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ARTICLE

Waterjetting to higher production

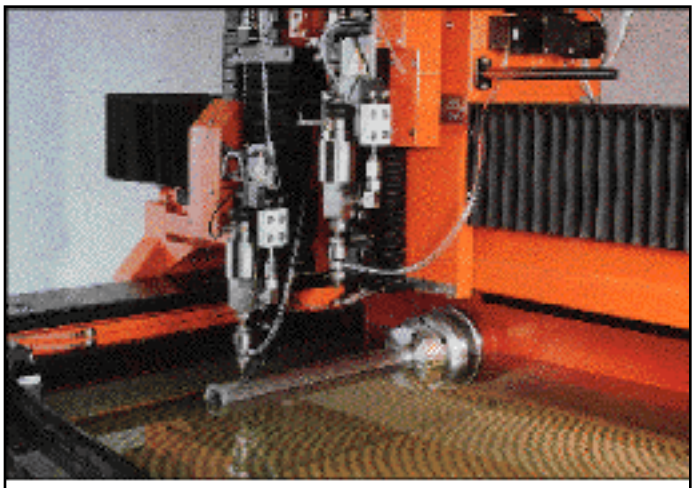
By Ted Giese
Contributing Editor

Anyone who has used a power washer to clean a deck knows that water can be a powerful tool for cleaning. But to watch a pencil of water and abrasives cut a 4´´ thick plate of stainless steel is eye opening. Such is the growing awareness of waterjet cutting technology, for it's time to take waterjet cutting seriously.

That's the message that comes in loud and clear from a look at the state-of-the-art of abrasive waterjet technology. Waterjet cutting has been around commercially for more than a decade with applications split between water and water abrasives. The split comes between applications such as cutting food and paper products, where water is sufficient, and applications that require an entrained flow of abrasives in the water stream to cut metal, plastics, and glass.

Abrasive waterjet applications now comprise over 60% of the market according to Chip Burnum, sales manager, Flow Int'l, Kent, WA, a leading manufacturer of waterjet equipment in the US. While it is true that waterjet can cut intricate patterns in delicate and difficult-to-cut materials, the real usefulness to manufacturing will come from cutting some of the more mundane products and materials. Waterjet has moved from what Mr Burnum calls "gee whiz" technology to what serious tool manufacturers can apply to new and old problems.

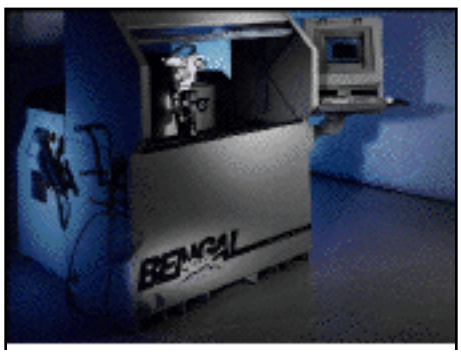
A useful cutting technology



Individual cutting heads on the Bystronic waterjet cutting system, each equipped with automatic height sensing systems and an optimum regulation of the abrasives, result in high cutting quality.

In the time since Flow first introduced its waterjet machines in 1984, the core technology has evolved enough to make it a plug-in-technology. Expanding from a niche industry with limited applications and high priced machines that demand patience and specialized expertise, waterjet has become a big business as some heavy hitters are now including waterjet systems among their offerings of cutting systems, each adding the advantage of their unique experiences. For example, ESAB L-Tec, Florence, SC, recently introduced its Hydrocut at Fabtech to complement its line of plasma cutting systems. Bystronics Inc, Hauppauge, NY, manufacturer of laser cutting systems, added waterjet equipment as an option.

Companies are finding that abrasive waterjet complements other cutting systems and metalworkers can expect to see more integrated systems incorporating waterjet with flame cutting (oxy-fuel cutting), routing, plasma cutting, or EDMing. Predrilling holes with waterjet, for example, increases performance of some EDM processes. EDM and laser cutting are finding that waterjet extends their capabilities to reflective and nonconductive materials. Also users frequently mention that precision is often less important than the flexibility and speed of waterjet in these applications.



The Bengal unit from Flow Int'l, Kent, WA, has a small footprint and is designed for jobs shops.

The flexibility and cool cutting characteristics of abrasive waterjet makes it a welcome tool for manufacturers faced with applications for new materials such as composites and sandwiched materials that present special machining problems. The low forces applied to the workpiece during waterjet cutting allows cutting fragile materials without the fear of distortion or breakage. Generally waterjet has a higher damage-free cut rate than EDM, plasma, and flame-cutting for precision cutting of metals thicker than 1/2 ´´.

