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Class Conscious

Impact of graphite selection on electrical discharge machining.

Ask any sinker-EDM operator in North America what his top choice is for an electrode material and chances are he'll answer "graphite." And, the use of graphite electrodes is growing elsewhere in the world as well. They're replacing copper electrodes in Europe and Asia.

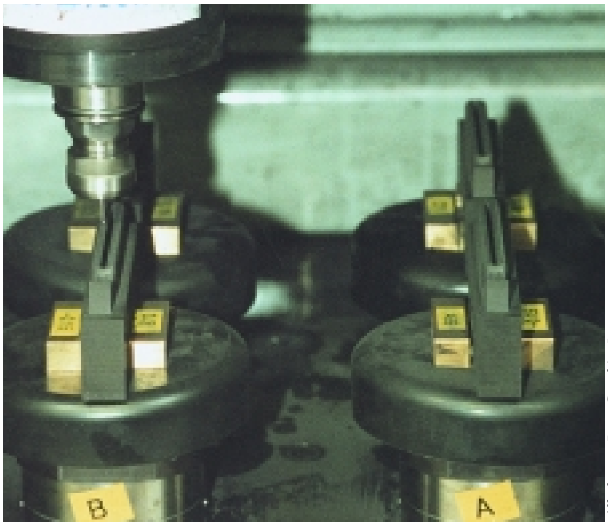
Why? The reasons are straightforward: Graphite is especially conductive and wear-resistant. Furthermore, dust collectors designed to fit high-speed machining centers used to produce graphite electrodes have reduced complaints about hazardous airborne particles.

Despite the advances, selecting the right classification of graphite is still critical to successful EDMing. To aid in this effort, this article examines the major classes of graphite offered and discusses their machinability.

Five Basic Classes

A wide range of graphite grades is available from a number of manufacturers. Each producer uses different processing techniques, raw materials and process controls, which means the end product varies from one supplier to the next. In addition, since all graphite looks alike, it can be difficult to select the best grade for a particular application, based solely on appearance.

To complicate the issue further, some manufacturers allow their products to be sold as private-label brands. Or, the same product may be sold under many brand names. The truth is that each grade of graphite is specially designed for specific applications—regardless of its brand name.



All photos: Poco Graphite Inc.

High-speed machining centers facilitate the manufacturing of thin-rib electrodes.

Graphite has evolved along with other EDM products, albeit at a slower pace. Primarily, graphite performance has been enhanced through improvements in the microstructure of the graphite materials.

There are five major classes of graphite: medium, fine, superfine, ultrafine and angstrofine. The medium classification has an average graphite particle size exceeding 20µm and is unsuitable for EDMing. The fine class' particles range from 11µm to 20µm, superfine particles measure from 6µm to 10µm, ultrafine particles are from 1µm to 5µm and angstrofine's particles are less than 1µm. When particle size spans a small range, the microstructure of the material is more uniform and less porous.

Particles are bound together by chemical or mechanical means. And it's the breakdown of the binder that leads to electrode material being released into the gap when EDMing. If the material's particles are small, uniform in size and tightly packed, erosion of the electrode is minimal.

Particle size also dictates the level of surface finish that an electrode can impart. Since the electrode reproduces its structure in the workpiece finish, a fine surface finish cannot be obtained with graphite that has large particles and/or a nonuniform microstructure.

The growing demand for molds with finer finishes has led graphite suppliers to streamline their product offerings. For example, within the last decade, sales of fine and superfine grades have remained flat, and sales of ultrafine graphite have risen. Therefore, most of the real developmental efforts have centered on this class. The reason is because many plastic consumer products require molds with fine detail and finishes, which can easily be imparted with ultrafine graphite electrodes.

However, producing ultrafine graphite is both challenging and expensive. The mechanics of the manufacturing process, for example, make it very difficult to control the uniformity and physical properties of the ultrafine class.

Regardless of classification, all graphite should consist of tightly packed particles with little size variation, because these characteristics improve an electrode's wear- and heat-resistance.

The microstructure of the graphite is

Enclosed high-speed machining centers have reduced complaints about airborne graphite particles.

EDM production comes of age

Global competition has forced moldmakers to reduce lead times and production costs while producing more sophisticated molds. To support these demands for improved performance, manufacturers have had to develop next-generation machines and materials.

Rapid advancements in machine and computer technology have brought EDMs out of the back room and onto the shop floor, where they now complement other operations. With minimal training, an EDM operator can routinely turn out completed cavities while running several machines or performing other duties.

And, high-speed graphite-machining centers can produce a seemingly endless supply of accurate electrodes, readily mountable onto the EDM. Described below are a number of technologies that have dramatically improved EDMing in recent years.

Machining Centers. High-speed machines have made electrode fabrication extremely clean and efficient (see main article). Once a program is loaded, electrode fabrication is fast, accurate and repeatable. This holds true when producing multiple electrodes or redressing an existing electrode.

Toolholders. From the simple shank tooling for mounting the finished electrode, tooling systems have been developed for mounting premachined blanks that go from a high-speed machining center to the toolchanger without indexing. The use of automatic chucks allows toolholders to be mounted on a variety of machines. Robotics further increase tool-changing capabilities and pallet changers are available for loading multiple jobs into the fluid tank to increase the length of an unattended operation.

EDMs. The ability of EDMs' sensors to monitor gap conditions and adjust the machining parameters during the burn eliminates the need for operator intervention. Once an operator has loaded the program and responded to the menu prompts, the machine works until the desired results are achieved. Additional functions can be added that send out beeper notification when the job is completed or in trouble. Off-site monitoring of the job is possible with telecommunication equipment added to the machine.

