NEW SUPERFINE GRAIN GRAPHITE FOR ELECTRICAL DISCHARGE MACHINING (EDM) APPLICATIONS

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Introduction

During the past several years, UCAR Carbon Company has employed a totally different manufacturing approach for developing different graphite grades with significant finer grains. The resulting isomolded isotropic superfine graphites with distinct characteristics have found acceptance in the continuous casting industry and shown excellent performance in introductory trials in the semiconductor industry. Having achieved these successes, a campaign was launched to investigate the potential use of these graphites for electrical discharge machining (EDM) applications.

Experimental

Five grades of UCAR superfine grain graphite and two commercial EDM grades were tested at an EDM machining training facility. The properties of these different grades are shown in Table 1.

The tests were conducted in two phases: first using the 1"x1"x2" with 1/8" diameter flush hole lengthwise solid electrode test; second with 0.02"-thin ribs test. All grades were tested in a CNC Charmilles Roboform 31 machine. Hardened A6 tool steel (Rockwell 48 - 50) was used as the working metal. For the solid electrode test, five different current levels and four power on-time setting combinations were used. Three different peak currents were used in the thin-ribs test. The data obtained from the solid electrode test were: end wear ratio, corner wear ratio, metal removal rate, and surface finish. An optical comparator, a height gauge, and a Taylor Hobson surface finish measurement instrument were employed for all the measurements. The thin-ribs electrodes were machined in the high-speed machining center with the speed of 10,000 rpm.

Results and Discussion

To test the performance of the electrode materials in both fine finish burns and aggressive production burns, rough-EDM and finish-EDM burns were planned at five amp settings for solid electrode test: 6, 8, 16, 32, 48 amps with 1.6, 12.8, 50, 200 μs power on-time combinations. For the thin-ribs test, electrodes were subjected to 16, 24, and 32 amps using a depth of the cut of 0.3".

Selected results from the solid electrode tests are shown in Figures 1 and 2. For the thin ribs test, at 16 amps peak current level, all grades passed the test without failure or excessive wear. At 24 amps, both grades A and B demonstrated excessive wear at the rib corner, while the three UCAR's grades survived the 0.3 in. depth of cut. With the even higher peak current of 32 amps, the UCAR grade DB52 showed excessive wear at the rib corner and the Producer A grade B failed the test because of breakage at the edge of the rib. However, all the other grades completed the test without failure.

Graphite EDM electrode materials are generally classified by their average particle size. These materials are grouped into the five classifications shown in Table 2. Physical properties that typically determine the performance of a particular grade are flexural and compressive strength, density, and hardness. The microstructure of the graphite is also important to the EDM user.

Conclusions

It is clear from the cited test results that the newly developed UCAR superfine/ultrafine grain graphites will perform well in electrical discharge machining applications. The extremely fine grain size of the new superfine materials is distinctive. The characteristics of high strength, high density and fine texture make these graphites ideal for the EDM applications. This combination of properties has a direct impact on the performance of the graphite electrode and the surface finish of the metal mold.

Table 1. The Physical Properties of the Selected EDM Tested Graphite Grades

	UCAR			Producer A	
Property	**DB52**	**TS5220**	**DB58**	**Grade A (catalog)**	**Grade B (catalog)**
Particle Size (μm)	5	5	2	10	<5
Density (g/cc)	1.88	1.88	1.89	1.82	1.81
Flexural Strength (psi)					
4 point	8,355	11,907	12,860	---	---
3 point	---	---	13,631	9,000	13,500
YM, $x10^6$ (psi)	1.70	1.98	1.95	---	---
K, w/m•k	122	96	77.60	---	---
Compressive Strength (psi)	12,671	22,079	25,218	16,000	21,500
Tensile Strength (psi)	6,474	9,421	8,146	---	---
Hardness					
Rockwell, H	77	99	104	---	---
Shore	63	74	83	64	76
CTE (RT-100°C) $x10^{-6}$/°C	4.17	4.70	5.13	---	---
Specific Resistance (μΩm)	10.7	14.0	17.5	12	14

Table 2. EDM Graphite Classifications and Their EDM Applications

Graphite Classification	EDM Application
Angstrofine (< 1 μm)	Cavities with extremely fine details and tight tolerances
Ultrafine (1 - 5 μm)	Small Cavities with fine detail
Superfine (6 - 10 μm)	Large cavities with moderate detail
Fine (11 - 20 μm)	Large cavities with noncritical detail

Figure 1 UCAR Standard 1"x1"x2" Test at 32 Amps

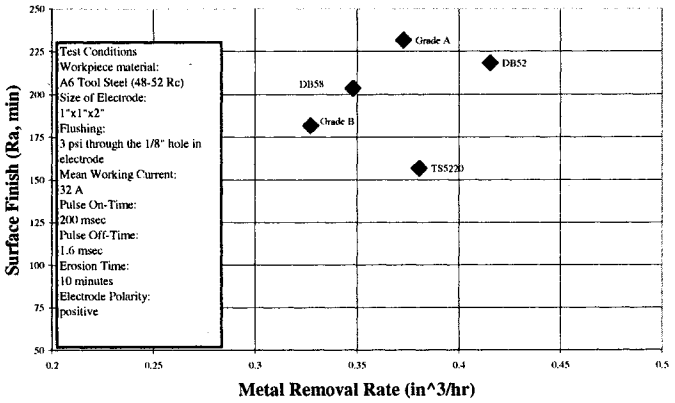

Figure 2 UCAR Standard 1" x 1" x 2" Test at 32 Amps