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Compatibility of Copper Graphite as an Electrode in Sinking EDM Accordance of Electro Thermal and Mechanical Properties

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***Abstract* - Copper and graphite separately are used widely as an EDM electrode and it has its own advantages and disadvantages. In this paper the research and development of copper graphite composites used as electro thermal components are studied. Graphite powder varying from (7-27) % weight proportion is combined with copper powder to form copper graphite composites via powder metallurgy process. At different composition of copper and graphite, electro thermal and mechanical properties are investigated. Study insists that copper graphite composites can be used as electrode in die sinking EDM.**

1. INTRODUCTION

Electric discharge machining process is one of the Nontraditional machining process. In EDM the mechanical properties of the tool electrode have almost negligible effect on machining performance [3]. However the electrical and thermal properties such as electrical and thermal conductivity, coefficient of thermal expansion, heat to vaporize from room temperature, melting and boiling temperature have considerable influence on the EDM process performance in term of material removal rate, electrode wear and surface integrity of workpiece [3].

There is wide range of materials used to manufacture electrode, for instance copper, graphite, brass, tungsten carbide, copper tungsten alloys. Copper and graphite are most widely used electrode material for sinking EDM applications. As an approach the thermo electrical properties of copper graphite are investigated in detail and suitable characteristics are highlighted. Copper- graphite composites combine the positive characteristics of its components i.e. high thermal and electrical conductivity from the copper and low CTE from the graphite [1] [7] [16]. According to Tech tips, India Today, copper graphite manufactured with a controlled amount of interconnected porosity in graphite which is infiltrated with copper by capillary action in furnace. Resulting material has increased electrical conductivity and mechanical strength [8]. By adding particles of graphite it is possible to get improved properties of thermal, electrical and stress properties in comparison with other Cu-based MMCs [2]. The characters of the Copper graphite offer the combined ease of fabrication of graphite and the burn stability [8].

2. EXPERIMENTAL PROCEDURES

According to the He et al., Copper powder of particle size of not greater than 10µm and purity of about 99.9% is mixed with graphite powder not greater than 5 µm. Zn, MoS_2 and Si are used as additives. Powder mixing is performed at relatively slow speed, such as about 150 rpm in conventional milling. The well mixed powder is pressed using a pressure in the range from about 500 to 1600 MPa and then sintered at temperature range of 960 ºC to 1100 ºC under an atmosphere of H_2 and N_2.

3. RESULT AND DISCUSSION

3.1 Physical property

3.1.1Density

Density of Cu-graphite composites with different graphite composition is shown in Table No.1. Density of the composites varies from 6.163g/m^3 to 7.545g/m^3 with varying composition of copper and graphite.

TABLE NO.1 Density with varying composition

Sample No	Weight proportion in initial mixture (%) Cu	graphite	Zn	MoS_2	silicate	Density (g/cm3)
1	92.0	7.0	—	0.5	0.5	6.984
2	89.0	10.0	—	—	1.0	7.049
3	87.0	11.0	1.5	—	0.5	7.545
4	85.0	15.0	—	—	—	6.372
5	82.0	17.5	—	—	0.5	6.656
6	68.0	27.0	2.0	1.5	1.0	6.163
7	80.0	15.0	—	5.0	—	7.119
8	78.0	16.5	—	5.0	0.5	6.837
9	75.0	15.0	—	10.0	—	6.370
10	70.0	23.5	2.5	4.0	—	6.300

3.2 Thermal properties

3.2.1 Melting point

Melting point of the composite varies from 1085 ºC to 1100 ºC. Melting point of pure copper is 1083 ºC. Variation of the melting point with composition is represented in Table No.2. Achieved melting points of the composites are in range of the pure Copper.

3.2.2 Coefficient of thermal expansion (CTE)

Copper is good thermal conductor but its Coefficient of thermal expansion (CTE) is high. Therefore copper matrix composites containing low CTE fillers such as graphite flakes are used. CTE apparently decreases with increase of graphite content. Lowest value of CTE is 10.65×10^(-6)/ ºC when graphite is mixed in 27% of weight proportion and highest value of CTE is observed when graphite content is 7% of weight proportion. Detail value of CTE with varying compositions is given in Table No.2.

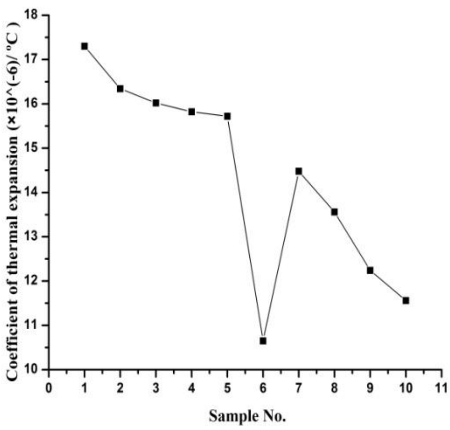

Fig.1 Variation of CTE with variation of graphite composition in different sample.

