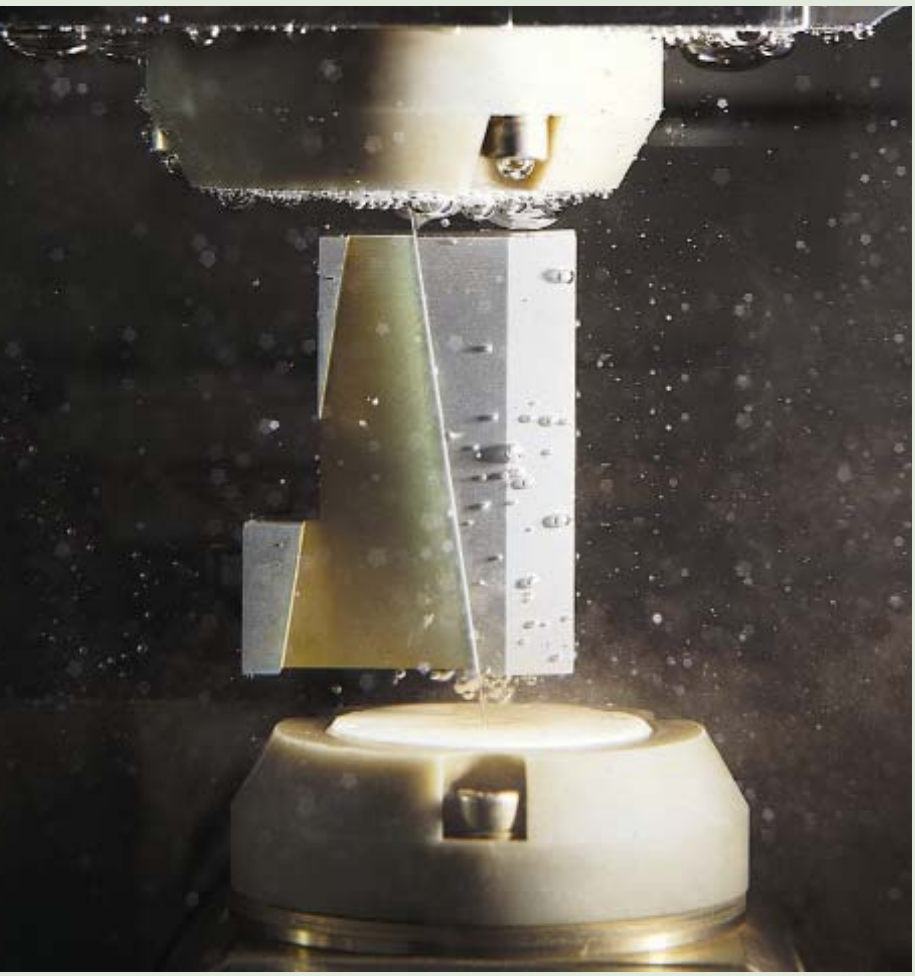
Combined Processes Speed Production



Marriage of abrasive waterjet and wire EDM maximizes shop production

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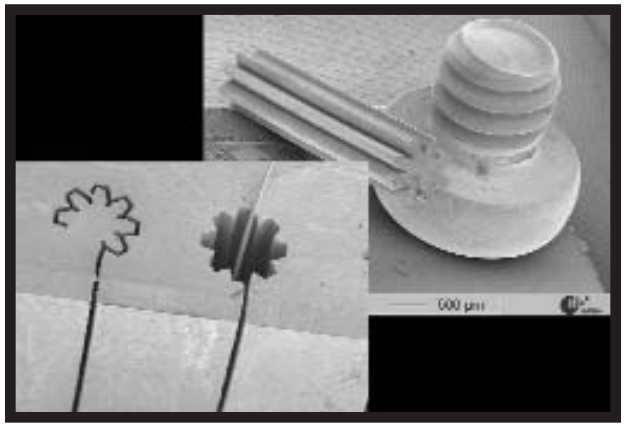
In applications requiring large tapers, EDM's capabilities surpass those of waterjet.

