



► BY DANIEL MARGOLIS, ASSOCIATE EDITOR

# Slimming Down

**Thinner-wire EDMs are at the forefront of the miniaturization trend, delivering hard-to-see parts.**

In the popular 1966 movie *Fantastic Voyage*, a surgical team was miniaturized (along with their submarine) and injected into the bloodstream of a critically ill diplomat in order to travel to his brain and remove a blood clot. When the time comes for the tiny team to be extracted from the patient's eye, a full-size technician has a hard time seeing the minisurgeons.

Many shops using wire EDMs are on a similar voyage, using thin wires

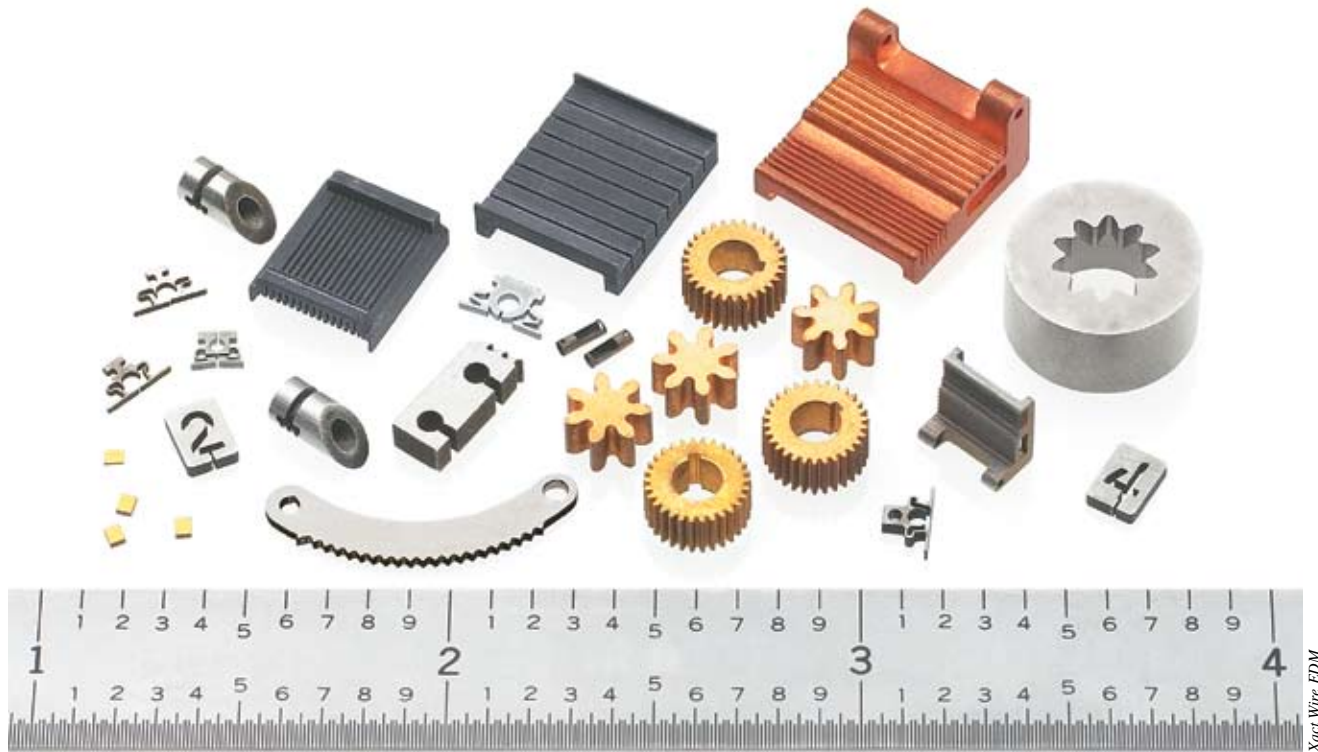
to machine miniature parts. In addition to the challenges of machining parts much smaller than a thumbnail, shops must find innovative ways to locate the hard-to-see parts once the job is done.

Wire EDMing is well suited to small-part machining. According to Ron Vogel, owner of EDM supplier EDM Network Inc., Sugar Grove, Ill., wire EDM is at the forefront of small-scale machining. "The diameter of the wire as a cutting tool is so small that

no other cutting method can equal it," Vogel said.

Glynn Fletcher, president of EDM manufacturer Agie Ltd., Lincolnshire, Ill., agreed. "Basically, everything that needs to be produced in that miniaturized range, even down at the nano level, is being produced or is in the process of being developed on wire EDM," Fletcher said.

Fletcher noted that the process stands out when used to produce unusual,



A spread of small parts cut with a wire EDM.

nonlinear geometries. They include the inner workings of microelectronics, medical tools and implants inserted through veins, and tiny spinneret dies for textile manufacturing.

