Study of the influence of machining parameters when machining tungsten carbide using EDM

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Abstract - Copper electrodes with diameter of 10, 12 and 15 mm were used in electro discharge machining (EDM) of tungsten carbide at two current setting of 4 and 8 A to find out the possible relation between the EDM parameters (current) and the responses (material removal rate and electrode wear rate). Each machining test was performed for 15 mins and paraffin was used as the dielectric fluid. The MRR of the workpiece and EWR of the electrode material were obtained from the calculation of the percentage of mass loss per machining time. The MRR and the EWR were not only dependent on the diameter of the electrode but also closely depends on the supply current.

Keywords: EDM, Electrode wear rate, Material removal rate, Current

I. INTRODUCTION

Electrical Discharge Machining (EDM) is a non-traditional manufacturing process based on removing material from a part by means of a series of repeated electrical discharges (created by electric pulse generators at short intervals) between a tool, called electrode, and the part being machined in the presence of a dielectric fluid. Electrical Discharge Machining (EDM) is a process that is used to remove metal through the action of an electric discharge of short duration and high current density between the tool and the work piece.

The basic process in EDM is carried out by producing controlled electric sparks between tool electrode and workpiece, both immersed in a dielectric fluid. The electric spark raises the surface temperature of both the electrode and the workpiece to a point where the surface temperatures are in excess of the melting or even boiling points of the substances. [1-3]. Both electrode wear and material removal process take place and the surface generated by EDM consists of debris, which has been vaporized or melted during machining process and has an important relation to various aspects of EDM.

II. EXPERIMENTAL DETAILS

2.1 Workpiece and Electrode Material

In this study, tungsten carbide was selected as workpiece material and electrolytic copper rod was selected as tool material. The workpiece was cut to 50 mm X 50 mm X 10 mm in size. The hardness was found to be HRA87.0.

Density (g/cm³)	15.1
Melting Point (˚C)	2597
Hardness	HRA87.0
Tensile Strength (kg/mm²)	179
Compressive Strength (kg/mm²)	410

Electrolytic copper rod of diameters 10, 12 and 15 mm was taken as tool material with following properties.

Density (g/cm³)	8.904
Composition	99.9% copper
Melting Point(˚C)	1083
Electrical resistivity (μΩ cm)	9
Hardness	HB100

2.2 Experimental techniques

During this study, a series of experiments on EDM of tungsten carbide of size 50 mm X 50 mm X 10 mm was conducted on a ECOWIN MIC-432C electrical discharge machine and paraffin was used as the dielectric fluid. Machining tests were carried out at two current settings i.e 4 and 8 A, with a total machining time of 15 min for each size of electrodes. During this experimental setup two assumptions were made: (i) temperature and pressure of the dielectric fluid were assumed to be constant; (ii) current consumption was constant throughout the experiments.

A blind hole was selected to be machined, in order to obtain the data to show the relation between the machining parameter i.e current and the machinability factors i.e MRR and EWR. A number of blind holes were machined where the diameter of holes was the same as the diameter of the electrodes used.

Material removal rate of the workpiece material and the electrode wear rate were obtained based on the calculation of the percentage of mass loss per machining time. The MRR and EWR were recorded every 5 min throughout the EDM experiments.

III. Results and discussion

3.1 Material Removal Rate

The percentages of mass loss of workpiece material when machining with electrodes of diameters 10,12 and 15 mm with two current settings 4 and 8 A are shown in Fig1 and Fig 2 respectively.

It has been found that the percentage of mass loss at higher current (8 A) setting is greater than at lower current setting (4 A) and the curves are similar in nature. The mass loss for the first 5 min of machining is almost the same for all electrodes. In Fig 1, at current setting of 4 A, the initial value is 0.07-0.09 wt%, while in Fig 2, at current setting of 8 A, it is 0.10-0.17 wt%.

From Fig 2, it has been concluded that the electrode with the larger diameter (15 mm) results in a higher percentage of mass loss of workpiece material than the electrode with the smaller diameter. (10 and 12 mm). In addition, the results in Fig 1 shows that the electrode with the smaller diameter (10 mm) performs better than the larger diameter (12 and 15 mm) electrodes. It says that the electrode diameter of 15 mm is ineffective when used at a current setting of 4 A, but performs better when the current setting is at 8A. So based on this evidence, it can be concluded that the material removal rate is not only dependent on the diameter of the electrode, but also depends on the current setting. Low current is found suitable for small diameter electrode while the high current for larger diameter electrode. When current is assumed to be constant throughout the EDM tests, the mass loss per machining time is assumed to be linear. The curves obtained in Fig1 and 2, concave behavior of curves is observed to represent the relation between the percentage of mass loss to machining time.

Amin and sardar [4] also found that the relation of cumulative metal removal to time was not exactly linear which is due to number of reasons.