Over the last forty years, the waterjet has evolved from an experimental wood cutter to a reliable, high-speed machine that cuts materials with speed, power, and precision. Long regarded as a low-tolerance, specialty process for machining large sheet materials, abrasive waterjet now performs in areas previously dominated by traditional cutting technologies. From rapid hole drilling in slow-cutting materials like titanium and steel to slicing minute details in stone, composite, ceramics, and glass, this former niche technology has found many applications.



When micromachining parts with extremely high accuracy requirements, waterjet is not an option.

Henry Ford once said, "If you need a machine and don't buy it, then you will ultimately find you have paid for it but don't have it." As abrasive waterjet overtakes wire EDM in speed and cost-effectiveness for mixed-tolerance cutting, the process continues its development from novelty to practical necessity. But while abrasive waterjet machines parts with great speed, wire EDM does so while maintaining far greater tolerances with superior accuracy.

Despite their differences, many see the two cutting processes as complementary technologies that, if used together, can offer cost-effective, high-speed cutting with ultra-high precision. But when should a shop use one process instead of the other, and, most importantly, when should they be used in tandem?

Omax Corp. and Agie Charmilles recently partnered to perform a comparative study of production times and costs for a part selected by the Society of Manufacturing Engineers. The companies were tasked with machining a 3" (76-mm) stack of 12 turbine disks, first to ±0.005" (0.13-mm) tolerance using separate processes, and then to ±0.0008" (0.020-mm) tolerance with the technologies working in concert.

Many see [these] two cutting processes *as complementary technologies.*

For their end of the study, Omax chose to use the company's 55100 JetMachining Center, a large-footprint machine capable of accommodating sheets of material up to 5 × 10' (1.5 × 3 m) while holding tolerances to 0.003" (0.08 mm). Running the 55100 at 50,000 psi (334 MPa) with a model P3050 pump, Omax machined a single ¼" (4.2-mm) turbine disk in 20.5 min.

Abrasive waterjet, which is well-suited for short-run part production, just-in-time manufacturing, tooling, and prototype part development, made quick work of the 3" (76-mm) stack. The 55100 cut through the 12 ¼" (311-mm) thick layers at a consistent 20.5-min clip for a total of 4.1 hr of production time.

Omax regards precision abrasive waterjet as the world's fastest and most versatile cutting solution. When dealing with thicknesses of less than 2" (51 mm), and tolerance requirements between ±0.005 to 0.001" [0.03 mm], it can cut virtually any profile with almost no limitations in geometric flexibility.

Abrasive waterjet ignores material aberrations *that cause wire EDM to lose flushing, and maximizes material yield.*

Abrasive waterjet ignores material aberrations that cause wire EDM to lose flushing, requires no tool changing or cutting oils, and maximizes material yield for use in additional operations. Additionally, it cuts materials without creating mechanical stress, noxious vapors, or heat-affected zones. These capabilities reduce the need for secondary operations and fixturing, while producing burr-free edge quality and maintaining precision and accuracy.

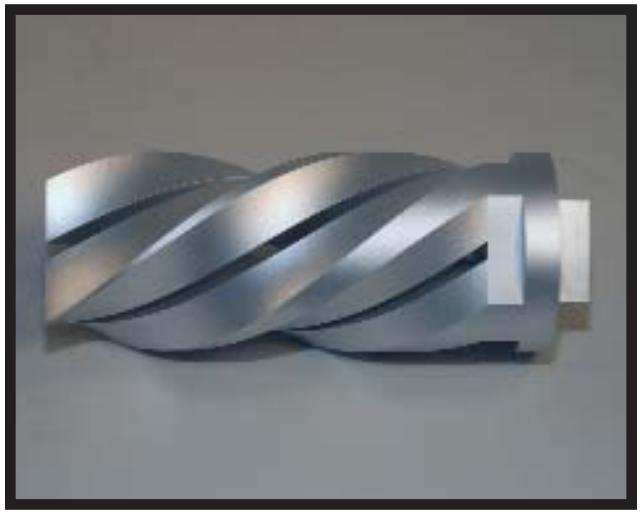
Considering this list of benefits, one would think that abrasive waterjet was on the verge of overtaking wire EDM as the preferred cutting technology, but looks can be deceiving. Though offering high speed, machining capability in nonconductive materials, and CNC control for accuracy and repeatability, abrasive waterjet is held in check by one small but unavoidable factor—physics.

