWJ.** Abrasive water jets can machine a wide range of thicknesses and materials, including metals (aluminum, stainless steel, titanium, inconel, gold, copper, etc.), plastics, glass, and ceramics. Even materials that have been heat treated can be cut with an AWJ.
- **Quality finish.** Materials cut by the abrasivejet have a smooth, satin-like finish, similar to a fine sandblasted finish.
- **No heat in machining process.** Abrasivejets abrade material at room temperatures. As a result, there are no heat-affected areas or structural changes in materials. Abrasivejets can also machine hardened metals and materials with low melting points. Since the workpieces are water cooled, there is very little temperature increase in the actual cutting zone compared to traditional machining methods.
- **Environmentally responsible.** Abrasivejets use garnet as an abrasive. Garnet is a reddish natural crystal, with a Mohrs hardness of 6.5 to 7.5. No noxious gases or liquids are used in abrasivejet machining, nor are there any oils used in the machining process.
- **No tool changing.** A wide range of conventional processes can be performed with this single tool, such as sawing, drilling, profile milling, gear cutting, punching, spline cutting and slitting.
- **Minimal burr.** No heavy burrs are produced by the abrasivejet process. Parts can often be used directly without deburring.
- **Flexibility.** You can machine virtually any 2D shape. The only limitation is the radius of the jet, which usually limits inside corners to a radius of 0.015″ or larger.
- **Can maintain moderately high tolerances.** Most modern AWJ systems can produce part tolerances of ±0.005" in materials up to 1-½" thick.

Examples of Parts Cut with AWJ

All flat parts were machined on an abrasivejet, including the logo



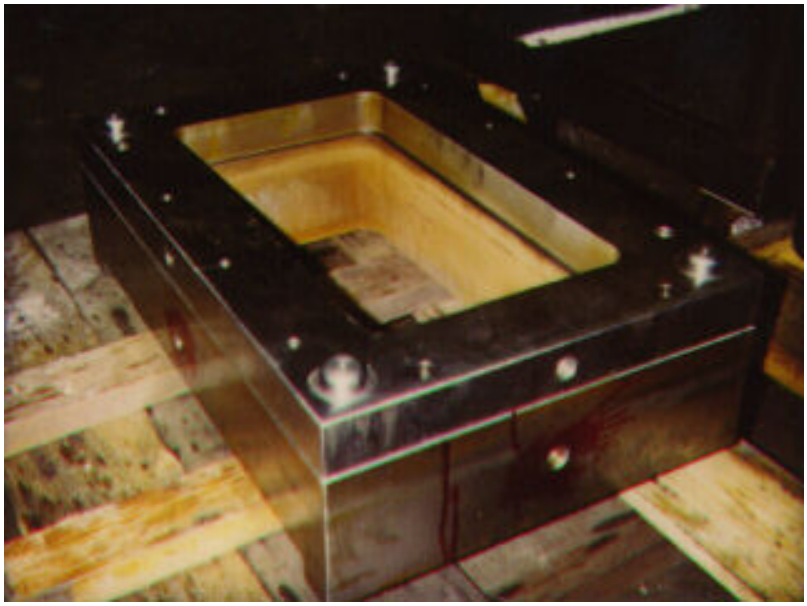
Various quality levels. On this particular part, each finger took approximately the same time to cut. As you can see, the quality of 5 is the best and 1 is the worst (but adequate for many [part features).

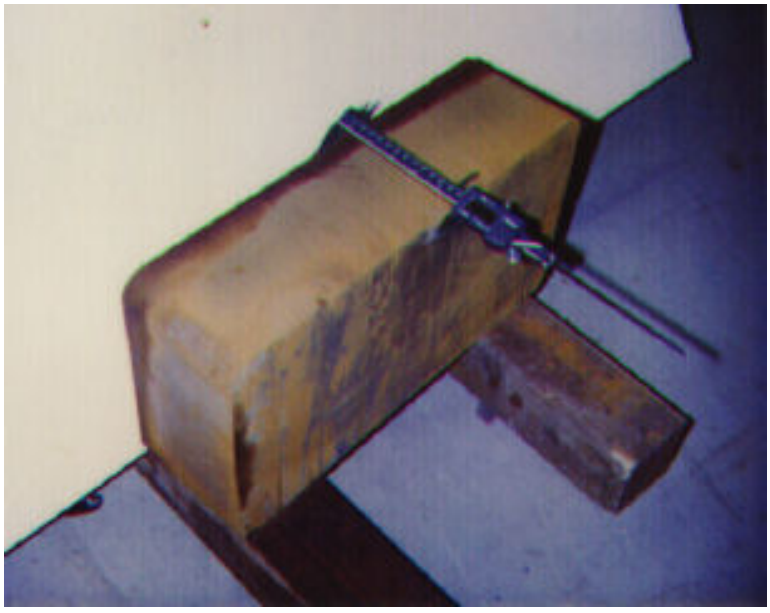
Material Thickness vs Cutting Speed

Cutting speed is an exponential function of material thickness:

