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Enhancement of EDM Performance by Using Copper-Silver Composite Electrode

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EDM, Composite Electrode, Copper-Silver, Tool Wear Rate (TWR), Surface Roughness (SR).

ABSTRACT

Discharge Machining is a non-traditional machining technique and usually applied for hard metals and complex shapes that difficult to machining in the traditional cutting process. This process depends on different parameters that can affect the material removal rate and surface roughness. The electrode material is one of the important parameters in Electro –Discharge Machining (EDM). In this paper, the experimental work carried out by using a composite material electrode and the workpiece material from a high-speed steel plate. The cutting conditions: current (10 Amps, 12 Amps, 14 Amps), pulse on time (100 µs, 150 µs, 200 µs), pulse off time 25 µs, casting technique has been carried out to prepare the composite electrodes copper-sliver. The experimental results showed that Copper-Sliver (weight ratio70:30) gives better results than commonly electrode copper, Material Removal Rate (MRR) Copper-Sliver composite electrode reach to 0.225 gm/min higher than the pure Copper electrode. The lower value of the tool wear rate achieved with the composite electrode is 0.0001 gm/min. The surface roughness of the workpiece improved with a composite electrode compared with the pure electrode.

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1. Introduction

Electrical Discharge Machining (EDM) is a thermo-electrical material removal process with the implementation of accurately controlled electric sparks generated between tool and work piece, both the work piece and tool are separated by dielectric fluid-like Kerosene oil during machining [1]. The machinability of the EDM process is affected by several parameters. These parameters can be classified into two categories; electrical parameters, such as discharge voltage, current, frequency, and time, but non-electrical parameters are as electrodes rotation, electrode substrate and flushing of dielectric fluid [2, 3]. The electrode material is one of the important parameters that are responsible for surface quality and generation of electric sparks. The main properties of the material tool are thermal conductivity and electrical with a high melting point during the machining, The most common materials used in manufacturing electrodes are Graphite, Copper, and Steel [4,5]. The compound electrode is a multiphase substrate that a significant ratio of the characteristics of both the component and therefore a better combination of properties is realized as compared to pure materials [6]. Optimizing the production of the electrical discharge machining process, some researchers to analyze the performance of compounds electrodes. Maradona and Wykes [7] presented a new method to optimize the removal rate of EDM with Cu-W tools using Taguchi method and they achieved the enhancement of MRR. Khanra et al. [8] showed the improvement in higher metal removal rate and lower wear tool of the ZrB2–40 wt.% Cu composite electrodes compared with the Copper electrode. Tsai et al. [9] studied the effect of the Cr–Cu composite electrodes on the EDM process parameters and found higher the material removal rate than Cu electrode and also increases in the corrosion resistance. Beri et al. [10] investigated the performance of EDM with copper tungsten tool made by powder metallurgy technique (PM), Cu tool for higher MRR, and CuW tool for higher surface finish. Goyal [6] studied the material removal rate mechanisms in EDM process of composite electrodes fabricated from the different ratios of Copper-Manganese powders. It was observed that the material removal rate of copper and manganese electrode ratio (70:30) is better than the Copper-Manganese ratio (80:20) electrodes. J Prasanna et al. [11] Study the tool wear rate (TWR) and material removal rate (MRR) evaluation Using Tungsten: Copper composite electrode. Goyal et al. [13] studied the material removal rate and tool wear rate of the pure copper tool and copper tungsten tool its observed that the higher performance and wear resistance when used composite material tool.

The work focused on the use of a new composite electrode (Cu:Ag) to enhance the performance of EDM process. Composite electrode (Cu:Ag) was prepared by casting method, while the workpiece used from high-speed steel to investigate the tool wear rate, material removal rate and surface roughness. Furthermore, the performance of composite electrode was compared with the Cu electrode.

2. Fabrication of Composite Electrode Materials

The composite electrodes were prepared from pure Cu (99.8%) at a weight ratio of 70% mixed with pure Ag (99.9%) at weight ratio Ag 30%. To prepare (Cu -Ag) electrodes, the pure copper was melted at 1100 ◦C, and then silver was added and left for a period and then mixed by a graphite electrode to prevent the pollution. The obtained mixture was cast into a cast-iron mold preheated to 200 ◦C. After cooling, the cast was extracted. The electrode was formed in a shaft of 10 mm diameter as shown in Figure 1.

