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ELECTRODE MATERIAL EFFECT ON CNC EDM

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Introduction

Unrivaled advancements in EDM technologies have become an intrinsic means of ensuring success in today's global competitive environment. Shops today must find a method of reducing manufacturing costs while boosting productivity and providing a quality mold, on time while meeting ever-increasing demands in customer specifications. Oftentimes this entails the upgrading of capital equipment to current technological capabilities. This article will examine the use of adaptive control and introduce the effects that an electrode material may have on the efficiencies of this function and describe the details of a test conducted with an identical rib detail machined from materials of two different classifications programmed to complete the same task.

What Is Adaptive Control?

While much has changed in die sinking technology, one of the foremost advancements is the development and continual improvement of adaptive control, or fuzzy logic, to eliminate the guesswork and allow the machine to take control of the metal erosion process.

Historically, the EDM operator was required to be diligent in monitoring the EDM application and have the necessary skills to correct any complications in the EDM cut. These talents are hard to find in the current labor market and come at a high price. This facilitates the need for improved capabilities in EDM CNC control. With the caliber of adaptive control in today's EDM sinker, the machine continuously monitors the EDM gap in search for signs of impending failure. Once identified, the sinker automatically adjusts the machining conditions to overcome the threat; therefore, allowing the operator to focus on other tasks. Unfortunately, this often results in complacency of the operator while believing the adaptive control of an EDM sinker will also provide the most efficient means possible to complete an application.

With this, a common occurrence is to use a more economical, lesser quality electrode material. After all, the sinker has the ability to overcome any complication in the cut and will be able to complete the task at hand, right? While this may be true in some cases, the fact is that the electrode material will affect the machine's ability to fully optimize the EDM process and provide the most cost-effective means of completing the application. In other words, the adaptive control of the EDM sinker will optimize the application only to the level of what it has to work with.

The purpose of the adaptive control in an EDM sinker is to read the conditions of the EDM spark and translate these conditions into digital signals that are fed into the machine's controller. The controller translates these signals, determines the efficiency of the EDM cut and makes adjustments accordingly. One of the conditions monitored by the machine's adaptive control technology is contamination in the gap. If excess contamination in the gap is present, this creates the potential for an EDM arc or diminished performance. The controller must then make adjustments that do not affect the overburn or surface integrity of the workpiece. This generally involves changes in the gap voltage, increasing the offtime, altering the jump cycle or a combination of any of these.

While this may rectify the issue, the problem is that none of these are conducive to truly optimizing the EDM performance. Using lesser quality electrode materials often creates the need for the machine's controller to make continual adjustments; therefore, slowing down the EDM cut.

The old adage, "If it ain't burning, it ain't earning" comes to play here. For example, as the controller increases the off-time in an EDM cut to overcome excessive contamination in the gap, the corresponding duty cycle of the electrode material is reduced and the EDM cut is slowed.

Spend a Dollar to Save a Dime

Frank-Peter Amdt, BMW's Production Chief once said, "Anyone who saves money in the wrong area in tough times is putting his competitiveness at risk over the long term."

In order to calculate the true cost of the EDM application, shop owners must not only take into consideration the cost of the electrode material and machining, but should also account for the cost of the EDM time and any polishing that may be required in the end. Moving to a lesser quality material just to save a little in the price of an electrode may end up costing more in the long term and reduce the competitive advantage a shop may have.

Taking Mr. Amdt's statement in mind, a test was conducted to evaluate the effect of a more economical, lesser quality electrode material on the adaptive control function of the EDM sinker. Materials from the superfine and ultrafine classifications were used and a ribbed electrode was programmed to provide a depth of 1.5" with a surface finish of 27 VDI.