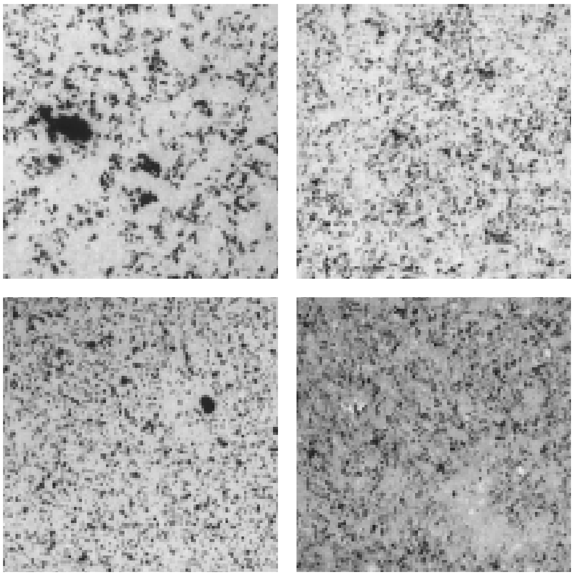
Recent technological advances have made unattended EDMing a reality. Here, operators load programs.

Operators. Qualified operators were once hard to find, because EDM training was only available through an apprenticeship program. Sometimes an operator would pass along information acquired through years of trial and error. Often this consisted of a notebook that contained a combination of machine settings that produced stable cuts for typical jobs. EDM training is now available to anyone with the desire to learn. Operators with the necessary skills come from high school, vocational centers, community colleges and special training programs. Machine manufacturers are providing more training and support today than has ever been available in the past. There is also a vast amount of published information available on EDM operation.

—J. Mercer

often the limiting factor in EDM performance. A nonuniform microstructure can have soft spots (large, porous areas) and/or hard spots, which are clumps of congealed graphite caused by inconsistent blending.

Impregnating the porous areas of the material with coal-tar pitch and then reconstituting the material can also lead to hard spots, giving the particles and the pitch-impregnated areas different hardness values. Since these flaws are microscopic, there is no way to visually detect them prior to machining. The most reliable method for identifying such problems involves examining photomicrographs of an electrode that has undergone destructive testing.



The uniformity of graphite often depends on the supplier selected. Shown are four photomicrographs (100x magnification) of ultrafine-class graphite from four different suppliers. The dark spots are pores within the graphite (the light areas).

High-Speed Machining

EDMing a thin-ribbed mold is difficult. Without adequate flexural strength, thin-ribbed electrodes can deflect—due to flushing pressure—or break during orbiting. The corners and edges of electrodes made from tightly packed, small-particle graphite are better able to resist erosion than electrodes manufactured from material with large particles and pores.

The ideal class of graphite for EDMing thin ribs has a flexural strength above 10,000 psi—namely, the ultrafine class. An electrode with thin-ribbed features made from an ultrafine grade can successfully EDM a cavity, whereas the same-shape electrode made from a coarser class of graphite may crack or chip during the cut.

High-speed machining centers have made it possible to produce intricate forms in almost any class of graphite, a task that is impossible using manual or slow CNC machines. The reason why is that the spindle on a high-speed machine can make multiple passes in the same time a slower machine needs to take a single pass. The result is a lighter chip load with the faster spindle, which means minimal pressure is exerted on the rib sections of the electrode.

The ability of a machining center to cut fine details into almost any grade of graphite, however, does not mean an EDM operator won't have trouble producing a cavity if an inappropriate grade is chosen for an application. High-speed machining amplifies microscopic inconsistencies in graphite, which can lead to problems. For instance, hard spots can cause the tool to deflect, resulting in an out-of-specification electrode. Furthermore, a material with hard spots is more likely to chip or break during machining. Soft spots can decrease accuracy, too, because the material may not have the strength to support the cutter and keep it on the designated tool path. Machinists who regularly machine materials with this kind of microstructure learn to reduce feeds and speeds, thus increasing machining time.

All of these machining flaws can be detected with a coordinate measuring machine.

Finishing Thoughts

The surface finish in the cavity of an EDMed part is a mirror image of the electrode's surface. And while an operator can request a particular surface finish from the EDM's control menu, if the graphite grade is physically incapable of imparting the required surface finish—due to excessive porosity and/or large particles—the machine will simply EDM the part without ever achieving the desired finish.

Also, when the optimal class of graphite is not used, metal-removal rates tend to decrease. The EDM's sensor monitors the gap and adjust the machining parameters as necessary to maintain a stable cut. Excess or large particles in the gap cause the ram to retract and advance slowly as cutting resumes. This leads to overly rapid electrode wear.

Graphites with uniform microstructures tend to be high-performance materials that allow aggressive machining parameters to be set. In fact, a high-performance material can trim hours off an operation, as well as eliminate the waste otherwise caused by graphite that wears easily, can't maintain a stable cut or fails during the cut.

For these reasons, the graphite chosen is critical to optimizing an EDM operation.

Assistance with selecting the best grade is readily available. Some graphite manufacturers support their materials on the shop floor. Their application specialists can make recommendations and troubleshoot operations. A number of these manufacturers also offer EDM training that covers graphite technology.

Taking advantage of these services will help ensure that a company's EDM department is consistently "first in class" when it comes to workpiece quality and productivity.

About the Author

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