

Getting Wired Into EDM

TECHNOLOGY EMPHASIZES HIGH ACCURACIES AND IMPROVED SURFACE FINISHES

Matthew Jaster & Lindsey Snyder

Wire electrical discharge machining (wire EDM or spark machining) is an extremely accurate manufacturing process. The predictable and easy to automate technique was commercially developed in the 1970s, allowing manufacturers to work with harder materials while maintaining precision cutting. It's a process that involves a thin, single strand metal wire in conjunction with de-ionized water to cut metal using heat from electric sparks.

Online you'll find crowded manufacturing forums where engineers and machinists debate the technology's relevance in relation to gear manufacturing. As with any specialized machining technique, there's a fair share of supporters and detractors. The question is whether this could change in the future. For specialized gears or prototypes, it's a perfectly reasonable method of operation with definite advantages. But if you need to punch out thousands of gears in a short amount of time, there's probably a better way.

Mitsubishi/MC Machinery Systems, Agie Charmilles and Makino are three wire EDM companies that have experience working with gear manufacturers. With new machines and technologies debuting at IMTS in Chicago this September, there are more reasons for gear manufacturers to consider the benefits of having wire EDM equipment on their shop floors.



Wire EDM allows for increased accuracy, improved machining performance and a superior surface finish (courtesy of GF AgieCharmilles).

Mitsubishi/MC Machinery Systems

"Wire EDM benefits to gear manufacturing comes in many layers," according to Greg Langenhorst, technical marketing manager for MC Machinery Systems (Mitsubishi EDM/Laser).

Although *Gear Technology* has not discussed wire EDM cutting for gears very often, there are various benefits to the process for gear manufacturing, one of which is that it is not as complicated as using a slew of cutters specific to the gear parameters required. "With

wire EDM, all we need is an NC program of the tooth form and the blank that needs the teeth cut on it," Langenhorst says.

Investing in software specific to gear cutting is a commitment MC Machinery systems made in the early '80s. Partnering with DP Technologies, they developed a software package, *ESPRIT*, to create involute gear profiles from the standard gear data describing tooth form.

"After inputting the gear data into the system, it generated a half tooth of geometry, and then we just copied it as many times as needed to create the complete gear. This takes a total of about 15 minutes from data input to NC program output," Langenhorst says. "The gear blank is then fixtured onto the machine table, the wire threaded, and with a press of the start button, the cut begins. So from getting the gear data on a sheet of paper to cutting the first part can happen inside of one hour. Try that with a hob or a broach if you don't have the cutters in house!"

Another big benefit of the EDM process for gears is that they can cut very hard material. As long as a material is not electrically conductive, a wire EDM can cut it. "With wire EDM, the blank can be heat treated first and then wire cut, which can reduce the possibility of material movement during heat treating," he says. "Wire EDM cuts hard steel, in most cases better

than soft—and faster, too.

“Difficult-to-cut materials such as some of the high nickel steels used in aerospace, special materials used in the medical industry and even polycrystalline diamond used to create high production tooling inserts all end up in a wire EDM.”

There isn’t really a typical gear MC Machinery Systems cuts, although the EDM process cannot cut helical gears. Taper angles are possible by tipping the wire, so bevel gears, straight tooth helical gears and gear cutters like spline broaches are certainly within the EDM capabilities.

“Extremely small gears can be cut with wire sizes as small as .001 inches where the gear external diameter is as small as .050 inches and has six teeth,” Langenhorst says, describing the range of gear applications possible. “On the other end of the spectrum, we have shops cutting gears for large mining shovels that are 20 feet in diameter with teeth bigger than your hand and 16 inches thick. We’ve cut screw machine tooling with involute forms, spline broach rings, powder metal and stamping punches and dies in all sizes with the tip and root radius determining the wire diameter.”

One real disadvantage to using wire EDM for gear cutting is the lack of speed the process is known for. “It’s a slow process compared to the way large production batches of gears are produced, but for prototyping, small quantity production, repair parts, quick turnaround pieces and gear tooling, you can’t beat it,” he says.

Another challenge with wire EDM is that it runs using de-ionized water as a dielectric, which can cause rust on some low grades of steel. In order to minimize this effect, MC Machinery developed an anti-electrolysis power supply, so it is only an issue on the much lower carbon type steels.

As far as new EDM technology coming from MC Machinery Systems goes, Langenhorst pleads the fifth. Generally speaking, increasing automation and cutting speed are always a goal, as well as boosting the large knowledge database the machines draw from as they monitor cutting processes. Despite tight lips on the subject of new developments, EDM is an area

to keep watching in regards to unique future applications. “Small slots that require very small wire diameters, parts that can’t have any machining burs and now with the ability to add a servo controlled B or rotary axis, some really crazy stuff is moving to using wire EDM.”

