➤ BY SUSAN WOODS, ASSOCIATE EDITOR

Electrode Choice

The pros and cons of graphite and copper electrodes for sinker EDMing.

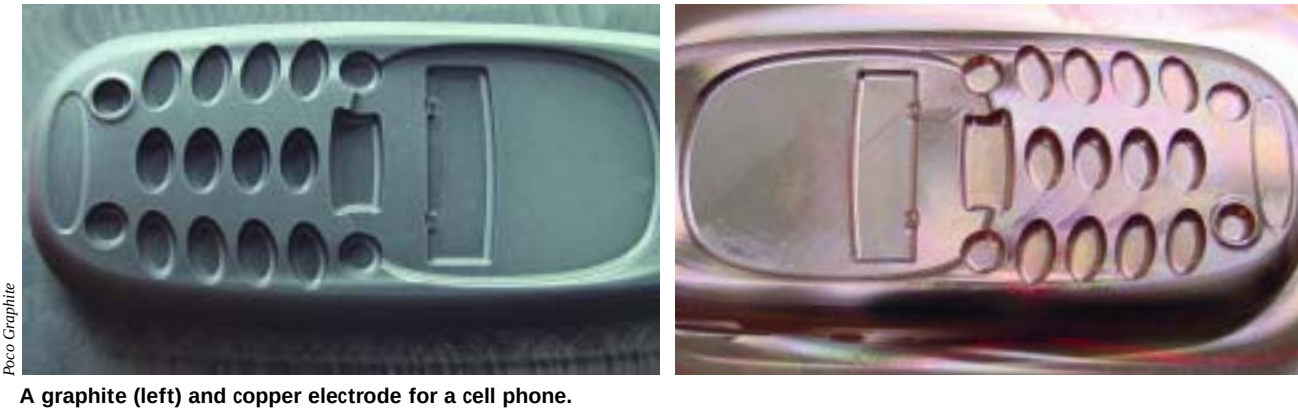
The ideal electrode material for sinker electrical discharge machining would be usable at a high metal-removal rate, highly wear-resistant and able to produce a fine surface finish. But because no such electrode material is available today, EDM shops select a material that possesses the best combination of these characteristics for the specific application.

Graphite is by far the most used material in the U.S. for sinker elctrodes. Copper is a distant second. In Asia, however, copper is still the preferred material.

According to Philip Evans, international sales manager for Poco Graphite Inc., Decatur, Texas, 30 percent of the electrodes used for sinker EDMing in Asia are graphite and 70 percent are copper. In Europe, the numbers are 60 percent graphite and 40 percent copper.

Both graphite and copper can be combined with one another or with other materials to make them more efficient. Combinations include copper/tellurium and copper/tungsten. With copper/tungsten, for example, copper is more conductive so it actually removes material at a higher rate, but tungsten wears longer and retains its shape better.

When choosing between graphite and metallic electrodes, specifically copper, there are some key characteristics to consider, such as ease of machining, mrr, wear resistance, surface finish and cost.



Poco Graphite

A graphite (left) and copper electrode for a cell phone.

Machining Ease

Copper is a relatively soft material, making it somewhat difficult to machine. It tends to tear during machining and can gum up the wheel during grinding. And, handwork is usually needed to remove burrs on the edges, especially when the material is ground.

Graphite is easier to machine than copper and so higher cutting speeds can be used. Graphite machines two to three times faster than copper and requires no handwork, according to Poco Graphite.

However, graphite is dirty. When cut, its chips take the form of a black abrasive dust, which must be controlled. This dust can adhere to machine tool components, causing them to wear prematurely.

However, a good vacuum system can effectively control the dust. For companies that do a lot of graphite machining, several machine tools have features expressly designed to address this issue.

Also, because of their hardness, some grades of graphite are prone to chipping. To prevent chipping, machinists need to use suitable cutting tools and the correct speeds and feeds.

