

► BY DANIEL MARGOLIS, ASSOCIATE EDITOR



An AWJ head cutting through ¼"-thick aluminum.

AccuStream

JET *Propelled*

Improvements to abrasive waterjet systems are increasing their use.

Abrasive waterjet machining offers numerous benefits to the end user. The cutting force it produces is low, so fixturing requirements are minimal. The types of material cut, as well as how thick the workpiece can be, are practically unlimited. Since the process produces no heat, there's no heat-affected zone on the part. And the cost of an AWJ system is relatively low; it's one-third the cost of a laser-cutting system, for example.

Beyond these benefits, AWJ ma-

chining has been continually improved upon in recent years. General manufacturers and job shops are employing it more than ever before, attracted by its increased reliability and versatility.

As a result, the market for AWJ systems is expanding. Recognizing this, traditional machine builders are beginning to build AWJ systems. In fact, next month, MC Machinery Systems Inc., Wood Dale, Ill., a division of Mitsubishi Corp., is adding an AWJ system to its product line. The company expects half of its 6,000 customers will

purchase one.

According to Nicolas Giannotte, MC Machinery Systems' vice president, the company reasons that AWJ cutting is "beginning to be used the way wire EDM is," adding that AWJ cutting is 10 times faster than wire EDMing.

Job shops utilizing AWJ systems are well aware of this. "Waterjet allows us to be more competitive with wire EDM," said Ryan Moran, waterjet operator for Robinson Machine, a De Pere, Wis.-based shop. Moran added

that AWJ cutting holds tolerances as tight as a wire EDM, but “the waterjet cuts the [cycle] time in half.”

Robinson Machine runs two AWJ systems, each with a single cutting head. One was purchased in August 2005 and the other in February. The shop also runs two laser-cutting systems.

According to Moran, Robinson often opts to AWJ-cut a part instead of laser cutting it, even in situations where the laser would make more sense. “We will waterjet-cut some materials, even though the laser might cut them quicker, because either the laser produces too much heat and the part might warp, or because the laser can’t cut a small enough hole in the material.” He stated that while lasers are better at cutting thinner sheet metal, AWJ is the better option for stainless steel thicker than 1/4", 3/8" and thicker mild steel, and 3/16" and thicker aluminum.

Moran has seen the shop’s AWJ systems equalized with its laser-cutting systems in the last few years, even as lasers themselves improve. “It’s going two ways,” Moran said. “The lasers are getting more powerful, and able to cut thicker material, but, at the same time,



A gear being AWJ-cut from a brass workpiece.

the waterjets are getting more precise and increasing their feed rates.”

Diamond Head

AWJ systems are getting more precise via a number of means, but perhaps the foremost improvement has been that, more and more, they are incorporating diamond orifices, rather than ruby or sapphire orifices, within the cutting head’s nozzle. Eric Chalmers, president of AccuStream Inc., a waterjet equipment supply company based in Mounds View, Minn., noted

that “the acceptance of the diamond orifice has gone up rapidly in the last year.”

This is key to precision. “Anybody who wants precision will use a diamond orifice, there’s no question about that,” said John Dedic, marketing manager for high-pressure waterjet equipment supplier KMT Waterjet Systems Co., Baxter

Springs, Kan. “The diamond gives you a much [more precise] stream for a much longer period of time. It lasts over 1,000 hours, versus the sapphire, which might last 200 hours.”

This enhances AWJ systems, which are achieving tolerances as tight as ±0.001", not just in terms of precision, but also in terms of reliability, giving shops the confidence to take on high-value parts and unmanned operation.

“Putting a diamond in to replace a sapphire or ruby eliminates worry or concern,” said Hal Arnold, general

[part], you ruin two or more parts,” explained Mark Baessler, purchasing manager for Metal and Services Co., a metal plate cutting service center based in Addison, Ill.

Metal and Services runs AWJ systems with multiple heads, and has further tweaked the concept; it’s running a machine with an AWJ head and a plasma torch. According to Baessler, it is one of only two such machines operating in the U.S.

“We’re able to mix the two cutting technologies on the same part,” said Baessler, who outlined a situation where this would be particularly useful. “There are customers who don’t require critical tolerances all over the entire part. For instance, on a ring, when the customer needs a close tolerance on the ID, with no heat-affected zone, we waterjet cut the ID. Then, the plasma torch comes over and cuts the OD. It’s a lot faster, so the cost for that part is considerably lower.”

—D. Margolis

manager of AWJ system builder H₂O Jet Inc., Olympia, Wash.

Ted Jernigan, president and CEO of H₂O Jet, called the orifice the “proverbial weak link” in the AWJ machining process. “It’s the most vulnerable and susceptible to damage because of contaminants or water [pressure],” Jernigan said, adding that a diamond orifice takes that issue off the table. “This is one of the key reasons that waterjet technology today is [becoming] more and more competitive with other types of cutting.”

Initially, a diamond orifice costs substantially more than a ruby or sapphire orifice. A diamond generally costs between \$400 and \$600 compared to \$10 to \$20 for a ruby or sapphire. But, in the long run, it ends up costing the end user less. “If you look at cost per hour, a ruby is around a dollar per hour of usage, whereas a diamond ends up being 50 cents an hour,” said Dennis DesMarais, sales manager for PaR Systems Inc., Shoreview, Minn., a builder of AWJ systems.

Full Tilt

A standard AWJ system has its cutting head fixed at a 90° angle to the workpiece. This limits how fast an AWJ system can cut, because the faster the system is cutting, the more taper it creates on the edge being cut.

But AWJ systems are moving over to dynamic cutting heads that automatically compensate for any taper; the head basically tilts and eliminates the taper. This allows AWJ systems to cut faster.