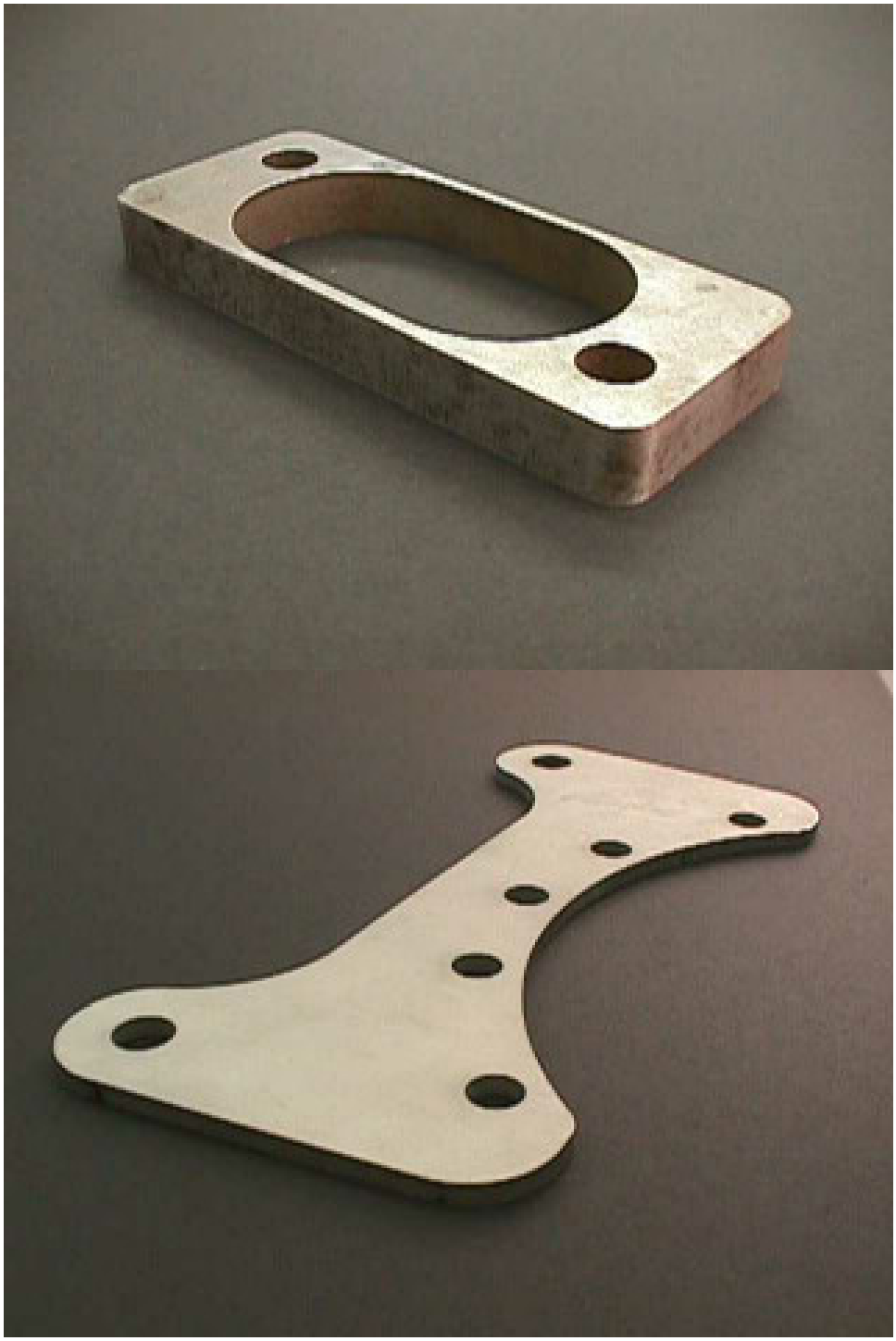
Cutting Speed ~ 1 / (Thickness^1.15)

This means parts under 0.5" (13mm) thick will machine quite quickly, while parts >1" (25mm) thick are much slower.