3.2.3 Thermal conductivity

Thermal conductivity of composites is obtained by multiplying density, specific heat and heat diffusivity. Thermal conductivity of Cu-graphite composites with different graphite content is shown in Table No.2. It is noted that maximum thermal conductivity is obtained with 10% graphite weight proportion and minimum with 27% graphite weight proportion.

TABLE NO.2 Thermal properties w.r.t composition

Sample No	Melting point (°C)	Coefficient of thermal expansion (x10^(-6)/ °C)	Thermal Conductivity (W/m K)
1	1085	17.30	336
2	1085	16.34	354
3	1085	16.02	346
4	1085	15.82	338
5	1085	15.72	326
6	1100	10.65	271
7	1100	14.48	318
8	1100	13.56	310
9	1100	12.24	299
10	1100	11.56	278

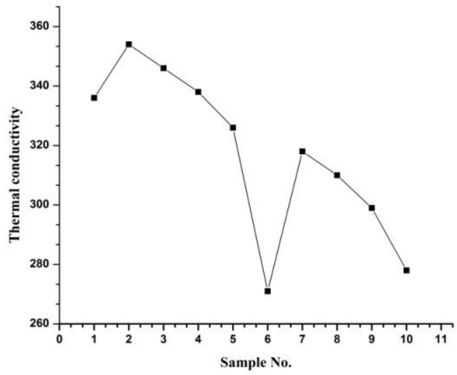

Fig.2 Variation of thermal conductivity with variation of graphite composition in different samples.

3.3 Electrical properties

3.3.1 Resistivity and Maximum current density

Resistivity varies from 4.74μΩcm to 8.42 μΩcm at 20ºC and maximum current density noted to be 20amp/mm^2 .The current capacity is calculated from the electrical current which can pass through 1mm^2 area of material with no damage to that area at maximum operational temperature. Since electric current is our "Cutting tool", higher conductivity (or conversely, lower resistivity) promotes more efficient cutting. Current density is an important performance parameter for the EDM electrode. With the increase of current density machining performance of the electrode also increases. Value of electrical properties at operating voltage of 600V is given in table 3.

TABLE NO. 3 Electrical properties w.r.t composition

Sample No	Operating voltage (V)	Maximum Current density amp/mm^2	Resistivity (μΩ cm 20°C)
1	600	18	5.05
2	600	20	4.74
3	600	16	6.14
4	600	15	5.25
5	600	15	5.39
6	600	14	7.74
7	600	13	5.60
8	600	13	8.24
9	600	12	5.85
10	600	10	8.42

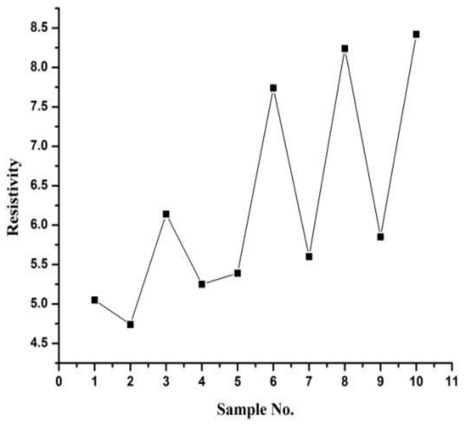

Fig.3 Variation of thermal resistivity with variation of graphite composition in different samples.

3.4 Mechanical Property

In EDM the mechanical properties of the tool electrode have almost negligible effect on machining performance however it proofs advantageous while machining of the tool.

3.4.1 Hardness

Hardness value measured in range of 58HV to 92HV. Highest value of hardness noticed in Sample No 9, which has composition of 75% Cu, 15%Graphite and 10% MoS_2. With the increase of percentage composition of binder material MoS_2, hardness attains the highest value. Hardness is often a function of the binder material. Hardness can be very important to the success of machining and grinding operations.

TABLE NO. 4 Hardness w.r.t compositions

Sample No	Vickers hardness (HV)
1	78-80
2	68-86
3	60-69
4	60-79
5	80-90
6	65-72
7	70-89
8	75-82
9	86-92
10	58-67

4. CONCLUSION

In the 21st century, composites could be the materials of choice in high performance machining electrode in Die sinking EDM because of their properties. The study of the thermo electrical and mechanical properties of thermal management material, Copper graphite composite is done and following conclusions are drawn:

(a)Density of the composite is less than copper which signifies lighter weight compared to copper for same dimensions. So tool holding problem for machining of large dies and other can be solved.

(b)Melting point of the composite is in range of copper.

(c)Lower Coefficient of thermal expansion (CTE) can be attained compared to copper which improves the dimensional accuracy of machined work piece.

(d)It is noted that maximum thermal conductivity is obtained with 7% graphite weight proportion and minimum with 27% graphite weight

(e)Highest value of hardness is noticed for 86-92HV which has composition of 75% Cu, 15%Graphite.With the increase of percentage composition of binder material MoS_2, hardness attains the highest value. Surface roughness and MRR is often a function of the hardness.

(f) Resistivity varies from 4.74μΩcm to 8.42 μΩcm at 20°C and maximum current density noted to be 20amp/mm^2 .

So according to the study of electro thermal and mechanical properties, results conclude that copper graphite composite can be used as electrodes in the Die Sinking EDM with better performance.

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