When layer thickness increases, the production time of abrasive waterjet begins to slow, because the process cannot 2simultaneously maintain high speed and tight tolerances.

A jump in layer width from ¼ to 3" results in an additional 31.4 hr of production time. Abrasive waterjet produces maximum efficiency operating at and below 2" of thickness.

Additionally, as a water stream traverses a cutting surface, it encounters resistant forces that cause a loss of momentum and lowering of tolerances, creating kerf width and taper.

Kerf plays a key role in precision on rounded corners and nesting capability. Even with the best computer programming and nozzle adjustments, kerf width on abrasive water-



Though waterjet can only machine in two dimensions, GF AgieCharmilles' Turn while Burn technology enables wire EDM machines to produce complex 3-D shapes.

jet cutting beams ranges from 0.020 to 0.060" (0.51–1.5 mm), a far cry from the 0.001–0.012" (0.03–0.31-mm) range of wire EDM. But taper, a natural phenomenon that extends erosion into the vital sections of a machined piece, has been dealt with.

Under the leadership of John Olsen, a pioneer in the abrasive waterjet industry, Omax developed the Tilt-A-Jet nozzle, a cutting head that allows for virtually zero taper in most materials. The Tilt-A-Jet works in conjunction with Omax's software to automatically calculate and compensate for the natural taper produced by abrasivejet machining. Through these automated adjustments, taper is moved to the scrap material, resulting in parts with smooth, taper-free edges.

But the development of preventive measures notwithstanding, abrasive waterjet still fails to meet the levels of accuracy and superior surface finish offered by wire EDM.

Although a slower process than abrasive waterjet, **wire EDM produces accuracies as high as ±0.0001" (0.003 mm).**

The Agie Charmilles team used the Charmilles Robofil 440cc with a 0.013" (0.33-mm) coated wire to tackle their portion of the case study. With a wire EDM cutting speed of 42 in.^{2}/hr (271 cm^2/hr) and a wire size 0.0008" smaller than abrasives used in the Omax 55100, the FI440cc machined the ¼" turbine disk in 3.6 hr. When used to cut the stack of 12 disks, the FI440cc churned out a product in 11.3 hr. While the length of production time may be discouraging, the FI440cc actually increased its speed as the process went along, averaging 57 min per disk.

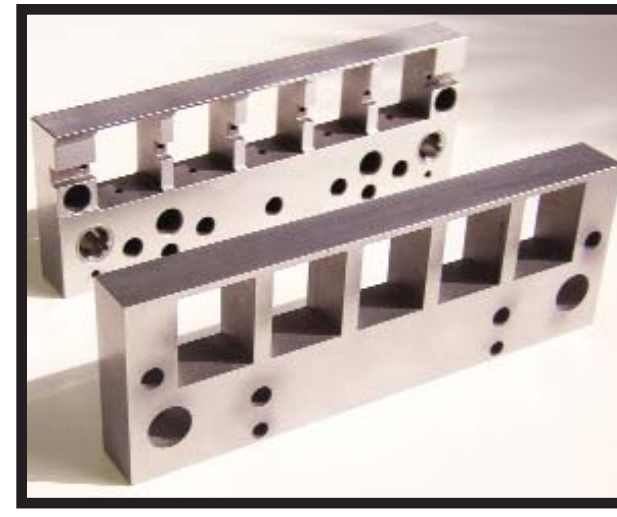
Although a slower process than abrasive waterjet, wire EDM produces accuracies as high as ±0.0001" (0.003 mm), narrow cut widths, and small radii on inside corners. The EDM process can also cut 30° tapers for any workpiece thickness up to 15.75" (400 mm), while physical limitations prevent abrasive waterjet from achieving similar results.

Another factor that contributes to the flexibility of GF AgieCharmilles' wire EDM is its *Turn while Burn* technology. This innovation enables wire EDM machines to rotate workpieces while burning in the *X* and *Y* axes. Unlike other turning units that can only index parts, *Turn while Burn* allows simultaneous *B*-axis action through servo controls for complex 3-D part-shape burning with five-axis machining.