Wear Away

The ability of an electrode to produce and retain detail is related to its resistance to wear. Compared to copper, graphite electrodes can be run at a higher mrr in relation to wear. Copper's low melting point, approximately 1,083° C, often causes too high of a wear rate in relation to its mrr. Therefore, because of the low wear resistance of copper, the number of electrodes needed to complete a cavity could be more than the number needed when using graphite.

When roughing, according to Poco Graphite, it is possible to put a graphite electrode in a "no-wear" condition, which means less than 1 percent wear. In a no-wear situation, some of the molten metal that enters the gap remains soft as it hits the electrode and sticks to it. Many splatters will create a thin film of plating over the leading edge of the electrode, protecting it. Care must be taken to avoid too much plating, however, as it can cause electrode growth.

Plating on a copper electrode is difficult because of the excessive on-times required and low melting point of copper.

Because graphite is available in numerous grades, it is important that the appropriate grade and machine parameters are used to achieve the desired results. Generally, graphite grades that have a small grain size, uniform microstructure and high strength are ideal for producing fine detail and a good finish. Graphite grades with a large grain size are generally chosen because they can be run at a high mrr in roughing applications, when producing intricate details is not critical.

"For applications where you would want to remove a lot of material out of the workpiece using roughing, or high mrr parameters, I recommend a lower-density graphite because when it comes to working with those parameters, a low-density graphite electrode holds up better," said Graham Ruck, sales and applications manager for Leer Technologies, a part of Saturn Industries Inc., Hudson, N.Y. "It wears less than a high-density one."

	COPPER	GRAPHITE
Electrode milling time for producing two electrodes	3 hours, 27 minutes each electrode	1 hour, 32 minutes each electrode
EDM time to burn one cavity using the roughing and finishing electrodes	7 hours, 16 minutes	3 hours, 29 minutes
Total time	14 hours, 10 minutes	6 hours, 33 minutes

Source: Poco Graphite

Comparison of time required to machine copper and graphite electrodes used to produce an 85mm × 35mm × 7.5mm cavity in tool steel.

Ruck added that if someone wants to use a fine-detail electrode, then high-density graphite is better because it is stronger and is going to hold up better at the lower mrr needed for finishing.

With copper, the polarity is almost always going to be positive, except when cutting titanium, carbide and certain exotics. Graphite can be run with either positive or negative polarity, although positive is more common in sinker EDMing. However, graphite wears significantly more during negative-polarity applications.

"You get the highest metal-removal rate on your workpiece with graphite running negative," said Ruck. "But, if you want to lower the wear of the electrode, then run your graphite positive."

Ruck added that for most common EDM applications, graphite is run positive because the shop wants to retain the shape of the electrode. In cases where the electrode is considered "expendable," negative polarity is used. This might occur when roughing simple shapes, applications in which the electrode can be easily fabricated or redressed, or when EDMing through-holes.

When seeking a finer workpiece finish, the result depends on the finish on the electrode. If the electrode stays stationary during the cut, copper produces a finer finish. If the electrode is moving during the cut, a mirror finish can be obtained with either a copper or high-density-graphite electrode.

There are technologies available on some machine tools that promote mirror finishes, according to Poco Graphite. One is adaptive controls and another is powder-additive systems.

At What Cost

Generally, when considering the cost of an electrode, there is more to it than just looking at the cost of the basic material itself. In fact, that is usually only a minor part of it. The cost to actually make and use an electrode in a specific application is what is important. The cost per cubic inch of electrode material is often insignificant when compared to the number of electrodes needed and the machining, EDMing and finishing/polishing time.

"If a graphite electrode is cutting quicker or if you can get away with using one electrode to get to the end of the burn in graphite and you need two in copper because of the difference in the wear, then graphite would be cheaper," said Ruck.

"It is usually graphite, though," he added. "I can't tell you the last time I used copper for a sinker electrode."

The following companies contributed to this report:

Poco Graphite Inc.
(800) 433-5547
www.poco.com

Saturn Industries Inc.
(800) 775-1651
www.saturnedm.com