Greater Productivity:

Flow's Waterjet Advancements Help Manufacturers

Through ongoing research and development, waterjet technology has evolved to help solve challenges faced in waterjet cutting – resulting in improved cut speed, part accuracy and tolerance in cutting flat-stock materials.

Flow International Corporation
800-446-3569 or 235-850-3500

For several years, ultrahigh-pressure waterjet technology has continued to be the fastest growing major machine tool process in the world. Many manufacturers believe the reason is that waterjets are versatile and easy to operate. But, as is the case with every machine tool process, waterjets have limitations, leaving telltale signs on a cut part. For example, milling machines leave small, repetitive scratch marks on the cut part from each rotation of the tool, meaning the faster the tool traverse speed for a given rotational speed the greater the visibility and spacing of scratches. Plasma leaves a burned edge, with the more heat transfer from the flame to the material the greater the heat damage. For waterjets, cut-part geometry errors caused by the bending of the waterjet are the telltale signs of waterjet cutting. Additionally, the most common request for waterjets is to engineer the machine to cut parts faster, which can translate to lower cost cutting and the ability to produce more work on machine.

Every machine tool technology is under continuous development to improve shortcomings. Incremental advancements are important and expected. In looking at machine tool history, major advancements in technology tend to spark giant leaps of usage by the manufacturing world. For example, CO_2 lasers saw such leaps in usage years ago when wattage jumped to 1.5 KW, and special assist gases were used to enhance performance. EDM (Electro Discharge Machining) saw tremendous increase in popularity when the wire-EDM process was developed in the 1970s based on the Plunge EDM technology.

Waterjets also have realized tremendous advancements to improve the technology. To keep pace with customer and manufacturing industry demands for cost-effective methods for parts production, Flow International Corporation recently introduced the Dynamic Waterjet®, a revolutionary new waterjet cutting process that can cut parts up to 400 percent faster than traditional flat-plate cutting machines, while further improving part quality.

Introducing: The Dynamic Waterjet

Dynamic Waterjet is a cutting system that tilts the cutting head to produce more accurate parts at higher cutting speeds. In other words, the waterjet no longer remains stagnant at a 90-degree angle to the plane of a flat plate but tilts automatically as required depending on the material and part. To best describe the Dynamic Waterjet, it is important to understand the errors that traditional waterjets can produce on a part.

Powered by software that controls the wrist, the patent-pending Dynamic Waterjet is a highly advanced system involving complex kinematics, high-speed 3D motion, and sophisticated software. Dynamic Waterjets manipulate the contact angle of the jet to compensate for geometry errors created by traditional 2D cutting systems. In effect, Dynamic Waterjets are small 3D "wrists" placed on flat stock machines. The result includes:

- Parts cut 25% to 400% faster than a traditional flat-plate cutting machine.
- Cost per part is reduced by 25% to 400%.
- Taper will be eliminated.
- Thick precision cutting becomes a reality with a waterjet.

Simply put, the Dynamic Waterjet cutting head is tilted by a few degrees to take all the taper off the "good side" of the part. Inside corners are improved because the entrance angle and exit point are altered to ensure the stream does whatever it needs to while in the material to produce an accurate corner with minimal speed reduction. Angling the jet as the arc is cut eliminates the cone effect.

How Dynamic Waterjet Improves the Cutting Process

The waterjet process is similar to a "beam" process. As the beam cuts material it loses energy, and the stream begins to lag (the exit point of the jet trails behind the entrance point – see Figure 4).

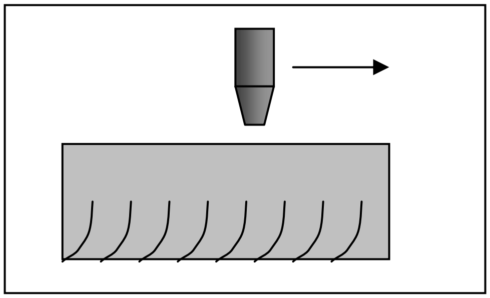


Figure 4:
As the abrasivejet travels from left to right, the exit point of the stream from the material tends to lag behind the entrance point. This is the cross section of a cut. Slowing down the nozzle traverse speed will reduce this stream lag.

Abrasivejet cutting is a flexible process with bending and deflecting of the jet as it cuts material. As the jet travels through material left to right, the exit point of the stream in the material lags behind the entrance point. The faster an operator tries to cut the material, the greater the stream lag. This stream lag can cause significant errors on the inside corners of a part. For example, if you wish to cut a square window out of a piece of material near the maximum cut speed, the damage to the inside corners will be significant. Figure 5 shows an example of this damage.