Figure 1: Composite Electrode Copper: Sliver (70:30)

3. Experiment procedure

The electric discharge machine, manufactured by electronica machine tools (CHMER – 50N) Chine used to carry out the experimental to explain of material removal rate (MRR) as in Figures 2 and 3. Tool wear rate (TWR) and Surface roughness (SR) at various parameters machining using two types of electrode materials made by Copper and Silver (70:30) and pure copper of diameter 10 mm have been analyzed. The workpiece used in the experimental work is high - speed steel plate. The chemical composition of this material given in Table 1. A depth of cut of 0.5 mm adjusted on the workpiece for each run. Initially, the EDM with Cu -Ag electrode compound was conducted under similar conditions machining (pulse on-time 50s, and pulse of time 25s) and three different levels of current (10A, 12A, 14A). Consequently, the EDM process was performed with different pulses on time of 100 μ s, 150 μs and 200 μs and (peak current 14 A, and pulse off-time 25s). The MRR, TWR, and SR were measured for each run. Also, the Cu tool tested under the same operating conditions for the comparison study.

Figure 2: EDM machine (CHMER -50N)

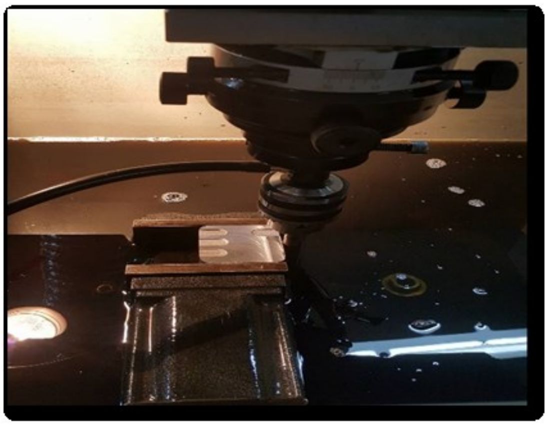

Figure 3: The work zone of EDM

Table 1: Chemical composition of the used work piece, Chemical analysis of work piece, equipped by company inspection engineering (S.I.E.R)

C%	Si%	Mn%	P%	S%	Cr%	Mo%	Ti%	Cu%	Al%	Fe
1.1	1.2183	0.700	0.0265	0.0416	1.08	0.0161	0.01	0.198	0.0547	balance

I. Calculation of material removal rate (MRR) and Tool Wear Rate (TWR)

The value of MRR and TWR was calculated from the weighting method. The workpiece sample and electrode are weighting before machining (wp1) and after machining (wp2), the MRR was calculated from the following formula (1) [12].

$$MRR = \frac{WP1-WP2}{T} \quad (1)$$

Where

T: the machining time

TWR was calculated from taking the weights of the electrode before machining (wt1) and after machining(wt2), TWR was calculated using Eq. (2) [12].

$$TWR = \frac{Wt1-Wt2}{T} \quad (2)$$

Surface roughness (SR) of the samples was measured by using a portable device (pocket surf) ,the test was carried out in laboratories of the department of production engineering.

4. Results and discussion

I. Analysis of the current effect on MRR, TWR and SR

The current represents a significant parameter in the EDM machining. It depends on power levels supplied by the EDM machine. Figure 4 explains the influence of current on the material removal rate. It observed from this Figure that Copper - Silver (70:30) electrode achieved the best MRR with the increase in discharge current as compared to the copper electrode that gives low MRR. The maximum value of the material removal rate reached with copper-Silver (70:30) is 0.106 gm/min, which is higher than that with the copper electrode under the same machining conditions. Figure 5 clarifies the effect of current on the tool wear. It is shown when the current increases will that the TWR increases, composite electrodes give the best TWR compared to copper electrode, the less TWR of the composite tool indicates its more wear resistance of the Cu tool. Figure 6 shows the effect of current on the surface roughness. It found that when an increase in the rate current due to decreases the surface roughness. When using copper -sliver electrode, it is seen that the surface roughness of workpiece is fewer less than that of the copper tool. Tables 2 list the experimental results when using composite Copper -Silver electrode and Copper electrode with the variation in current.