The cost difference between the two electrode materials seems considerable, so why use a more expensive material when the adaptive control of the EDM sinker is projected to complete the task at hand? As we can see in *Table 1*, the use of the more economical superfine material did not have the cost efficiency that was expected. This material did not achieve the required surface finish and took longer to reach the final depth. The added cost of polishing the cavity and extra EDM time actually caused this application to lose money. The use of a lesser quality material could be justified if the material cost is all that was considered. However, we can see that a mere savings on the electrode material cost can result in a much larger overall cost when all the factors of the EDM process are taken into consideration. In the case of this example, for every dime that is saved on material cost, a dollar is spent in the overall manufacturing cost.

Test Case

All too often, an EDM is purchased on the premise that optimum performance will be realized regardless of the electrode material used. The following test was conducted with an identical rib detail machined from materials of two different classifications programmed to complete the same task.

For each cut, two electrodes were used with one to rough and the second to finish the cavity to a 27 VDI surface finish at an EDM depth of 1.5". The objective of this example was to verify the effect of the electrode material on the ability of the machine to provide satisfactory results and determine the associated costs. The differences in the electrode materials used center around the particle size and microstructure. One material is from the ultrafine material classification while the other is a larger particle size material from the superfine graphite classification. In this example, the electrode detail is not deemed to be overly critical as the dimensions of the rib measured .040" x 1.00" with a 1° draft.

The electrode material from each classification completed the EDM process to the required depth with what appeared to be a similar surface finish. However, under magnification, we find that the material from the superfine classification did not provide the required surface finish; and therefore, the cavity will need to be polished after EDM.

The measurement of surface finish in this cavity averaged 31 VDI and exhibited a rough texture as

	Superfine	**Ultrafine**	**Variance**
Electrode cost (2 electrodes) Material and machining	$18.98	$29.10	+53.3%
Surface finish in cavity	31 VDI	27 VDI	n/a
Polishing cost ($15/in^2/VDI)	$90	$0	n/a
EDM burn time	2 H 37 M	2 H 14 M	-14.7%
EDM cost ($55/hr)	$143.92	$122.83	-14.7%
Total cost	**$252.90**	**$151.93**	**-39.9%**

Table 1 - Cost comparison for all factors of EDM

illustrated in *Figure 1*. On the other hand, the cavity EDMed with an electrode from the ultrafine material classification achieved an average surface finish of 27 VDI as illustrated in *Figure 2*.

You may wonder why the surface finish is different if the sinker is programmed to provide the same finish for both examples. The problem lies with the microstructure of the electrode material. The surface finish in the cavity is a reflection of the EDM parameters used in the program and the structure of the electrode material. As the particle size and corresponding porosity of the electrode material becomes larger, the surface finish in the cavity becomes rougher. The controller in the EDM sinker identifies the surface finish requirement as directed by the program and determines the EDM parameters to achieve this finish. It does not take into account the specific structure of the electrode material in regards to surface finish.

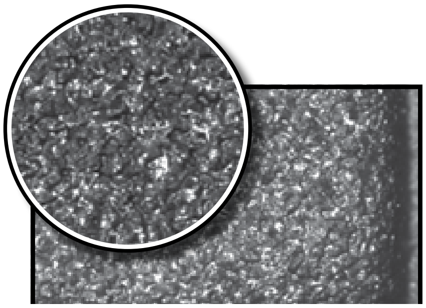


Figure 1 - Magnified surface finish of a cavity EDMed with an electrode material from the Superfine classification.

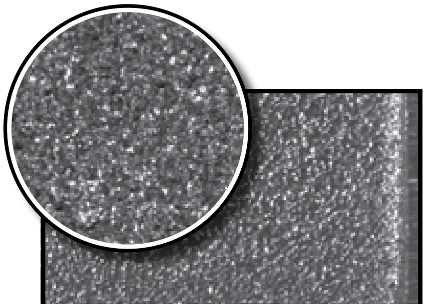


Figure 2 - Magnified surface finish of a cavity EDMed with an electrode material from the Ultrafine classification.

Even with consistent EDM parameters, the surface finish will be affected as the structure of the electrode material changes. As *Figure 3* shows, the variation in the structure of materials from the ultrafine and superfine classifications are considerable and provide different surface finishes in the cavity.