Sticker shock is less a problem today as systems and component prices continue to drop. Smaller machines such as Flow's new Panther is an example. Still justification for a waterjet system may hinge on a cost analysis of the tool and long term costs of making parts, according to Mr Burnum. With system improvements that allow a machine to run unattended for long periods of time and low maintenance costs, waterjet is often the best option.

In one case study, a sign maker replaced nine band saws with a single waterjet machine to cut letters for its products. Others are using waterjet for rapid prototyping because there are no tooling costs and faster turn around according to Jeff Gardner, Boride Products, Travers City, MI, a company that has been an active participant in the development of waterjet technology.

John Olson, general manager, OMAX Corp, says that in the last decade waterjet has evolved from a material severance process to a precision machining process. In material severance, waterjet was used to save material by cutting nested parts, which required additional machining operations before they could be used. The newer capabilities of waterjet cutting, however, make it possible to cut shapes very close to net size and finish. This dramatic shift in capabilities of waterjet was possible due to developments in software that properly modeled the waterjet cutting process, and developments of mixing nozzles that have phenomenally longer wear life.

New computer and software for controls and other improvements make waterjet cutting more accessible to manufacturers. For companies owning abrasive waterjet machines, software programming presented a significant limitation to system usefulness. New PC hardware and software like OMAX Corp's First-Move Later, however, have changed that. They are easier to learn and offer more capabilities than older control systems. Commercial waterjet motion control software now includes compensation for mixing chamber wear, bending of jet stream for specific materials, and variation in cutting speeds needed for corners and curves.

The software is critical to precision applications because factors such as the lag in the trailing waterjet stream are important for setting speeds and positioning of the waterjet head.

Mr Olson says that Boride's development of its Roctec 100 mixing tube was the enabling technology that gave the waterjet industry its present capability. Wear lives of nozzles of the closest competitor to Boride are shorter by a factor of 10 or more.

But this leap forward in technology, with average nozzle life jumping from 1 or 2 hr to 150 to 200 hr, didn't come easy, says Mr Gardner. Extensive research in materials and nozzle design at Boride laboratories and the University of Rhode Island laid the foundation for Roctec 100, the tough carbide mixing tube that appears in most precision OEM waterjet machines today.

That development started a cycle of improvements in computer controls, software, tables and controls that brought the technology to its present status, says Richard Ward, Richel Inc, Cleveland, OH, a consulting and training company specializing in waterjet technology.

What's next?

Despite their successes, makers of waterjet equipment continue to improve products.

Waterjet facts

Orifices are typically made of saphire with 0.006´´ to 0.014´´ opening and last approximately 400 hr. Cost approximately $5 to $50.

Nozzles are the highest wear item of the systems. Most US systems use a Roctec 100 nozzle from Boride Products which last from 125 to 250 hr. Cost $200 to $350 depending on the type of application. As the orifice wears the jet stream of water increases in diameter. Maintenance costs average near $15 to $35/hr of use.

Abrasives for precision cutting are typically garnet with premium quality crushed garnet. Cost varies with the type of abrasives but garnet costs $0.15 to $0.40/lb and a typical machine uses between 0.5 and 2 lb/min with a typical size of 80 to 120 mesh.

Pressures are typically 10,000 to 60,000 psi. Some work to increase pressures to 120,000 psi but this is still very experimental. Cleaning systems or abrasive slurry waterjets operate at lower pressures.

Accuracy quotes vary. Some manufacturers give accuracy of machine movements, while others quote accuracy of finished parts. Typical limits on finished parts are ±0.005´´. Accuracy of movement of robotic arms and gantry systems are factors. With compensating software and tweaking of an experienced machine operator ±0.002´´ is possible.

At one extreme companies like JetEdge make relatively modest improvements in their basic system components. A new intensifier pump, self-aligning cutting head, and attenuator are improvements the company recently announced. At the other extreme, Flow is experimenting with pressurized systems at 100,000 psi and above to provide higher energy systems. Although the general trend is toward higher water pressures, safety and the lack of commercially available pumps and tubing are important development issues.