Look for MC Machinery Systems at IMTS this year to find the company’s latest wire, CNC sinker EDMs, small hole EDM drilling machines, the high-speed graphite and hard milling line, as well as the waterjet line of machines. You may just find wire EDM is a good match for a new project.

“I’m not sure if most gear people understand just how accurate the wire EDM process is,” Langenhorst says. “We have feinblanking companies that make gear dies for starter ring gears that are 12 to 20 inches in diameter where the punch and die clearances are next to nothing. You can’t grind parts like that and hold those tolerances in the same amount of time.”

GF AgieCharmilles

The closed and controlled process involved in wire EDM is one of its lasting charms, according to Gisbert Ledvon, business development manager for GF AgieCharmilles. “This is a very predictable and easy to automate process if you want to make multiple gears; you’re always using a fresh tool. The machine has an expert system built-in that allows you to get the same results time and time again.”

For many years, GF AgieCharmilles has been working with F1 race car companies on their automotive gears. “These companies actually modify the gears based on each individual race track on the circuit,” Ledvon says. “The wire EDM process gives improved machining performance, faster cutting speeds, increased accuracy and a superior surface finish. Our equipment is pivotal in shaping the gears in the high-end gearboxes of these race cars.”

The high accuracy and exceptional surface finish found in these race car applications can be accomplished using one EDM machine in a single set-up.

Additionally, the company’s new CUT 1000 Oiltech machine makes sur-

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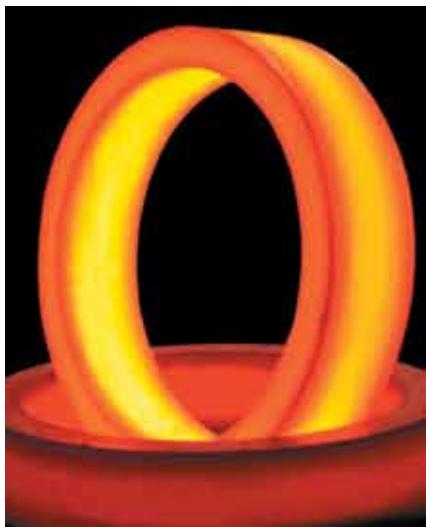
MC Machinery has 35,000 square feet of EDM showrooms across the United States, housing more than \$3.5 million in equipment, including this wire EDM at its East Coast showroom in Pine Brook, NJ.



These broach tools were cut by MC Machinery on a wire EDM.



Wire EDM can be used for micro-machining applications, including the gears found in watches (courtesy of GF AgieCharmilles).



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face protection a priority while serving as an accurate wire EDM. It was designed for micro machining and other precision applications.

"Aerospace, defense, semiconductor and medical applications for example," Ledvon says. "You need to have a strong background in micro machining first, and it will allow you to consider nanotechnology down the road. We're able to go smaller and smaller with each new innovation."

While most wire EDM machines use de-ionized water as an inert dielectric, the oil found in the CUT 1000 eliminates the effects of corrosion due to long periods of immersion. "The oil allows for a smaller distance between the wire and workpiece, producing smaller internal radii compared to water-based machining," Ledvon says.

It's also equipped with a dual-wire system that allows the machine to switch back and forth between a large diameter wire and a small diameter wire. "These multiple configurations allow for better position accuracy and taper cutting capability for high precision parts," adds Ledvon.

Software packages are available for gear manufacturers through the company's website. Once considered a complex programming endeavor for gear manufacturers, it's now pretty painless to setup your software specifically for gears. "There's a lot of good stuff out on the market right now and a lot more coming out in the next couple of years," Ledvon says. "We'll have a few new machines and technologies on hand at IMTS this fall that show off some of these improvements."

As mentioned earlier, the wire EDM process is not ideal for large production runs. This technology is more appropriate for special gears or prototypes, items that require difficult materials without the need to build tools. But Ledvon believes wire EDM could be a great starting point even for mass production.

"If you're building a mass product of some type, there are still benefits to the wire EDM process. You can cut the first gear on an EDM machine as a prototype and build the tools with the EDM machine before you go into mass production. A single setup can save you time and money when working on

prototype designs," Ledvon says.

Three years ago, Corey Hopwood, director of Hopwood Gear, purchased a Charmilles 440 cleancut machine. The machine has been cutting gears 24 hours a day since.

"Our main benefit is being able to cut very specific modules and DPs to drawings without the need for gear cutting tools to be manufactured," Hopwood says. "We can eliminate the need for some finish grinding of the teeth where possible, and very good accuracies can be achieved. We're also able to manufacture any splines with any sort of alterations the customer may require without the need to purchase expensive broaches."

