Enhancement of MRR in EDM by Composite Material Electrode on Die Steel

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***Abstract*— Electrical Discharge Machining (EDM) has become the workhorse for precision machining of electrically conducting hard materials. A lot of research has been done to find the optimum value of Material Removal Rate (MRR) in EDM process. The experiments have been performed using composite material electrodes on Die steel EN-31. Powder metallurgy technique has been applied to fabricate the composite electrodes with different ratio of Copper-Manganese powders. It was observed that copper-manganese (weight ratio:70-30) composite electrode shows better results than Copper-Manganese (weight ratio: 80-20) electrodes for material removal rate (MRR) while machining the work piece.**

***Index Terms*— EDM, Composite Electrode, Copper-Manganese powder, MRR**

I. Introduction

EDM is a material removal process with an accurately controlled electric spark through a very small gap between an electrode and work piece. Dielectric fluid like Kerosene oil is filled in around the place where spark occurs. Electric spark in the form of thermal energy is used to erode the material while machining the component in comparison to traditional manufacturing processes where harder tool is used to remove the softer work material. This process is appropriate for machining of very hard conducting materials which are very difficult to machine otherwise. Precise, accurate, complex shapes can be produced with this process. As in this process, cutting forces are small, therefore it is suitable for fabricating components having minute features. A composite electrode is multiphase material that shows a significant proportion of the properties of both the constituent phases and therefore, a better combination of properties are realized as compared to pure or alloyed materials.

The details about Electric discharge machining process is discusses by Fuller John[1]. Effect of Material removal rate on the work piece has been investigated by some of the authors[2-3]. A new method of surface modification by electric discharge machine was studied by N. Mohri et al [4] using composite material electrodes. Lonardo et. al. [5] studied that the Material removal rate is one of the most important parameter of EDM. A number of authors carried out their research work using composite material electrodes as tool because of their superior performance [6-8]. D.K. Aspinwall et. al. studied the powder metallurgy electrodes to initiate the work piece surface modification during electrode discharge machining[9-11].

However, to exploit the full potential of composite electrode combinations, research is still needed, so as to improve the machining performance and accuracy by controlling different machining parameters.

II. Composite Material Electrode Fabrication

The composite material electrodes were made through the process of powder metallurgy as shown in fig. 1 with different weight ratio of copper and manganese metallic powders. The Copper and Manganese powders were produced using Pulverization Method. Powder Metallurgy uses sintering process for making various parts shapes out of metallic powder. The metallic powder is compacted by placing in a closed metal cavity i.e. die under pressure.

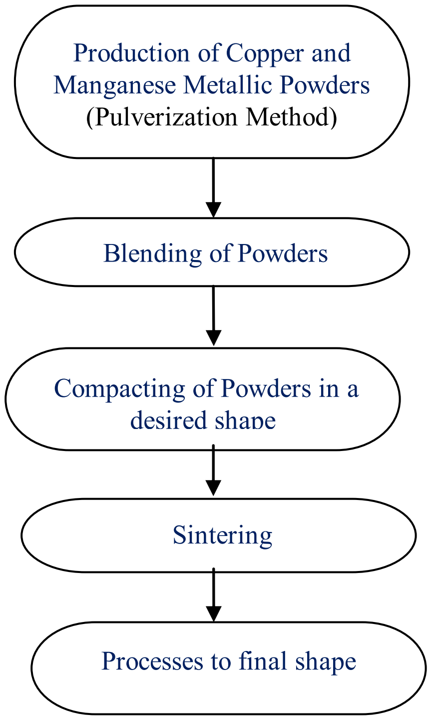

Fig. 1: Process to fabricate Cu-Mn Composite material electrode

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This compacted material is placed in an oven and sintered in a controlled atmosphere at high temperature and the metal powders forms a solid.

The copper metallic powder and Manganese metallic powder are used. They are mixed according to a fixed weight ratio i.e. 70:30 and 80:20. The initial height of the composite metallic powder in the die is about 2.5 times that of presses composite material powder. Therefore, the composite material electrode of Copper and Manganese (Cu : Mn :: 70:30 and Cu : Mn :: 80:20 were fabricated with powder metallurgy process as shown in the diagram.

III. Experimental procedure and Results

The electric discharge machine with servo head and positive polarity for electrode and negative polarity for work piece (i.e. reverse polarity) was used to conduct the experiment for study on material removal rate (MRR) at different machining parameters using two different electrode materials namely copper and Manganese (70:30) and copper and Manganese (80:20). Experiments were performed on the machining of hardened EN-31 die steel (Chemical composition given in table I) using composite of Copper-Manganese electrodes.

Table I: Chemical composition of EN-31 die steel

Element	Composition (%)
Carbon	0.9 to 1.20
Silicon	0.1 to 0.35
Manganese	0.3 to 0.75
Chromium	1.1 to 1.6
Iron	Balance

The output parameter i.e. Material removal rate (MRR) of work material after machining under the different input machining conditions like pulse on time, pulse off time, discharge current are presented in table II and table III . Three different levels of pulse off time of pulse on time of 20µs, 50µs and 100µs and discharge current levels of 4 A, 6 A, 8 A were taken while the pulse off time was kept fixed for all experiments.

