Effect of EDM Process Parameters on Composite Material Electrode Wear

Parveen Goyal

***Abstract*— Electric Discharge Machining has been established as standard process for machining of electrically conducting hard materials. The intrinsic nature of the EDM process results in electrode wear while machining the workpiece. The electrode wear rate as response parameter is required to be studied for maximum performance of the electrode while machining the work piece. Therefore it is desired to find the effect of EDM process parameters on the Electrode wear. The experiments have been performed with Cu-Mn composite material electrodes on hardened EN-31 die steel as work piece. The composite material electrodes were made through the process of powder metallurgy with different ratio of Cu-Mn metallic powders. It has been observed that Copper-Manganese composite material electrode made with 80-20 weight ratio gives less electrode wear rate as compared to copper-manganese (weight ratio 70-30) composite material electrodes for machining of work piece.**

***Index Terms*— Electric Discharge Machining, Electrode wear, Copper, Manganese**

I. INTRODUCTION

For ductile material, material removal can be achieved by using an Electrode that is harder than work piece using conventional machining methods. To machine the materials which are harder than the electrode, a number of non conventional machining processes have been developed that although relatively slow and costly can effectively remove excess material in a precise and repeatable fashion. One of the processes is Electric Discharge Machining (EDM) based on electric phenomenon and is used primarily for hard materials. This process is being widely used to machine intricate shapes of hardened press and die tools. This process removes metal by discharging electric current stored in a capacitor bank across a thin gap between the Electrode (cathode) and the work piece (anode). Thousands of sparks per seconds are generated and each spark produces a tiny crater by the melting and vaporization. The role of the dielectric fluid is to confine the spark and to flush out the chips. EDM process is being used for machining of hard metal or alloys which cannot be machined easily by conventional methods.

The electrode in EDM is formed to the shape of the cavity desired. As in convectional machining, a few materials have better cutting and wearing qualities than others. Electrode material therefore must be good conductor of heat and electricity and produce efficient metal removal from the work piece. At the same time, electrode material must exhibit low electrode wear rate. Much experimentation has been carried out to find a good, economical material for the manufacture of EDM composite material electrodes. Copper-Tungsten, Silver-Tungsten, Yellow Brass, Chrome plated material, Graphite and Zinc alloys are some of the materials which has found certain applications as electrode materials. During the discharge process, the electrode as well as the work piece is subjected to wear or erosion. As a result, it is difficult to hold close tolerance as electrode gradually loses its shape during the machining operation. Much development and research remains to be done to reduce wear rate of the electrode.

A composite electrode exhibits a significant proportion of the properties of both the constituent phases; therefore better combinations of the properties may be utilized as compared to pure or alloyed material. Many authors have investigated the performance of work piece machining using composite material electrodes. Electrode wear and dimensional accuracy of the machined surfaces plays very significant role in production and is a function of process parameters. Performance of Nickel Copper composite electrode and tungsten copper alloys has been described to exploits its potential of high corrosion and wear resistance [1-2]. Material removal rate, Overcut, Surface roughness process parameters were studied by Puertas et al [3-4]. Taweel [5] found the relationship of EDM process parameters with novel electrode material such as Al-Cu-Si-TiC composite product using powder metallurgy technique. Dielectric flushing pressure, Peak current and pulse on time were considered as input process parameters and the performance parameters i.e. MRR and EWR were evaluated in this investigation. Dewangan et. al. [6] investigated the effect of EDM process parameters like Peak current, Pulse on time and electrode diameter on material removal rate (MRR) and Electrode wear rate (EWR). Composite of copper and graphite has been used to evaluate the machining performance of Cr, Mo, V steel for die casting [7]. Herpreet Singh et. al. [8] studied the influence of operating parameters like pulse-on-time and pulse-off-time for responses such as Metal removal rate (MRR) and Electrode wear rate (EWR) on the EDM using steel as work piece and cryogenic and non-cryogenic electrode of copper material.

Some researchers have also explored the use of powder metallurgy electrodes and metal powders dispersed in the dielectric fluid, to initiate the surface modification of work piece during electric discharge machining [9-11]. Moreover hardly any attempt has been made to study the effect of various controllable machining parameters while using a composite of copper and manganese as electrode material in EDM. Authors concluded that for better Electrode wear, Peak current, the pulse on time and pulse off time are the most significant process parameters.

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To exploit the full potential of composite electrode, it is essential to select best combination of process parameters as shown in table 1 for an optimum machining performance.

Table 1: Process Parameters and Performance Measures Used In This Experiment.

EDM		
Sr No.	**EDM Process Parameters**	**EDM Performance parameters**
1	Peak Current	Electrode Wear Rate
2	Pulse on Time	Material Removal rate
3	Pulse off time	Dimensional accuracy/Overcut
4	Electrode material	Surface roughness

Electrode material has a significant influence on important output parameter. A composite material electrode with copper and manganese material have been taken for the experiments as this combination should provide better qualities of conductivity, hardness and toughness to the electrode material. Manganese material is readily available in the market and its cost is only marginally higher than copper. Keeping all other input machining parameters same, the performance of Copper-Manganese electrode material (70:30 and 80:20) have been studied for different values of peak current and pulse on time with regard to Electrode wear ratio.

II. EXPERIMENTATION AND RESULTS

Electrode material selection is very important and affects the micro hole accuracy, electrode wear (EW) and material removal rate (MRR). So the material of electrode should be selected such that it less electrode wear rate. Copper and brass are most used materials for composite material electrodes. Copper is having good conductivity while Manganese (Mn) material is a powerful oxidizing agent and it is very hard metal. Thus a composite of copper and manganese may be employed in EDM to achieve improved machining performance. The composite material electrodes were prepared by powder metallurgical processes using different weight ratio of copper and manganese metallic powders.