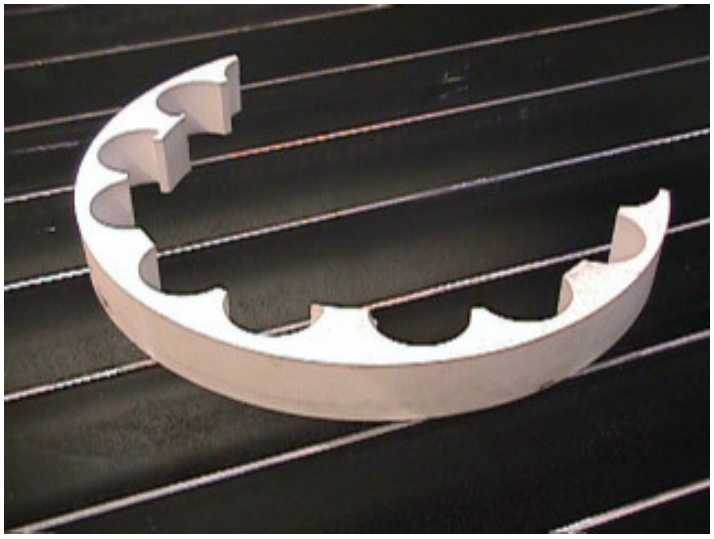


5" (~130mm) thick slug machined from the center of a very heavy chunk of steel. Total cut time was 9 hours!



Pictures of simple parts cut from titanium with an abrasive waterjet

Dragons cut from Black Granite, Bullet-proof glass, and Marble

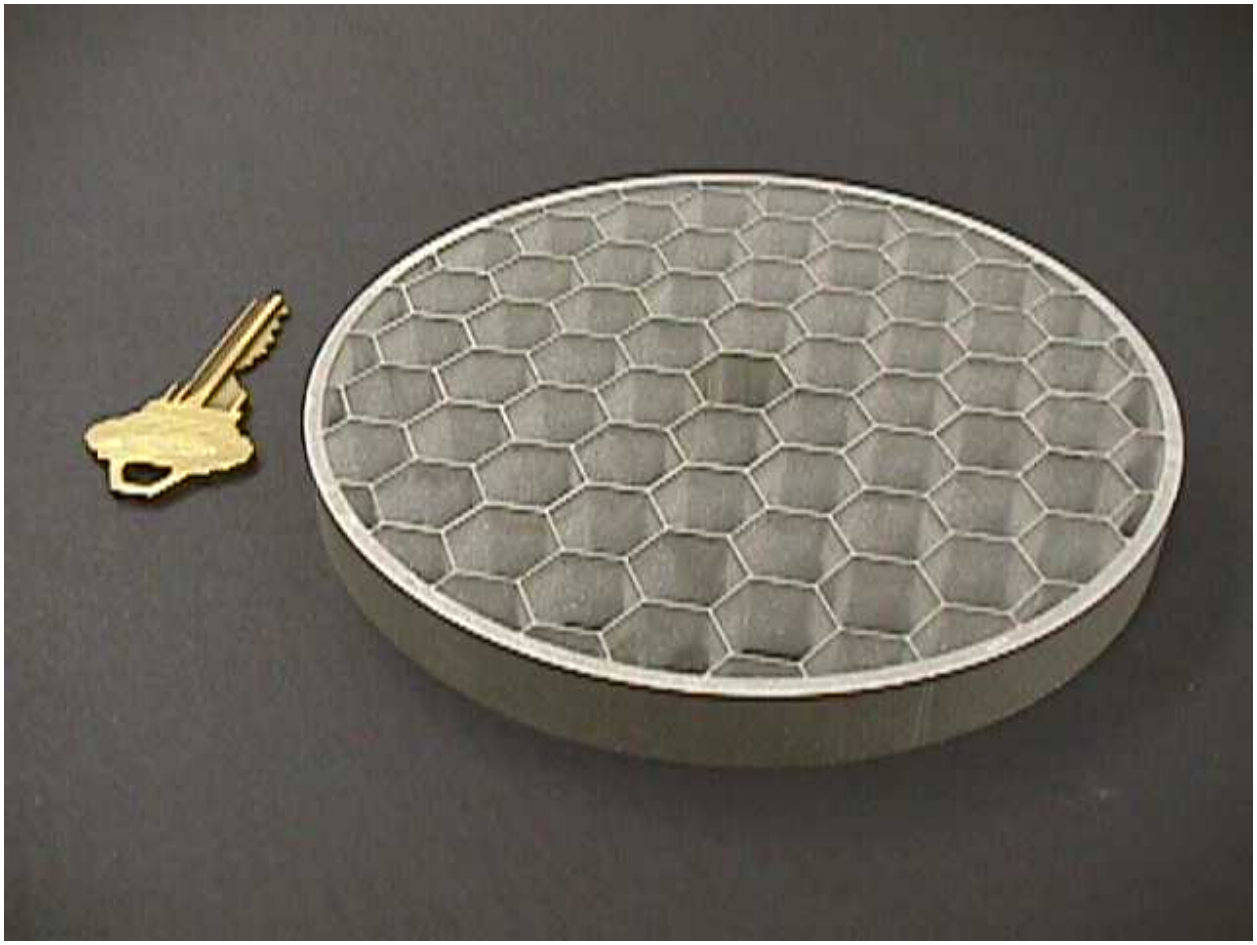


Scrap from part cut out of ceramic and etching capability.