Firstly, there is a loss of thermal energy to the atmosphere and the dielectric fluid. Even if the dielectric fluid is assumed to be at constant temperature and pressure, thermal energy is absorbed by the dielectric fluid due to the high temperature generated during machining.

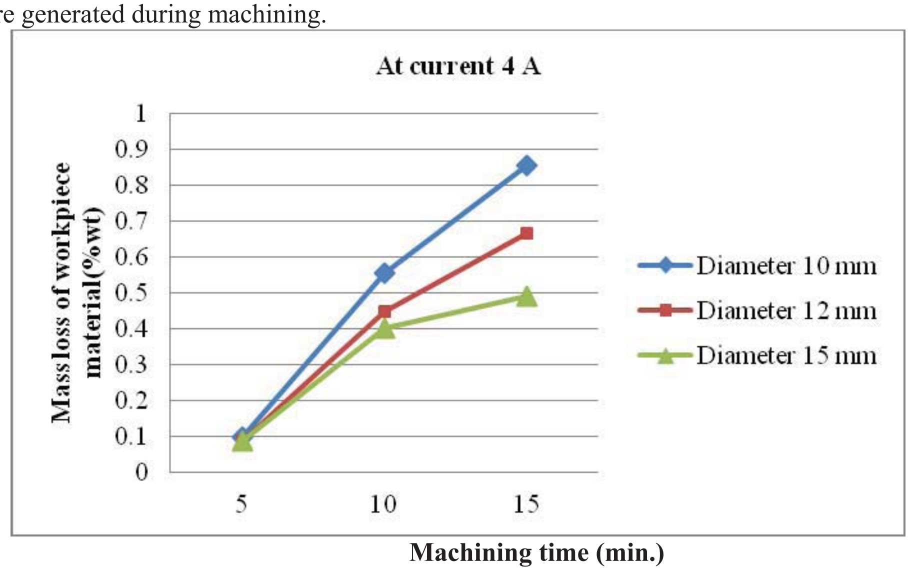

Figure 1. Percentage of mass loss of workpiece material at a current setting of 4 A.

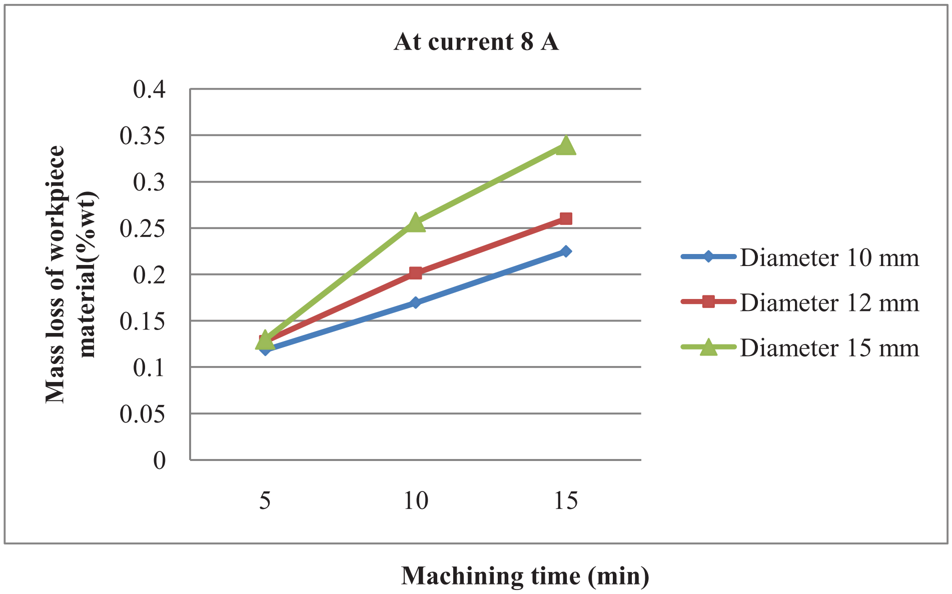

Figure 2. Percentage of mass loss of workpiece material at a current setting of 8 A.

3.2 Electrode wear rate

The percentages of mass loss of electrodes with diameter 10,12 and 15 mm when machining at two current settings of 4 and 8 Aare shown in Fig 3 and Fig 4 respectively.
The initial value of electrode wear for the first 5 min is almost same for all the electrodes which is similar to the results of material removal rate shown in Fig1 and Fig 2. The electrode wear curve of 10 mm diameter electrode at current setting of 4 A is found to be perfectly linear (Fig 3).