Other companies are searching for improved performance with systems at pressures below the 60,000 psi of

most production systems. Notable is the work of Dr Donald Summers, director at the High Pressure Waterjet Laboratory at the University of Missouri, Rolla, MO, who was a founding member of the Waterjet Technology Association and the Int'l Society of Waterjet Associations. He anticipates wider acceptance of abrasive slurry waterjets, a technology introduced in 1986 by the British Hydraulics Research Group (BHR) and widely accepted in Europe.

Unlike the entrained abrasive waterjets common in the US, BHR's waterjets, also known under the tradename DIAJET, pump a slurry of abrasives and water through abrasive nozzles for a cutting rate three to four times faster using modest pressures around 10,000 psi. Although technology opponents contend that wear on slurry system components prohibits successful commercialization of the technology, critical problems have been solved, according to Nick Woodhead, president of US Jetting, Alpharetta, GA, the first US company to offer abrasive slurry jet machines.

Mr Woodhead reports that the new Supracut model can cut 1´´ to 4´´ thick materials such as stainless steels, outperforming plasma and laser cutting equipment. He asserts that such aggressive cutting is possible holding a ±0.002´´ accuracy. Describing a military decommissioning program that recently purchased one of his machines, he commented that his equipment is priced at a fraction of the cost of comparable entrained abrasive systems. Though untested by the rigors of US industrial applications, there appears to be ample evidence of the material removal characteristics of abrasive slurry and the technology should find a niche market.

In another approach, Extrude Hone, Pittsburgh, PA, seeks to use lower pump pressures and a polymer containing a suspension of abrasives. Although the abrasive suspension jet program is still in research stages, Dr Summers projects that the approach has merit and US companies can expect to see it available commercially.

Down to the nitty gritty

For the most part, abrasive waterjet technology uses garnet as the abrasive. Although many other abrasives such as olivine and slag by-products are available, they have distinct disadvantages in precision applications. Garnet's hardness, density, and sharpness

provide a good compromise between cutting performance and nozzle wear. Harder abrasives such as aluminum oxide, for example, greatly shorten nozzle life. There still are no developments in diamond mixing tubes.

Recognizing the potential for market growth and the wide diversity of possible applications, companies like Cominco America have established new garnet mines and begun marketing the abrasives. Suppliers like FUSCO report that the choice of abrasive will depend on the finishing and cutting requirements for a particular application.

Barton Mines, North Creek, NY, continues as the major producer of premium quality crushed garnet used in precision applications. To Randy Rapple, vice president of sales, the decision is one of overall cost and the need for system performance. Lesser expensive alluvial garnet, like that from Barton's Australian operations, has users where precision and cutting rate are less important.

Trends for change and growth

The abrasive waterjet industry is growing and evolving through a wider diversification of applications. Research is leading to higher pressure systems and abrasives that are finer than the traditional 80 mesh used in systems today.

With the exception of a few large companies, makers assemble systems with components made by others who supply computer controls, software, pumps, waterjet heads, and gantry systems. Aware that simply combining components would not make a successful system, some companies are seeking alliances.

Source Box

For more information from any of the following companies circle the appropriate number on the Reader's Service Card.

ABB Flexible Automation, Farmington Hills, MI 800-242-3722

Boride Products, Travers City, MI 800-662-2131

Bystronics Inc, Hauppauge, NY 516-231-1212

The recent joint venture between Ingersoll-Rand and ABB Flexible Automation, both of Farmington Hills, MI, is one example. Control of waterjet cutting presents unique problems such as compensation for nozzle wear. Lag times and strategies for negotiating corners and curves are important for precision cutting. Therefore companies with experience and a database of material-specific data are best positioned to provide quality cutting systems. Mr Ward, for example, cautions that software written for robotic welding isn't satisfactory for waterjet applications.

Success spreads effectively by word of mouth, but experts agreed that understanding the capabilities of waterjet will come only through education both before and after purchase of machines. Machine tool controls that are quicker to learn and easier to use help overcome the fear factor common with new technology says Mr Burnum.

ESAB L-Tec, Florence, SC 803-664-4394

Extrude Hone, Pittsburgh, PA http://www.extrudehone.com

Flow Int'l, Kent, WA http://www.flowcorp.com

Ingersoll-Rand, Farmington Hills, MI http://www.irautomation.com/wjs

JetEdge, Minneapolis, MN 800-JET-EDGE

OMAX Corp, Auburn, WA http://www.omax.com

US Jetting, Alpharetta, GA

The state-of-the-art of abrasive waterjet shows a use and economical method of cutting a wide variety of common and exotic materials with precision and safety.