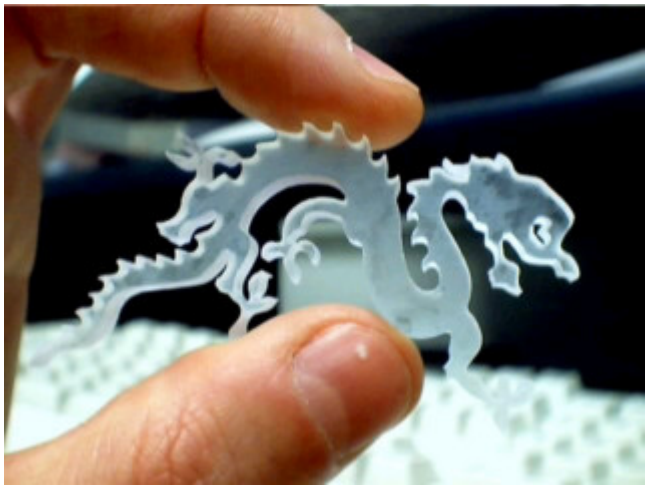
Various items cut with an abrasive waterjet from different materials.

Racks and gears machined with an abrasive jet. Material: ½" steel.

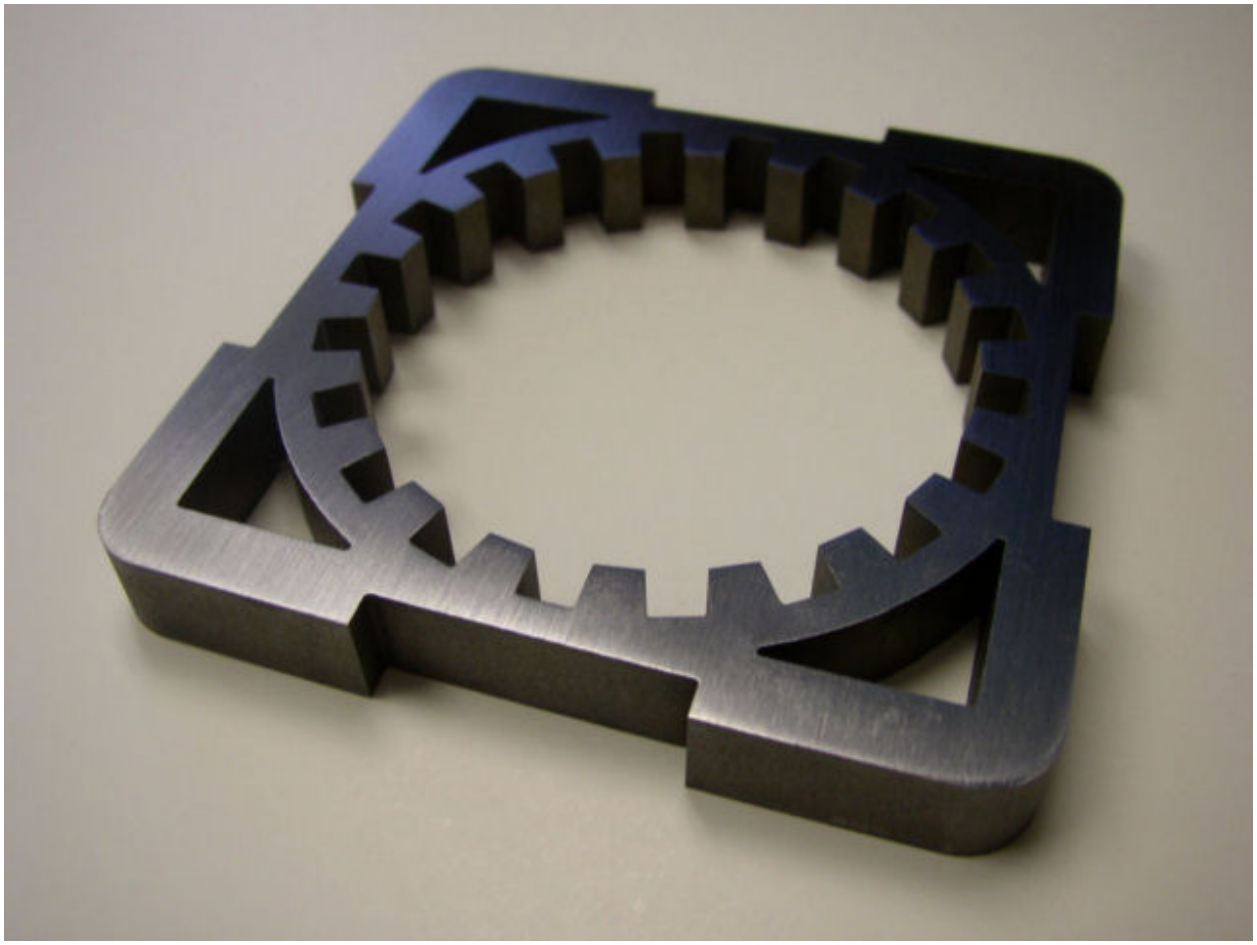
Abrasive jets have the capability to cut very small parts as well…