The depth of machining was set at 0.1 mm, after mounting the work piece and one of the electrodes on the machine, the work piece was machined with 4A, 6A and 8A peak current using pulse on time of 20µs, 50µs and 100µs. The time of machining was recorded in seconds. The machining cycle was repeated for the other values of peak current. The effect of variation in peak current was studied for the electrode wear on the three settings of pulse on time and peak current on EDM for each electrode material, as shown in table 2 and 3.

Table 2: Electrode Wear rate for Composite Material Electrode (Cu: Mn-70:30)

Sr. No.	**Peak Current (in Amp)**	**T.on µ-sec**	**Time taken (T) (min)**	**Electrode Wear Rate (mm3/min)**
1	4	20	18.32	0.73
2	4	50	5.97	1.58
3	4	100	4.83	3.34
4	6	20	4.10	1.97
5	6	50	3.77	2.78
6	6	100	1.80	7.46
7	8	20	1.63	6.58
8	8	50	1.17	11.51
9	8	100	0.92	17.59

Table 3: Electrode Wear rate for Composite Material Electrode (Cu: Mn-80:20)

Sr. No.	**Peak Current (in Amp)**	**T.on µ-sec**	**Time taken (T) (min)**	**Electrode Wear Rate (mm^3/min)**
1	4	20	8.28	1.489
2	4	50	5.23	2.946
3	4	100	4.6	3.547
4	6	20	4.58	3.7
5	6	50	3.73	4.543
6	6	100	2.67	4.847
7	8	20	2.58	5.969
8	8	50	2.53	7.304
9	8	100	2.6	7.709

A graphical representation of the experimental readings is presented hare to get a better understanding of trends while machining of hardened EN-31 with Copper-Manganese composite electrodes.

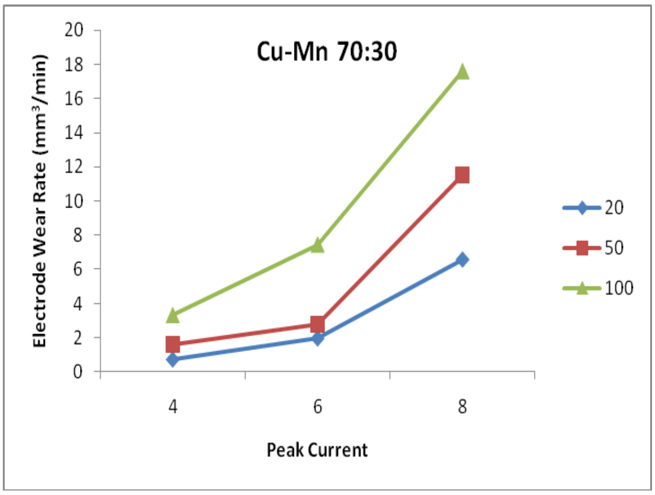

Figure 1: Electrode Wear Rate for machined surface with composite electrode (Cu: Mn- 70:30)

Line graphs (refer Figures 1, 2) have been drawn from the results obtained in the experiments. The variation in peak current has been taken along x axis and the output parameter taken along the y-axis for each level of peak current and the results for these electrode (Cu-Mn: 70-30, Cu-Mn: 80-20) materials have been displayed simultaneously to facilitate comparison.

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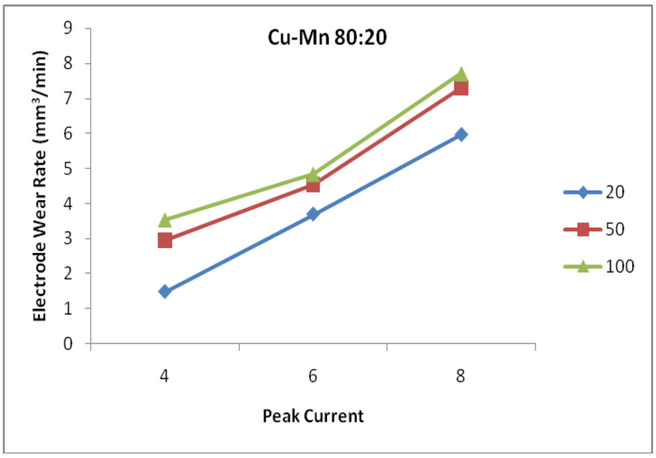

Figure 2: Electrode Wear rate for machined surface with composite electrode (Cu: Mn- 80:20)

Electric discharge machining has been done with reverse polarity (non conventional polarity). In this condition, the electrons (negative ions) strike the electrode surface and greater energy is liberated at this surface. It has been observed that Copper and Manganese (80:20) shows minimum electrode wear rate at high value of current as compared to Copper and Manganese (70:30) electrode and also the effect of increasing current and pulse on time is minimum for the electrode.

III. CONCLUSION

The investigations revels that the copper- manganese composite material electrode made with 80-20 weight ratio gives less electrode wear rate as compared to copper-manganese (weight ratio 70-30) composite material electrodes for machining of work piece. It may be concluded that definite ratio of manganese powder may be added to copper electrode for achieving optimum results. Copper-manganese (weight ratio 80-20) shows better results as compared to copper-manganese (weight ratio 70-30) composite electrodes for Electrode Wear rate. The performance measure i.e. Electrode Wear rate in our case is observed to be affected by process parameters viz peak current, pulse on time and pulse off time. 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. Based on the above conclusions an 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. Future scope of this study could be given by process could be experimentally investigated for varying different electrode material.

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