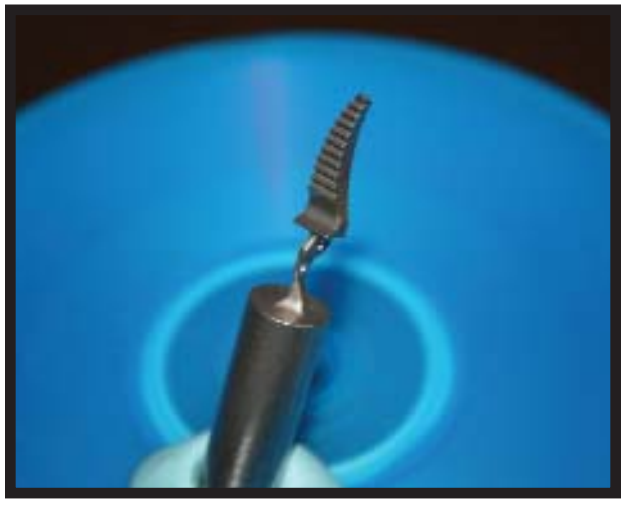
But what if your shop needs both speed and ultra-precision?

Part manufacturers should always think of production processes as a whole rather than optimizing a single step. Incorporating abrasive waterjet and wire EDM not only significantly improves lead time, but the quality and reliability of the processes as well.

The teams compared a combined wire EDM/abrasive waterjet process to wire EDM alone. Using the Omax 55100 JetMachining Center and the GF AgieCharmilles



Using a combined wire EDM and abrasive waterjet machining process reduced the production of this die frame component from 6 to 2 hours.



North-South Machinery produced this medical component by using abrasive waterjet to cut the profile and wire EDM for higher tolerance features and finishing operations.

Robofil 440cc, the Omax and Agie Charmilles teams machined a 3" stack of 12 ¼" turbine disks with dovetail slots at ±0.0008" tolerance and minimum inside radii of less than 0.010" (0.25 mm).

Due to the required tolerance and inside radius, most manufacturing engineers would never think of incorporating abrasive waterjet into the machining process. But by doing so, Omax and Agie Charmilles were able to manufacture the part in 7.7 hr. Abrasive waterjet enabled the teams to cut all features within the tolerance range and create initial blanks, wire EDM start holes, and holding fixtures in 2.3 hr. The teams then used wire EDM to complete the part, adding all close-tolerance features in 5.4 hr.

Part manufacturers should **always think of production processes as a whole** *rather than optimizing a single step.*

Incorporating abrasive waterjet machining resulted in a 32% decrease in production time. By optimizing production with a combined abrasive waterjet/wire EDM process, Omax and Agie Charmilles saved 3.6 hr.

The marriage of these technologies will not only save a shop time and money but it will also add to its capabilities, enabling it to reap the benefits of fast turnarounds and the ability to trade tolerance for speed from feature to feature on parts.

With abrasive waterjet functioning like a less-precise high-speed wire EDM, shops can use it for partial production of parts with mixed tolerance requirements, and quick production of prepierced blanks for parts requiring EDM accuracy and fixtures in support of wire-EDM processing. Once a workpiece is rapidly machined within the tolerances of abrasive waterjet technology, users will be able to perfect the part with the precision of wire EDM.

Though both wire EDM and abrasive waterjet should be seen as individual technologies with advantages and limitations rather than cure-alls for precision cutting, their combination enables machine shops to produce better products, faster and at a lower cost.■

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SME offers videos and books on EDM and waterjet technology. The book *Electrical Discharge Machining* discusses the theory behind the process, what causes overcut, and the importance of the dielectric. It also addresses the effect of the spark on metallurgy, and how the surface finish is produced and controlled. The video *Electrical Discharge Machining* presents both main types of EDM—ram and wire. It explains the differences between ram and wire, and covers the basic machine subsystems involved. The video *Thermal and Abrasive Waterjet Cutting Processes* provides a comprehensive introduction to the three most commonly used thermal cutting processes (oxy-fuel, plasma, and laser), and examines the best applications for waterjet cutting. For more information or to place an order, telephone SME Customer Service at 800-733-4763, 8 am–5 pm Eastern Time, Monday–Friday.