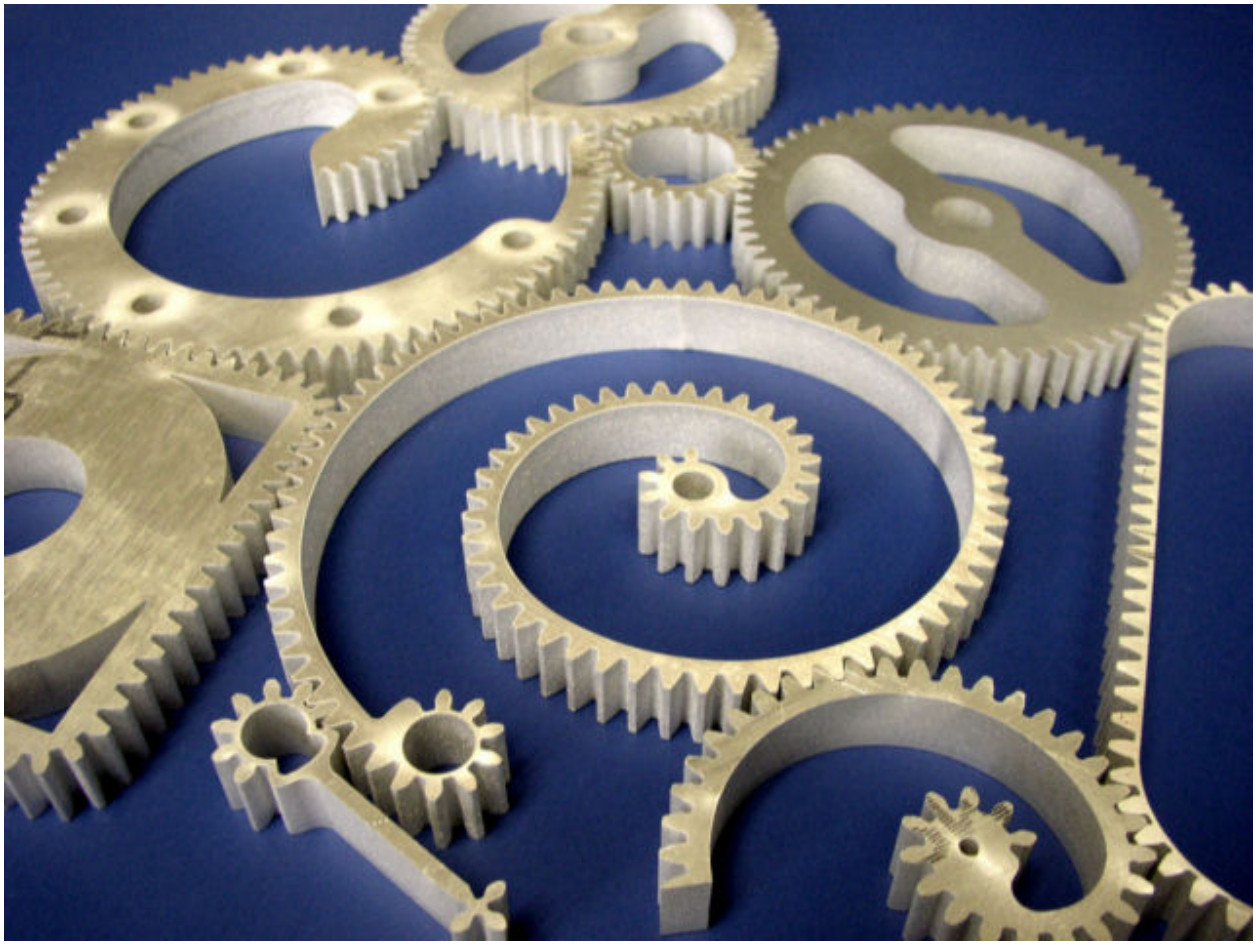
An example of thin wall cutting in ½" aluminum. Walls are .025".