Table II: Value of Material Removal Rate (MRR) for Copper-Manganese Electrode (70:30) with its parameters

Sr. No.	Discharge Current (in Amp)	T.on µ-sec	Time taken (T) (min)	dia of crater Dc (mm)	MRR{A*(b/T)}(in mm3/ min)
1	4	20	8.28	19.9	3.75
2	4	50	5.23	20	6
3	4	100	4.6	20.3	7.03
4	6	20	4.58	20	6.85
5	6	50	3.73	20.2	8.58
6	6	100	2.67	20.7	12.61
7	8	20	2.58	20.1	12.28
8	8	50	2.53	20.4	12.9
9	8	100	2.6	20.9	13.19

Table III: Value of Material Removal Rate (MRR) for Copper-Manganese Electrode (80:20) with its parameters

Sr. No.	Discharge Current (in Amp)	T.on µ-sec	Time taken (T) (min)	dia of crater Dc (mm)	MRR {A*(b/T)}(in mm^3/min)
1	4	20	18.32	18.8	1.51
2	4	50	5.97	18.8	4.65
3	4	100	4.83	19	5.86
4	6	20	4.1	19.5	7.28
5	6	50	3.77	19.5	7.92
6	6	100	1.8	19.8	17.1
7	8	20	1.63	20	19.22
8	8	50	1.17	20.2	27.46
9	8	100	0.92	20.5	35.99

The experimental observations i.e. Material Removal Rate has been expresses graphically in fig. 2 and 3.

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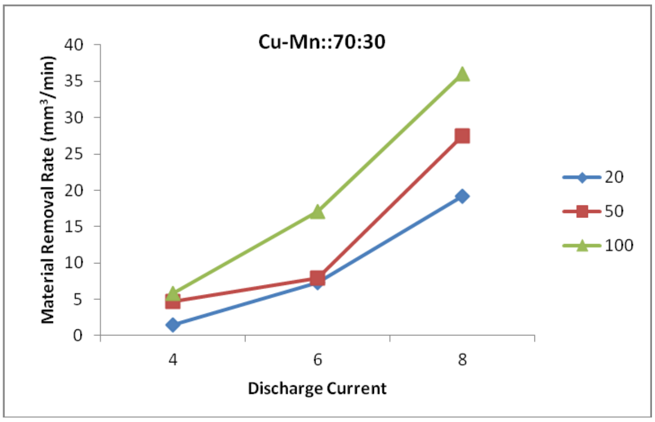

Fig. 2: Material Removal Rate for machined surface with composite electrode (Cu: Mn- 70:30)

Bar graphs have been drawn from the results obtained in the experiments. The variation in discharge current has been taken along x axis and the output parameter taken along the y-axis for each level of discharge current and pulse on time. The results for these electrode (Cu-Mn: 70-30, Cu-Mn: 80-20) materials have been displayed simultaneously to facilitate comparison.

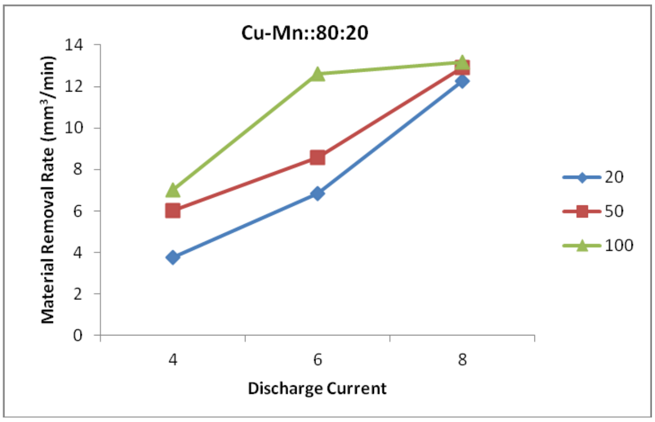

Fig. 3: Material Removal Rate for machined surface with composite electrode (Cu: Mn- 80:20)

It has been observed that material removal rate is low at low current values and as the discharge current is increased, MRR also increases. Similarly as pulse of time is increased, MRR increases. The experiment has been performed on reverse polarity (i.e. electrode positive and work piece negative) this is due to the fact that spark energy is low at low discharge current and pulse on time , and hence low MRR , and as the current and pulse on time is increased , MRR rises due to spark energy.

Copper- Manganese (70:30) is a better electrode material as it gives best material removal rate as compared to copper manganese (80-20). The highest value of material removal rate (MRR) achieved with copper-Manganese (70:30) is 48.46% higher than copper-Manganese (80:20) under the same machining conditions.

IV. CONCLUSION

Higher MRR through this composite material electrode with weight ratio of copper-manganese: 70:30 as compared to weight ratio of copper-Manganese: 80:20 has been demonstrated successfully in this research work. A selection of various gap current, pulse on time, pulse off time and sparking frequency indicates that this composite material electrode is capable to predict the EDM process in order to satisfy the desired product with four inputs and one output. Therefore this appropriate composite of Copper-Manganese electrode material can find application in various industries for machining of hardened EN 31 dies and other components to enhance the performance of EDM as per the requirements of the product.

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