Robinson Machine has upgraded to dynamic heads in the last year, which has improved the shop’s AWJ performance. “We used to cut 1/4" aluminum plate at 14 to 20 ipm, depending on the geometry,” Moran said. “Now, with the dynamic waterjet, we can run it at between 20 and 50 ipm and still have practically no taper on the part.” Cutting speeds of up to 75 ipm in certain AWJ applications are not unheard of.

PaR Systems specializes in this type of integrated-motion, multiple-axis, dynamic head cutting, selling the Vector line of AWJ systems, which are capable of 2-, 3- and 5-axis machining. “Integrated motion is more than just



A 2 1/4"-thick aluminum part cut on an AWJ table.

tilting a head; it’s fully simultaneous motion in all five axes,” DesMarais explained. “You could machine a sphere with it.”

The AWJ system’s software accomplishes this through a process called “programming compensation.” The machine compensates for the deflection of the waterjet stream in the workpiece to increase throughput while maintaining cut quality.

The emergence of integrated-motion technology has allowed AWJ to move beyond simple 2-D cutting to machining parts that require integral 3-D cutting for features such as chamfers, conical holes, bevels and contours.

Pumped Up

Another area where AWJ systems have seen significant improvement is in their pumps. Over the last year, KMT Waterjet Systems has refined the components of its pumps, extending seal life and giving them much greater reliability.

“On a [pump’s] high-pressure cylinder, there’s an end cap that goes on the end of the cylinder, which the plunger pumps water against,” KMT’s Dedic said, explaining that most pump manufacturers put a soft seal between the cap and the end of the cylinder.

KMT has been able to get these surfaces aligned so that a soft seal is not needed. Instead, the pump uses a metal-to-metal seal, which makes it easier for customers to do maintenance and reduces the number of pump parts they need to have on hand. “You’re going to have a lot less leakage and a lot less stress on the material,” Dedic said.

Another pump improvement KMT recently introduced is a computerized

balancing system for shops running multiple-pump systems. This feature connects pumps to a control that makes sure each pump is working at the same percentage of work level, which is difficult to accomplish manually. Without this control, one pump might be overexerting itself while another is doing no work at all, which causes that first pump to wear more quickly.

These improvements are allowing AWJ systems to take on parts that in the past would have been deemed too risky for waterjet machining, particularly in the aerospace industry.

Getting Dirty

Despite its increasing advantages,

The following companies contributed to this report:

AccuStream Inc.
(763) 717-7099
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H₂O Jet Inc.
(866) WATERJET
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MC Machinery Systems Inc.
(630) 616-5920
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Metal and Services Co.
(630) 627-2900

PaR Systems Inc.
(651) 528-5212
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Head count

As long as you’re cutting one part on an AWJ system, why not cut two? Or four? Or 16?

More and more users of AWJ systems are opting to run multiple cutting heads on their machines, which, after certain modifications, allows them to machine multiple parts and optimize cycle times.

This is generally something a job shop ramps up to. Eric Chalmers, president of AccuStream Inc., said first-time end users might buy an AWJ system with a 30-hp pump and one head on the machine. When these users are ready for increased capacity, “instead of [them] buying another machine, we put a 75-hp pump on the table, add a spreader bar, which allows you to mount multiple heads on the Z-axis, and add additional heads,” generally going up to four heads, Chalmers stated.

Recent advances in pump capability allow shops to add considerably more heads. In March, KMT Waterjet Systems



A four-head AWJ system at work.

Co. introduced a line of giant pumps—available in 150-hp and 200-hp versions—that are capable of running as many as 16 heads on an AWJ system.

There are potential downsides to running multiple heads. Obviously, disposal issues are multiplied at a rate corresponding with the number of heads added, and more parts are at risk of being damaged. “If the machine malfunctions, and that does happen once in a while, not only do you ruin one

there are disadvantages to AWJ machining that need to be taken into account when comparing it to other machining processes. Put simply, it's dirtier. When the waterjet stream pierces the workpiece, it causes water and abrasive to spray into the area surrounding the AWJ machine. This is problematic in a manufacturing environment containing other equipment that is sensitive to contamination.

"It's generally a little bit messier than a laser would be," Moran said, adding that Robinson Machine utilizes splash guards and trench drains around its AWJ systems. "It all depends on how you set up your shop."

AccuStream's Chalmers elaborated. "With waterjet, because you are dealing with dirty water, you want to put it in a location where it's isolated from machine tools that might use oils for cutting. It needs to be in its own loca-

tion, its own area."

Others counter that issues of this sort crop up with just about any cutting process. H₂O Jet's Jernigan pointed out that laser cutting presents potential shop contamination issues that are far more serious than dirty water. "When you're cutting with a laser, you have to be concerned with gas," Jernigan said. "You wouldn't want to laser-cut something that, if you burn it, it creates cyanide gas, for example."

Beyond contamination issues, AWJ systems may require more maintenance than other manufacturing processes.

"With waterjet, a good portion of the maintenance that you need to do you can do yourself in-house without having to have a special technician come in," Moran said, pointing out that this is not the case with his shop's laser-cutting systems. For those,

Robinson Machine has a maintenance contract where, once a month, a technician comes in, aligns the optics, cleans them and tunes the resonators. Meanwhile, Robinson Machine's own staff can handle maintenance on its AWJ systems, such as replacing seals on the intensifier pumps.

As KMT's Dedic noted, end users just need to be prepared for a different, perhaps more "hands on" type of machining experience when entering into AWJ cutting. "I've had people tell me, 'I was surprised to get this machine installed and immediately have someone tell me how to take it apart,'" Dedic said. "That's just something people who [try AWJ cutting] need to understand right off the bat." The machine "will need to be taken apart for maintenance. It's not a conventional machine tool—it's pumping water." △