Quartz glass dragon and amethyst bicycle demonstrate the extreme level of detail that can be done with ceramic work.

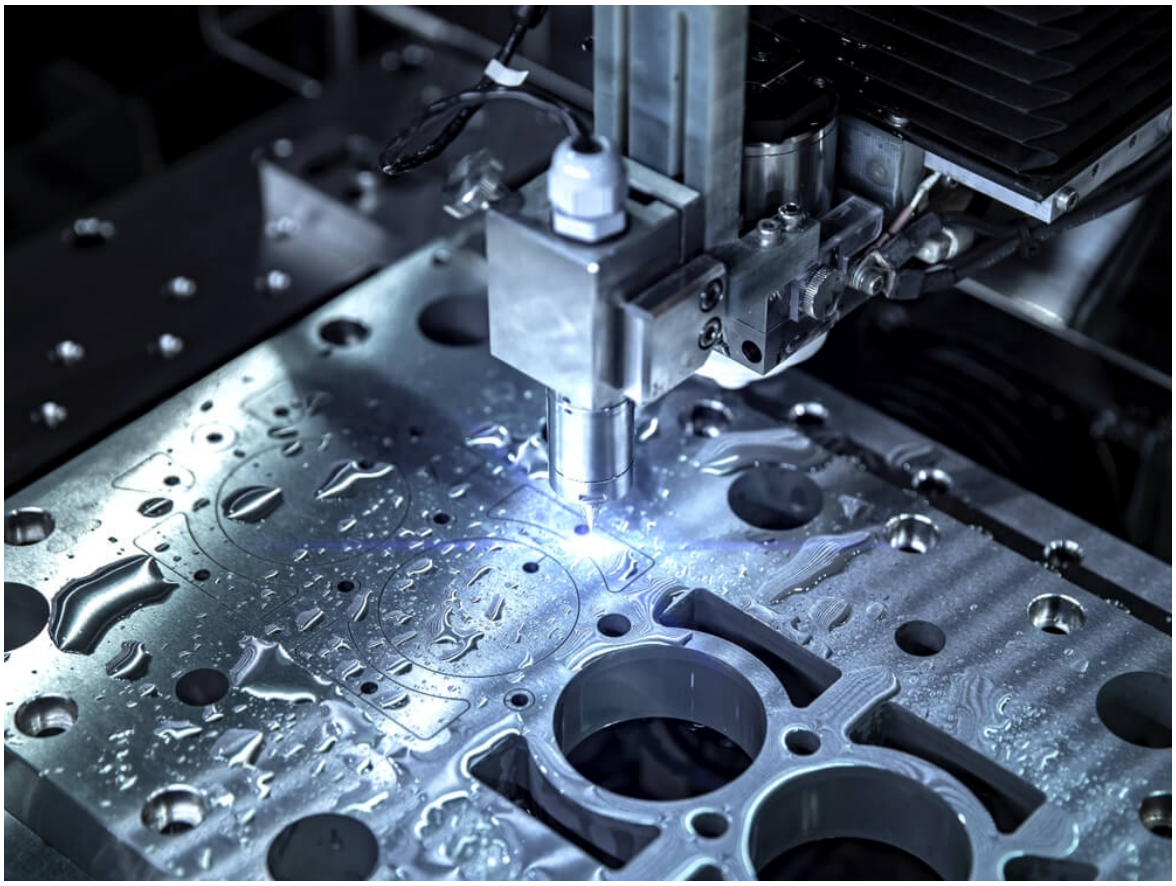


½" Steel. Sharp Corners. How else could you make this part?