Jeff Gubbins, co-owner of Xact Wire EDM Corp., Waukesha, Wis., countered that many of the parts his shop EDMs have simple geometries but include a feature that lends itself to the process. "The part may have thin, delicate walls, be made of a difficult-to-machine material and have small corner radiuses or narrow slots," he said. "Many times, we are simply EDMing small, round holes or cutting in a straight line when machining slots in a part."

In terms of surface finish for a machined workpiece, microEDMing is already a nanotechnology, according to a white paper published by Agie. "Roughness obtained in microEDMing using fine wire is 0.05 $\mu$ m; in nanotechnology terminology, 50nm to 100nm  $R_a$ . The impulse length controlled by the spark generator and process controller are below 200 nanoseconds."

The paper also noted that due to its flexibility, a microEDM can machine a large range of structures without

extensive tooling costs and preparation time. A test piece was machined with 0.02mm wire to 0.038mm on its narrowest part and 0.114mm at the end of a slit.

#### Market for Smaller Getting Larger

The width of a wire EDM cut is limited by the wire's diameter. A 0.004"-dia. wire can cut a slot about 0.006" wide, which means the smallest inside corner it could generate would be about half that, or 0.003".

To go smaller than that, an end user must apply a smaller wire. The smallest wire Mitsubishi EDMs can use is 0.004", which the company is trying to improve upon.

"The market for [smaller wire] stuff is getting larger," said Greg Langenhorst, EDM product manager for MC Machinery Systems Inc., Wood Dale, Ill., a division of Mitsubishi. "We're putting more focus on getting to at least 0.002"." He said Mitsubishi has a machine in production in Japan that handles wire down to 0.001", but it is currently too expensive to export to the U.S.

According to Fletcher, Agie's wire EDMs can machine parts 100 nanome-

ters in size. This is achieved using the smallest wire possible. "It wasn't so long ago that it was thought that wire diameters of 0.002" were extraordinary," Fletcher said. "Now we're down to 0.0008" and 0.0005", at the experimental level."

Wire EDM end users are taking notice. Bob Brademeir is president of Micro EDM Co., Cass City, Mich., an EDM job shop specializing in small parts. "I started Micro EDM 18 years ago and haven't had a part in here bigger than the tip of your thumb," Brademeir said.

He gives Agie credit for its efforts to make wire diameters 0.002" and below more accessible and "user friendly," but feels this will take time to be fully accomplished. The smallest wire his shop uses is 0.006". Said Brademeir: "I believe I've seen shops out there using 0.002" wire. [Below 0.001"] I have not seen in the real world. I just can't imagine it in a wire machine. Think about all the rollers and wheels you see in there. If there's a little groove, your wire won't even feed. It's got to be a pain."

It is. John Foster, vice president of EDM supplier Current EDM Inc.,

Mountain View, Calif., commented on the challenges posed by small-diameter wire. "Some of these guys are getting to sub-0.002" wire, and the machine has to be designed around that capability, and the operators have to know how to operate with that," which means they have to be able to see it.

"You've got to split a hair a few times to [match a] 0.002" wire," said Charlie Quillen, president of EDM builder AccuteX EDM, Dayton, Ohio. "An old fella like me, I can't even see it."

Agie's Fletcher concedes that with wire this small, "physics starts to play a part," pointing out that it's not only challenging to see wire that thin, it's also challenging to keep it under tension without breaking. This requires, as Foster pointed out, EDMs designed around small-wire capability, with more sophisticated wire transport systems, auto-threading systems, power supplies and controls.

#### Like a Needle in a Haystack

There's also the challenge of finding the part after it's been machined—no easy feat considering these are parts in the nanometer range, usually being cut out of a submerged workpiece.

Bill Mader, owner of Microcut Inc., York, Pa., described the smallest part he's ever cut, a round slug for a miniature hearing aid. The slug was 0.006" thick with a 0.015" OD. The tolerance was  $\pm 0.0005$ ". Microcut was not told and could not determine exactly what the workpiece was, just that it was "a special sintered material."

In machining the parts with a wire EDM, the challenge was not so much cutting them as "not losing the parts when you cut them off," Mader said. To accomplish this, the shop installed a screen basket underneath the workpiece, with strip magnets on the bottom of the basket so that the parts would fall off and be kept in place. "Otherwise they'd just blow away into the water," Mader said. The shop also reduced its water flush from 150 psi "down to almost a trickle."

EDM manufacturers offer rigging like this, including catch cans installed



Medical devices cut with a wire EDM.

in the tank, for small-part machining. "You just hope to get as many as you can in there," Micro EDM's Brademeir said, "because even when you drain the tank, they're floating around and will go into the filter."

Handling these small parts goes beyond rigging inside the machine. "You basically have to get yourself

into a clean room environment so that when you cut the pieces you can find them," Langenhorst said, adding that some wire EDM end users opt to nest parts in strips that are separated after machining. "You can take 10 parts out in a little string and then break them off once they're out, rather than try to get each individual piece."

