

Choosing and Using Waterjet Cutting



A Dynamic XD cutting head on a Flow Mach 4 machine cuts aluminum.

The tech has been around for a while, but improvements are making it all the more efficient.

By RAY CHALMERS / Contributing Editor

Since its introduction in the mid-1970s, waterjet cutting has grown in popularity based largely on its versatility. Chip Burnham, vice president at Flow (flowwaterjet.com) says the cold-cutting process is in use at virtually all automotive OEMs and tiers for cutting resins and foams for headliners and bumpers, and also superhard materials, including nickel-based alloys. There are 2D cutting heads for cutting flat stock in stacks and five-axis 3D heads for profiling and contouring, as well as multi-axis robotic systems.

“Pure” waterjet, a stream of water pressurized up to 94,000 psi and formed into a jet the diameter of a human hair, is the faster cutting process for softer materials. Adding garnet to the stream for *abrasive* waterjet, a process invented at Flow, slows the process somewhat, but increases accuracy, (as the stream thins and cuts become more precise), all with no heat-affected zone or work-hardening on metal parts.

Because increasing the fluid pressure makes waterjet cutting faster, the system’s pump is important. The linear intensifier pump is the original, and most common, technology used in waterjet cutting, according to Flow, using the “intensification principle” to pressurize water. Hydraulic oil is pressurized and pushes against a biscuit with a face area 20 times greater than the face of the high-pressure plunger that pushes against the water. This intensifies the pressure 20 times. In other words, 3,000 psi of oil pressure generates 60,000 psi of water pressure due to the 20:1 ratio of biscuit area to plunger area.

To create a pure waterjet stream the water pressure must be converted to velocity. This conversion takes place when the water is passed through a tiny jewel orifice. A hole in the sapphire, ruby or diamond orifice ranges from 0.003 to 0.020 inches (most common: 0.014 inch). The larger the orifice, the more water and horsepower are required to maintain pressure.

The top of the orifice has a very sharp edge for keeping the waterjet stream coherent. A rough or rounded edge will create a fuzzy, turbulent jet and may exhibit an angular trajectory not desired for higher-precision work, but is applicable to other applications such as surface texturing or coating removal.

A waterjet orifice will blow out for two reasons. First, calcium can build up on the orifice and break off, causing instant orifice failure. Second, the orifice edge can become rounded or break from particle impact. In waterjet, an orifice is usually either good or bad—gradual degradation is less common. A sapphire or ruby orifice can last 40 to 200 hours, depending on application and pressure, with good water. A diamond might be eight to 10 times more expensive but will last eight to 10 times longer.

With abrasive waterjet cutting, it's the garnet that erodes the material and makes the cut; the water is the accelerator. In the 1980s, waterjet speed averaged 1,500 mph at 55,000 psi. Flow's

HyperJet pump, introduced in 2004 and rated at 94,000 psi, bumped average speed up to 2500 mph. When high-pressure pumps accelerate the jet's speed, the stream becomes smaller and it cuts with less abrasive, upping the efficiency of the entire system.

Once the stream exits the orifice, it's all about velocity, according to Burnham. "There is no pressure in the waterjet stream once it exits the cutting head; pressure in the water has been converted to velocity as the water exits the waterjet orifice. A faster and smaller waterjet stream means the abrasive particles move faster, carry more momentum, and remove more material, more aggressively. Less abrasive is used per length of cut because each grain can erode more material. The goal is to make the abrasive go as fast as possible. Stream velocity is the key to efficiency."

One important way to improve processing is optimizing tool paths, according to Burnham. This allows the cutting heads to speed up on straight cuts and slow down where there are tight geometries.

Some systems feature taper compensation: an articulated wrist tilts the head over slightly to compensate for the naturally occurring V-shaped taper produced by waterjet cutting. 

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