At this point, there will be an added cost of polishing the cavity illustrated in *Figure 1* from 31 VDI to the required 27 VDI. In the event that the application required an EDM texture finish, the mold would require a secondary process, such as acid etching, to bring the surface finish down to the required value as any polishing will eliminate the texture and potentially scrap the mold.

As previously noted, the cost of EDMing the cavities should also be taken into consideration. Typically, materials of a larger particle size will yield faster metal removal rates and reduce the amount of time spent on the EDM process. Unfortunately these are not always the results that are experienced.

In this case, the larger particle size of the material from the superfine classification caused the adaptive control of the EDM sinker to compensate for conditions in the gap more often than what was required with the material from the ultrafine classification.

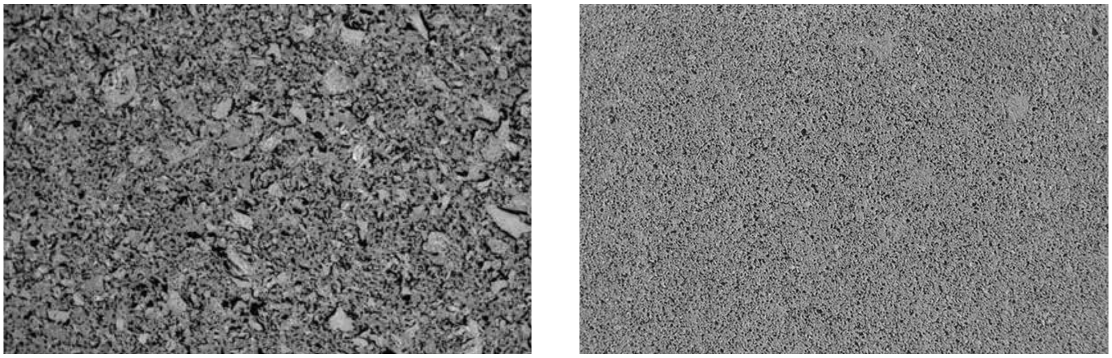
This is often caused by difficulties in flushing and extracting the larger particles of the superfine material or excessive contamination in the EDM gap from the increased electrode wear of the larger particle size material. In either case, the machine's adaptive control must continuously alter the program in order to keep the gap clear.

The cost comparison provided in *Table 1* shows that the EDM time for the larger particle size of the superfine material classification was slightly longer than that of the ultrafine material classification. The EDM burn time was reduced by 23 minutes with the use of the material in the ultrafine material classification. In this case, it is not only the 23 minutes that makes the difference, but instead the fact that EDM burn time is improved by almost 15%. While this test ran only for a short time, that 15% improvement in EDM time can be significant on a much larger EDM application. These savings alone often amount to much more than the added cost of the electrode material.

Conclusion

As illustrated, the use of inferior electrode materials interferes with the ability of the sinker to correct the problem, and therefore, often results in increasing the EDM cost.

The adaptive control in the EDM sinker provides confidence that most parameters of the application will be met. Today's technologies in machines are more capable to function under extreme conditions with the highest degree of mold detail and tolerances. Capabilities such as monitoring the gap, applying the proper current densities to extremely



Superfine Classification

Ultrafine Classification

Figure 3 - Example of differences in the electrode material structure from one material classification to another.

detailed electrodes and achieving reaction times for rectifying problems in nanoseconds have all but eliminated the concern that the EDM application will experience catastrophic failure.

However, the adaptive control does not determine the structure of the electrode material, but instead reacts to the conditions within the gap that is caused by the material's structure. Using a lesser quality electrode material that creates excessive fluctuation of a machine's adaptive control is counter-intuitive to the very reason that adaptive control was required in the first place.

The adaptive control is the safety factor should an issue arise within the EDM process. Often, the use of a superior electrode material allows the EDM burn to proceed without interjection of the adaptive control to overcome a problem. This results in a more efficient burn with consistency in mold integrity. Using inferior materials that result in overcompensation of the machine's control system may work for a while, but will ultimately end with disaster.

For More Information

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