From the graph in Fig 3, it was observed that the electrode with smaller diameter (10 mm) had a higher percentage of mass loss than the large diameter electrodes.(12 and 15 mm). While machining with a current setting of 8 A, the same result was expected that mass loss of the electrode with 10 mm diameter is higher than the 12 mm diameter electrode. But the curves in Fig 4 show that the mass loss of the electrode with 12 mm diameter is higher than the electrode with 10 mm and 15 mm diameter. There are two reasons for these unexpected results, i.e. melting point of the electrode material and thermal loss during machining. When electrode with 12 mm diameter was used, thermal energy lost to the atmosphere and the dielectric liquid was more than that using electrode with 10 mm diameter.

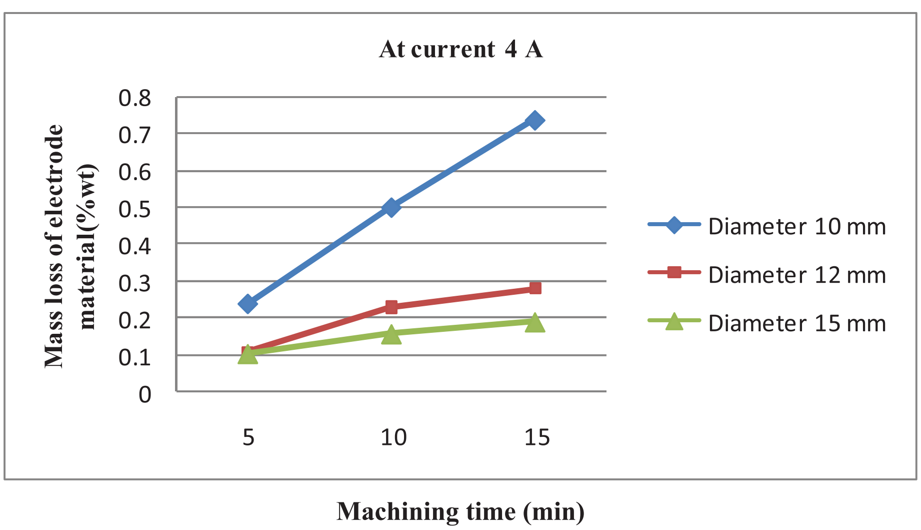

Figure 3. Percentage of mass loss of electrode material at a current setting of 4 A.

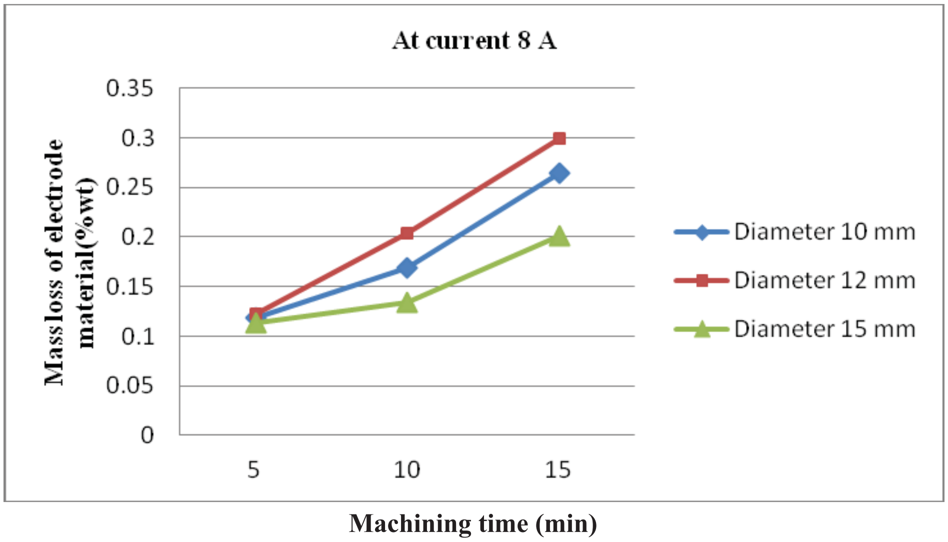

Figure 4. Percentage of mass loss of electrode material at a current setting of 8 A.

From the discussion of the material removal rate and wear rate, it can be concluded that the best performance is obtained by the electrode diameter of 15 mm with a current setting of 8 A, since this combination gives the highest material removal (Fig 2) and lowest wear rate (Fig 4).

IV. CONCLUSION

The following conclusions are drawn to clearly show the relation of the machining parameter (current) and the machinability factors (material removal rate and electrode wear rate) when machining tungsten carbide using EDM.

1. It can be concluded that the best performance was given by electrode with diameter of 15 mm at a current setting of 8 A, since this combination gives highest material removal and lowest electrode wear.

2. The initial value of mass loss, both for the workpiece and electrode material, for the first 5 min of machining was almost same for all electrodes used in the study.

3. The material removal rate and the electrode wear rate were not only dependent on the diameter of electrode but also has a close relation with the supply current. Low current was found suitable for small diameter electrode and high current for larger diameter electrode.

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