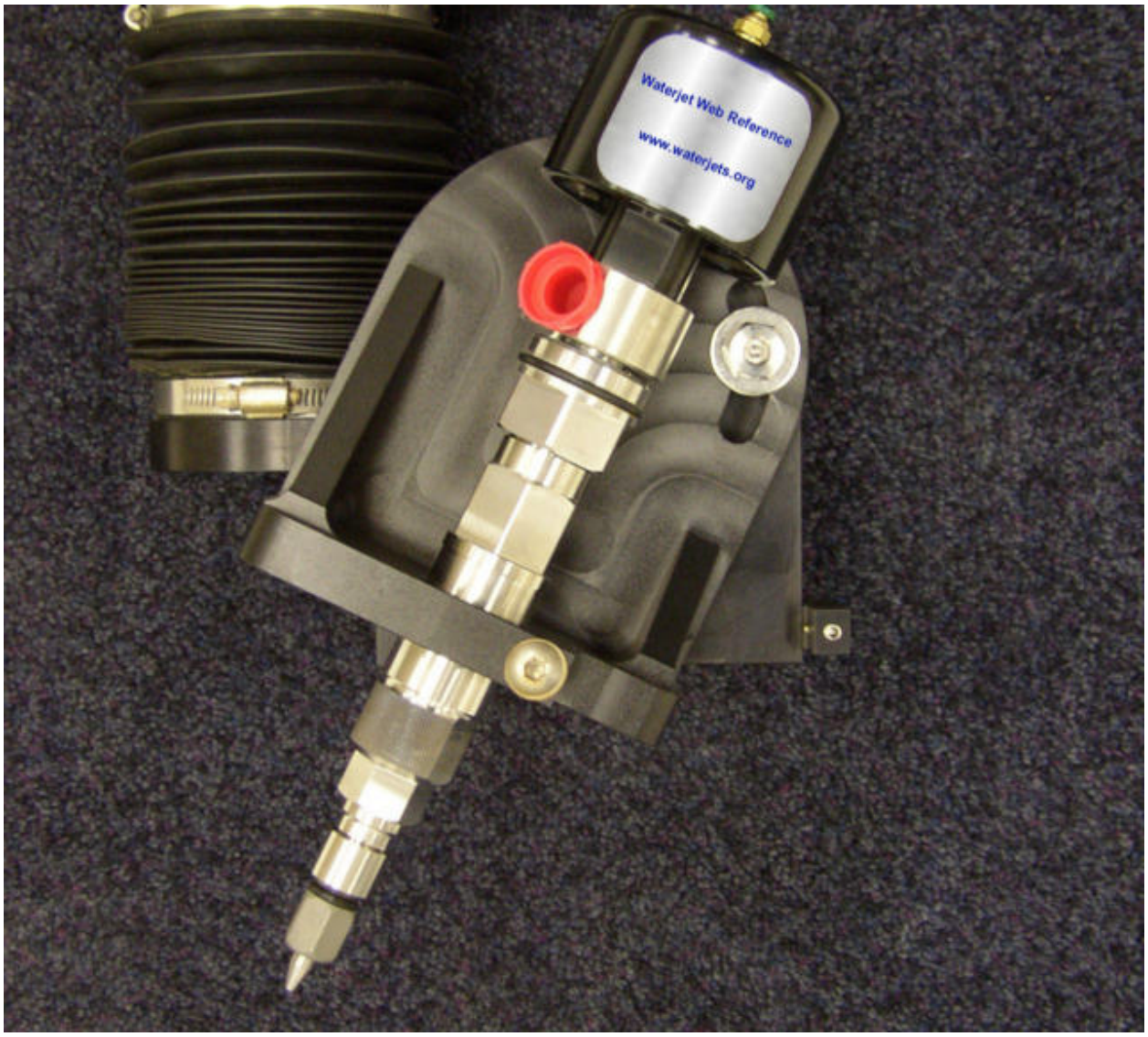


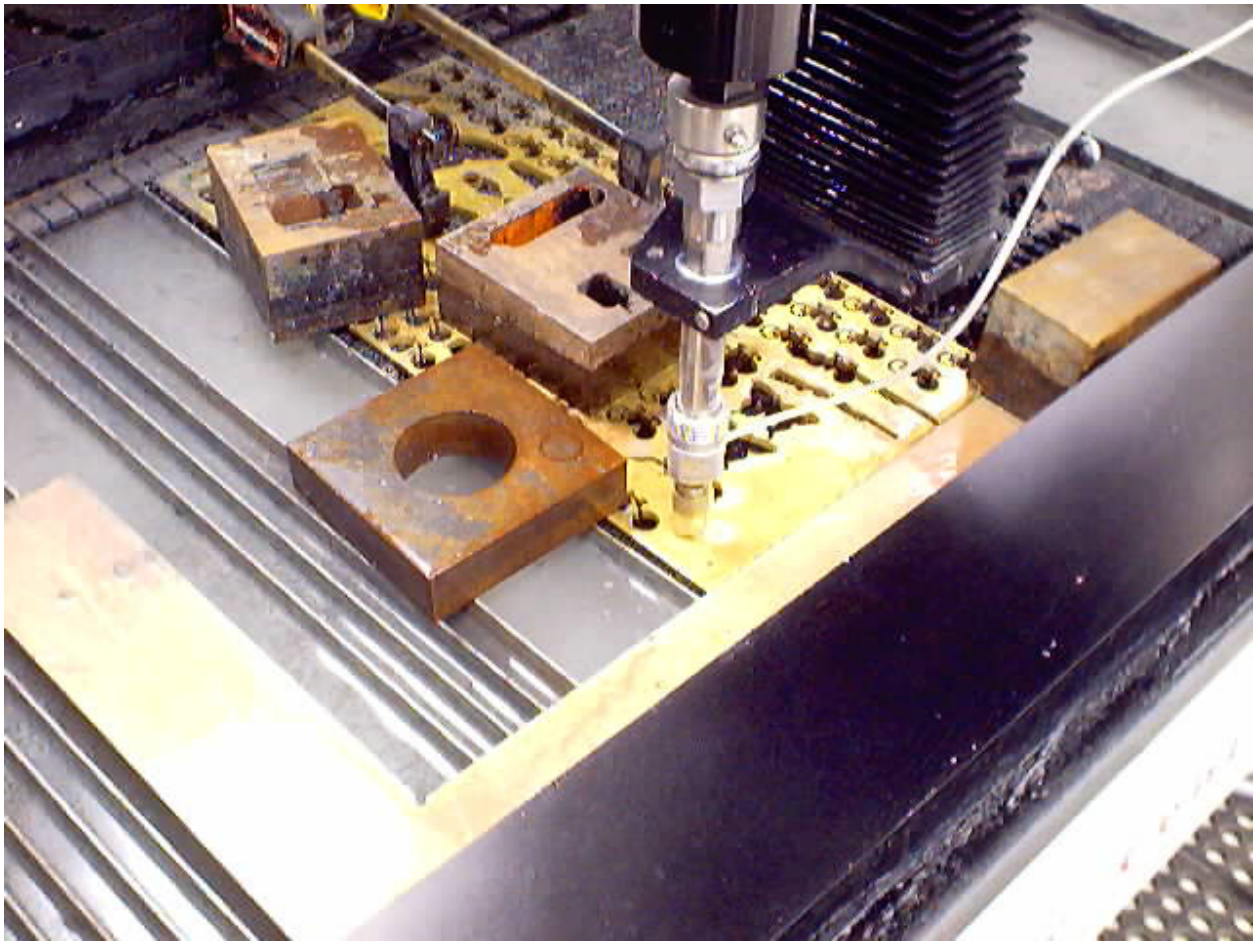
1/2" Aluminum. You can make ANY 2D shape you can think of.

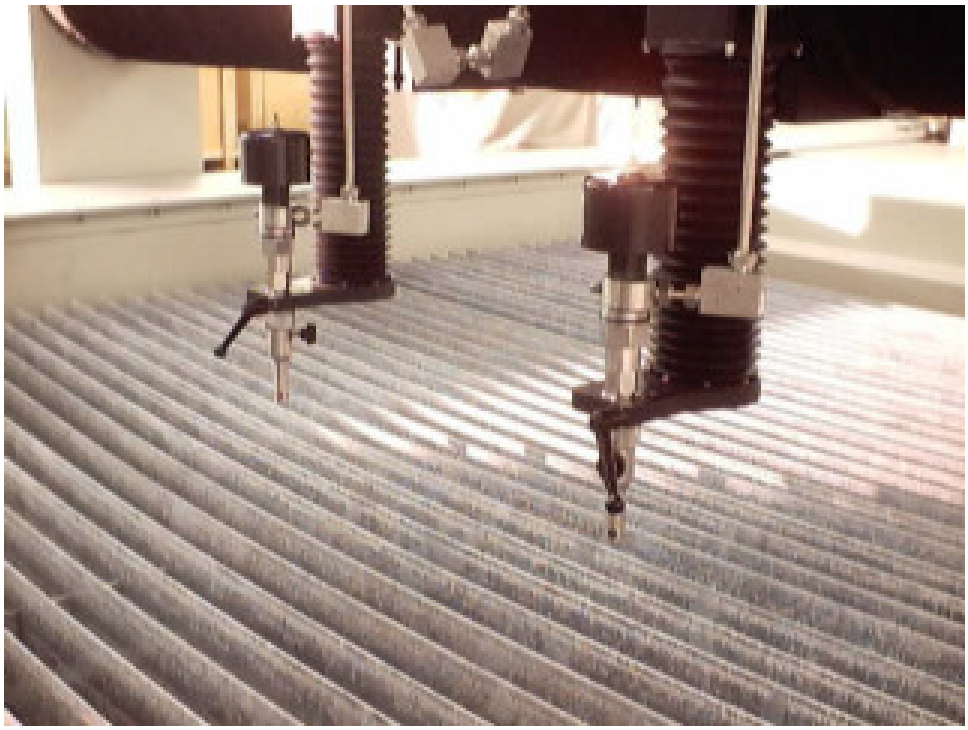
Cutting Printed Circuit boards (i.e. laminates/composites)



1" Thick Titanium.


Waterjet Web Reference
www.waterjets.org





Photos of AWJ machines and nozzles.