Comparative study for material removal rate, surface finish and electrode wear rate on die sinking EDM

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ABSTRACT - The electrical discharge machining (EDM) is one of non-conventional machining process where the erosion of the work piece take place based on the thermal energy between the electrode and the work piece. Two different work piece materials (copper and aluminum) was machined using die sinking EDM to study the characteristics of each material using copper electrode. The experiments conducted under the designed full factorial procedure where pulse on-time and pulse current are used as the input parameters. It was found that material removal rate (MRR) increases with increase in current and pulse duration, but MRR is higher during machining of aluminum than that of copper. In term of tool wear rate (TWR) it is found that the TWR resulting of machining copper is lower than aluminum.

1. INTRODUCTION

In case of requiring close tolerance, high precision and surface quality, EDM is one of the best processes that can be used to obtain the desired shape [1]. The erosion of the work piece take place due to thermal energy generated between the work piece and electrode. Both electrode and work piece are immersed in dielectric fluid (ionized water or kerosene usually used). When the high voltage is applied (300 v) in modulated pulses, this cause the free electrons of the tool be subjected to high force which in turn emitting the electrons. These electrons then accelerated toward the work piece via the dielectric fluid. As they are moving quickly from tool to work piece collision with dielectric molecules takes place. Because of this reaction between the free electrons and the molecules more positive ions and electrons will be generated due to the collision. These actions reoccurring again and again till the plasma channel where the temperature approximately 8000 to 10,0000C and because of the very low electrical conductivity that the plasma has, this makes the electrons move from the tool to the work piece whereas the ions move from the work piece to the tool [2]. The material removed from work piece due to the collision of electrode which is known as Material Removal Rate (MRR) which is desired whereas material removed from electrode due to the collision of ions this is known as Tool Wear Rate (TWR) [3].

2. EXPERIMENTAL DETAILS

In this experiment, copper electrode was used to machine aluminum and copper. The properties of those two materials are shown in Table 1. Sodick CNC EDM die sinking was used to machine 100x50x6mm work piece of copper and aluminum. 16 mm a radian and 75.20 high of copper electrode was used to conduct engraves. Pulse current and pulse on time are changed from time to time while keeping other factors such as pulse off time and voltage are constants. The values of these parameters are given in Table 2. In this study, direct polarity was used In order to achieve higher material removal rate and less tool wear rate [4].

Table 1 Properties of Aluminum and Copper work material

Material	Thermal conductivity (W/mk)	Melting point (^oC)	Density (gm. /cm^3)
Aluminum	173	580	2.70
Copper	401	1083	8.92

Table 2 Die sinking EDM conditions

Dielectric fluid	Kerosene
Reference voltage	22
Pulse current (A)	8,12,16 and 20
Polarity	direct polarity
Pulse on time (µs)	50, 100, 150 and 200
Pulse off time (µs)	50

3. RESULTS AND DISCUSSION

Two factors and four levels were used to compare the response values of MRR and TWR.

3.1 Material Removal Rate

The work pieces were weighted before and after machining to calculate the material removed from both aluminum and copper work piece see Equation 1.

$$MRR = (M1 – M2) / T \quad (1)$$

Where M1 and M2 are the weight of workpiece before and after machining (g), respectively. T is the machining time (min). From Fig.1 it is clear that the MRR increased with the increase of pulse currents for both

work when 50 µs is applied. It also shows that MRR is higher when aluminum is machined compared with copper this is due to the fact that aluminum melting point is lower than copper. When the melting point of the work piece is lower than the other this means for the same energy or current applied, more material will be eroded and the machining time will be lower [5].

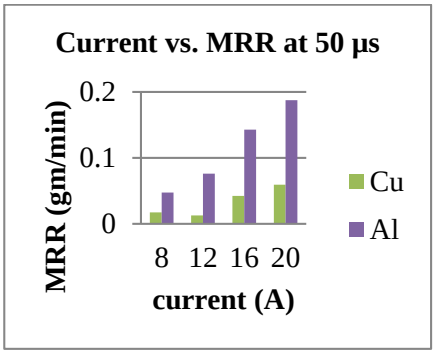

Figure 1 Current vs. MRR at 50 µs

3.2 Wear Rate

Tool wear ratio can be calculated using the Equation 2.

$$EWR\ (\%) = [EWW/WRW] \times 100 \qquad (2)$$

Where EWW = Electrode Wear Weight and WRW = Work Piece Removal Weight

It is noticed that machining copper using copper electrode has less TWR value compared to machining aluminum as shown from Fig.2 , this is becuase copper has higher value of thermal conductivity where the heat energy will be diffused easily. In case of using aluminum which has lower thermal conductivity compared with copper, the electrode showed more wear where the thermal energy cannot be diffused easily resulting in higher wear ratio.

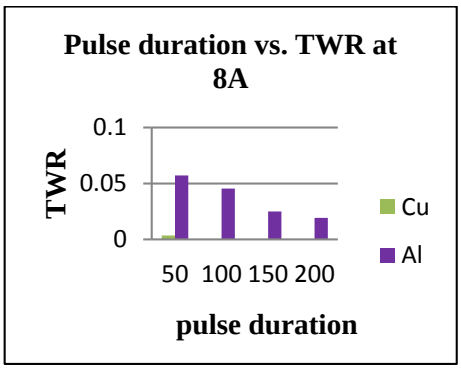

Figure 2 Pulse Duration Vs. TWR At 8A

4. SUMMARY

From the above analysis the following summary can be made:

i. MRR increases with the increase of current. MRR of aluminum is higher than that of copper due to less melting point of aluminum than copper
ii. Pulse duration has a little effect on the MRR
iii. TWR decreases with the increase of pulse duration due to the presence of carbon layer that precipitated on the surface of the electrode and the thickness of this layer increased with the increase of pulse duration and in turn decrease the TWR.
iv. Copper has little TWR when machined using copper electrode, this is because copper has higher thermal conductivity compared to aluminum.

5. REFERENCES

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