Figure 5.
Inside corner damage caused by stream lag. The material in this image is 1" stainless steel, though this damage will occur on any material. The thicker the material the more significant the damage. Slowing down the cutting speed at corners will reduce the inside corner damage.

The only way to solve this error with a standard 2-axis machine is to slow the machine travel speed as the jet approaches and leaves corners. PC-based control software helps slow the jet on corners to minimize inside corner damage but sacrifices part cycle time.

Another type of error associated with stream lag is the cone effect reflected in figure 6. As the abrasivejet is manipulated around an arc or a corner, the stream lag creates a cone shape. The closer the jet traverse speed is to the maximum cut speed the greater the cone effect will be.

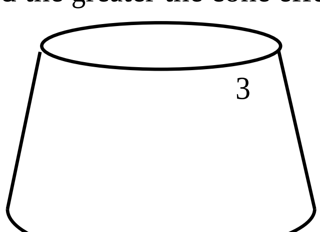
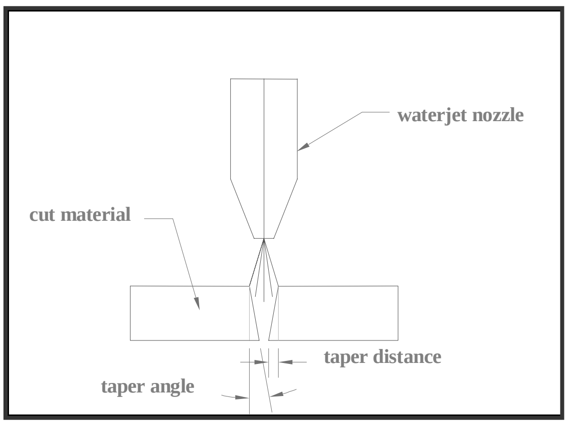


Figure 6:
Stream lag causes a sweeping out of arcs and corners. For example, a cone shape is produced when cutting a circle at relatively high speed. To minimize this cone effect, the nozzle traverse speed must be reduced.

Another error caused by the jet is the creation of a "V" shaped taper, sometimes called a draft angle. The jet loses power as it travels through the material. Much like stream lag, the closer you are to maximum cut speed the greater the taper will be. For example, if you can cut 1-inch thick steel at 7 ipm the machine will be traveling at a high speed relative to that particular material of that particular thickness. The taper will be approximately 0.009" per side (0.040" diameter entrance, and 0.022" diameter exit). To reduce the taper, the nozzle traverse speed must be reduced.



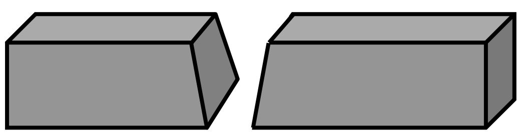


Figure 7: Abrasivejets produce taper. This taper is nearly always 'V' shaped.
Slowing the cutting speed will reduce taper.

When cutting a precise part with an abrasivejet, the taper is often the most difficult error to control. An abrasivejet can cut a finished part to an accuracy of + / - 0.003 inch on materials of 1-inch thick or less only if a very slow speed – usually about 15 – 20% of the maximum speed - is selected. That means if the machine can cut a material at a maximum speed of 100 inches per minute, the speed may need to be reduced to as low as 15 inches per minute to eliminate taper.

How Dynamic Waterjet Differs From a 5-Axis
Dynamic Waterjet is not just a 5-axis wrist stuck on the end of a flat-plate cutting machine. The heart and soul are mathematical models that control the jet attack angle, optimizing the geometry and cycle time for any part, thick or thin, in any material.

Any 5-axis machine can compensate for taper by having the user manually input a tool tip impingement angle, but the results will likely be very poor. The difference between the Dynamic Waterjet and a simple 5-axis waterjet machine is that the Dynamic Waterjet knows through the advanced mathematical models exactly what the stream is doing in the material by calculating how much the stream is deflecting, where is the exit point of the stream is in relation to the entrance, and how the jet should exit an inside corner to produce the best geometry at the fastest possible cycle time.

Dynamic Waterjets mark the next step in waterjet technology. The cost per inch reduction, productivity enhancements will provide the manufacturing world with capabilities and profits for years to come.