Hopwood Gear, located in Manchester, England, uses wire EDM technology to manufacture straight spur gears, internal and external. Any type of modifications can be made to the gear teeth for tip corrections and root alterations. "Unfortunately, helical gears cannot be manufactured using this method," Hopwood says. "It's a time-consuming process, and there's a fine line between the cost of tooling versus cost of time for large quantity



MC Machinery can cut basically any type of gear using wire EDM, except helical gears.

production jobs."

Hopwood also notes that oddball gears are achievable with wire EDM without the need for expensive tooling. He believes the technology will start regularly appearing in job shops across the globe.

"It's a technology you should not delay on. Our wire EDM machine is now the kingpin of our business, and we would struggle without it. The machine is three years old and performs as good as the day it was first installed."

Makino

Machine tools and software are the foundation of Makino's wire EDM technology. The company has spent years on R&D to come up with innovative EDM systems. Brian Coward, EDM applications engineer, believes the automated capabilities will continue to be of interest to the gear community.

"The operator can be off doing something else once the parameters are taken care of and the machine can be left unattended. It frees you up to accomplish other tasks on the manufac-

turing floor."

Makino's 4-axis horizontal machines are used in aerospace, automotive, die/mold, parts production and general machining. "These machines let you do multiple parts very easily, and the gear module program simplifies the process," Coward says.

Wire EDM can accomplish certain cuts and angles that other processes cannot. "I can cut a circle on the bottom of a part and a square on the top of the same part with no problem at all," Coward says. "A tapered gear can be accomplished in one shot depending on your input and how you control it. The flexibility of wire EDM is probably its biggest selling point."

While speed is a factor in wire EDM, Makino has created a few technologies that can improve cycle time and overall part quality; e.g., its High Energy Applied Technology (HEAT) process enhances machining speeds.

"HEAT is designed for applications where flushing is difficult or impossible," Coward says. "With this technology, we can maintain a good cutting speed and actually increase the



Makino's wire EDM machines allow users to do multiple parts with a great deal of flexibility (courtesy of Makino).

cutting speed by 50 percent. We can also hold tolerances of straightness to 0.0005 inch with one pass and 0.0002 inch with two passes."

Bellywizard software is another Makino technology that helps produce straighter parts with fewer passes. "Anyone that runs a wire EDM knows that inaccuracies to the belly or bow

continued

What are you waiting for? get cutting

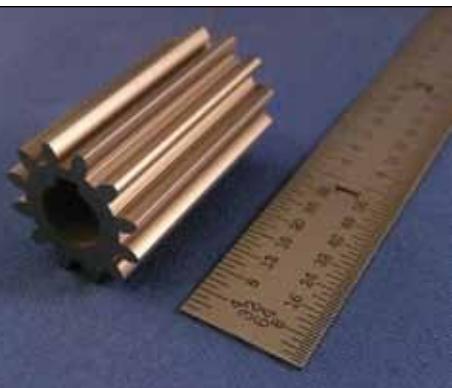
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Coward at Makino notes that the wire EDM process can accomplish angles and cuts that might be difficult for other cutting techniques (courtesy of Makino).

of a workpiece occur during the initial rough cut operation," Coward says. "You tend to get a little bend at the center of the part. *Bellywizard* was created to improve the straightness. I was cutting an 11-inch gear for an automotive company, and it needed to be straight within .002 inches. In order to achieve this, I had to use this software."

Bellywizard compensates for changes in the wire caused by erod-

ed wear and wire lag. Compensation is accomplished by automatically machining on a slight taper in the rough cut and through adaptive servo movements. These technologies, along with High Quality Surface Finish (HQSF) and *WireWizard* control technology, help bring more speed to more complex and involved geometries.

Makino also has an oil-based wire machine coming out at IMTS in September. "This will cut as fast as the water machines with a much better surface finish," Coward says. "We'll be featuring many of our technology packages along with our new machines in Chicago."

Coward is confident that the wire EDM process will continue to gain support in the gear industry as the technology advances.

"A lot of job shops use wire EDM, and a lot of shops don't," Coward says. "More shops are considering the technique; they just don't know enough about it. There are so many different uses for a wire EDM machine once you have one on the shop floor. People still aren't as comfortable with the process

as they are with broaching or milling, but that's going to change in the very near future."

For more information:

GF AgieCharmilles
560 Bond St.
Lincolnshire, IL 60069
Phone: (847) 913-5300
Fax: (847) 913-5340
info@us.gfac.com
us.gfac.com/company/contact/index.cfm

Hopwood Gear Ltd.
Moss Down Road, Oldham
Manchester, England, OL2 6HS
Phone: (+44) 1706 841154
www.hopkinsonandhopwood.co.uk

Makino EDM Group
Makino Die Mold Technology Center
2600 Superior Court
Auburn Hills, MI 48326
Phone: (800) 552-3288
www.makino.com

MC Machinery Systems
1500 Michael Drive
Wood Dale, IL 60191
Phone: (630) 616-5920
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www.mitsubishi-world.com

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