Micro EDM incorporates this approach and performs the work in a clean room. "The city checks my wastewater all the time," Brademeir said. "Our wastewater's cleaner than what's coming in. They just scratch their heads; they can't believe it."

Asked what limitations Micro EDM faces in machining progressively

#### Escalating copper prices make EDM a high-wire act

The cost of copper, and, therefore, one of its derivatives, brass wire, has been shooting upwards this year.

"All we've done is increase prices," said Wayne Moffett, general sales manager for EDM Supplies Inc., Downey, Calif. "Copper's gone through the roof." In the first 5 months of 2006, EDM Supplies saw a 58 percent increase in the selling price of its brass wire. As of mid-August, it cost between \$5 and \$8 per lb., depending on the manufacturer.

This has decreased EDM Supplies' wire sales, which the company tries to compensate for by announcing the price increases in advance so that customers can stock up.

Bill Mader, owner of EDM shop Microcut Inc., called the increase in the cost of copper "dramatic. Unfortunately, in a lot of cases, we've had to pass along some unbelievable cost increases. Wire has gone from almost an unimportant part of our cost structure to the most important factor in the last 6 months."

Mader was reluctant to give an exact dollar amount for how much the cost of wire per machine had gone up in his shop, but said in mid-August that it was roughly three times the price in January.

Microcut's customers have been understanding about the increase, as Mader assures them parts costs will come down when, or if, the price of copper comes back down. But no one's holding his breath.

"I don't think there's an end in sight when you look at the usage of copper and the general requirement for copper vs. the available copper," Mader said.

EDM manufacturers downplay the potential effect the increase could have on wire EDMing.

"Wire EDMing is becoming more efficient," said Glynn Fletcher, president of EDM manufacturer Agie Ltd., "and so the cost of the consumable—the wire—is increasing, but the efficiencies are outweighing—or certainly balancing—the increased cost."

—D. Margolis

smaller parts, Brademeir said there are problems programming IDs that are not so much physical as mathematical. "If you get too small, it becomes mathematically impossible for the machine to do it because you just can't make the circle," he said.

The smallest ID Micro EDM can cut is 0.010". Brademeir said surmounting this limitation will come as wire-handling systems become smaller and controls become more sophisticated.

Agie's Fletcher said the company's controllers allow end users to achieve constant surface speeds and adjust the rotary-axis speed to conform better to the diameter of a part, letting them produce more complicated shapes.

Microcut has adapted to meet programming limitations it encounters by customizing wire EDM programming to meet its needs. "If you have intricate corner radii or angular conditions, we find in many cases that canned programs just don't do the job," Mader said. "Our people are capable of going in and editing programs and making them do the job."

According to Mader, the only limitation Microcut has run into is cylindrical parts with extremely thin walls. "I'm talking about something that would be equal to the diameter of the human hair," Mader said. "We could maybe be two times the diameter of a human hair, but we can't do one time, because the [wall] material itself is just going to be eaten up as you go."

Another limitation is machining a part that is both big and small, with thick and thin features. As wire diameters get smaller, maximum workpiece thickness goes down along with it.

"When you get down to a 0.002" wire, you really don't want [a cut thicker] than about 3/4"," Langenhorst said.

### Slow Down

In recent years, EDM manufacturers have focused on increasing speed, since the process, once considered too slow for most production applications, is approaching speeds as high as 40 to 50 sq. in. per hour. But in small-part wire EDM, speed again becomes an issue.

"I'm always concerned with speed, because I want to give people the best price," Microcut's Mader said. "However, there are many cases where you just have to forget about speed and get the job done the best way that you can in order to give them the quality they need."

Mader illustrated how as wire diameter decreases, speed is reduced, so that by the time his shop is working with 0.004" wire, its speed is down to 0.96 sq. in. per hour or lower.

Micro EDM tries to maintain speeds of 30 to 40 sq. in. per hour, but Brademeir said that sometimes this has to come down to 1 to 2 sq. in. per hour. "Of course, you have to slow down every now and then," Brademeir said. "It all depends on the accuracy required."

Xact's Gubbins added that cutting time often represents a small percentage of the overall production process for small wire EDMed parts. "Many parts require more time to load, clean, inspect and package than they do to cut," he said.

Foster made the final point that speed becomes relative when wire EDMing is judged to be the best, or

### The following companies contributed to this report:

**AccuteX EDM**  
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**Agie Ltd.**  
(800) 438-5021  
[www.agieus.com](http://www.agieus.com)

**Current EDM Inc.**  
(650) 966-9676  
[www.currentedm.com](http://www.currentedm.com)

**EDM Network Inc.**  
(888) 289-3367  
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**EDM Supplies Inc.**  
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**Micro EDM Co.**  
(989) 872-4306  
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**Microcut Inc.**  
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**Xact Wire EDM Corp.**  
(800) 798-9228  
[www.xactedm.com](http://www.xactedm.com)

only, course of action for machining a small part. "It's going to be relatively slow, but faster than any other way you can do it." 