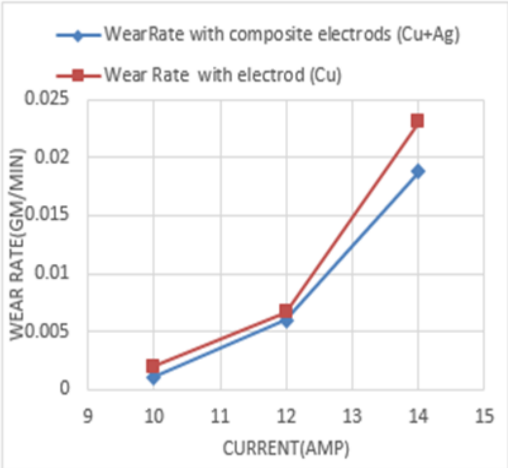

Figure 4 : Influence of Current on MRR

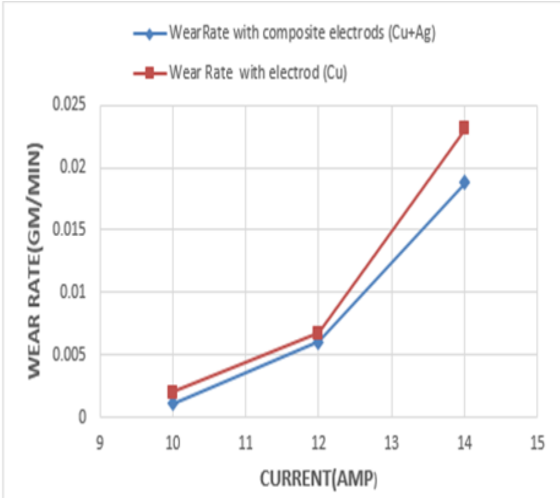

Figure 5: Influence of Current on TWR

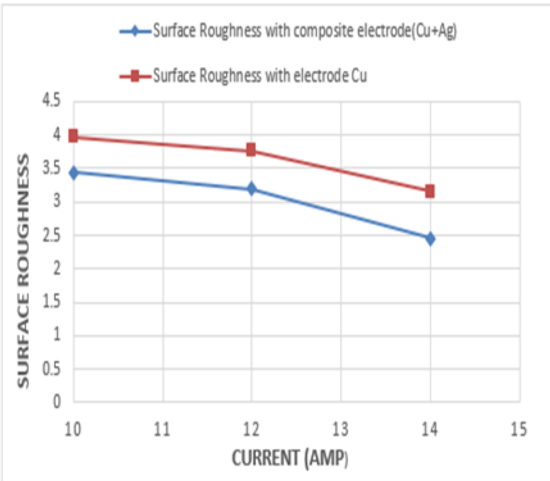

Figure 6: Influence of Current on SR

Table 2: The calculated value of Tool Wear Rat (TWR), Material Removal Rate (MRR) and Surface Roughness (SR) for Copper - Silver Electrode (70:30) and copper electrode with variation of current (10 Amps,12 Amps,14 Amps) at pulse on-time 50 µs and pulse off 25 µs .

Copper -Silver electrode			Copper electrode		
MRR (gm/min)	TWR (gm/min)	SR (µm)	MRR (gm/min)	TWR (gm/min)	SR (µm)
0.044	0.0011	3.44	0.041	0.002	3.97
0.096	0.0060	3.20	0.066	0.0067	3.76
0.106	0.0188	2.46	0.073	0.023	3.16

II. Analysis of the Pulse on time effect on MRR, TW and SR.

Material removal and tool wear rate for composite (Cu:Ag) electrode and copper (Cu) electrode with variation pulse on time are shown in Figure 7 and Figure 8. The MRR for both the electrode found to increase with increase impulse on time. From Figure 8, it is seen that the increase in pulse on time causes a decrease in TWR for both electrodes. The less TWR of composite electrode show more wear resistance of Cu pure electrode due to the existence of Ag increases the wear resistance for the tool. The investigation evidence the Copper-Silver (70:30) electrode gives more MRR with less TWR than copper electrode. Figure 9 It shows surface roughness of workpiece increase with the pulse time which due to increased input energy. The resulting illustration surface finish of workpiece improves for the composite tool than Cu tool. Table 3 experimental results when using composite Copper - Silver tool and Copper tool with variation in pules on - time.

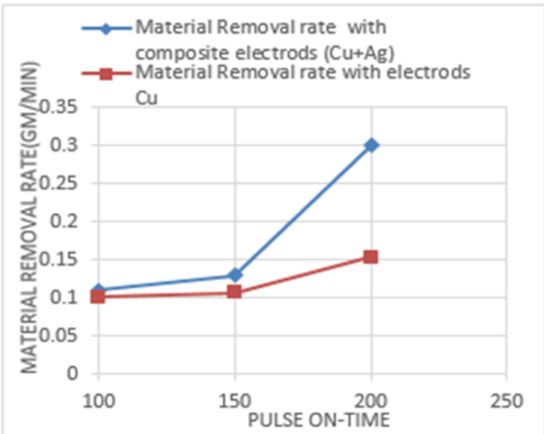

Figure 7: Effect Plus (Time - On) on MRR

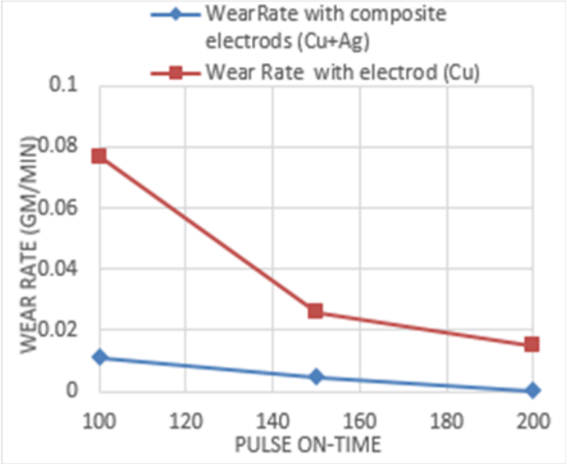

Figure 8: Effect Plus (Time - On) on TWR

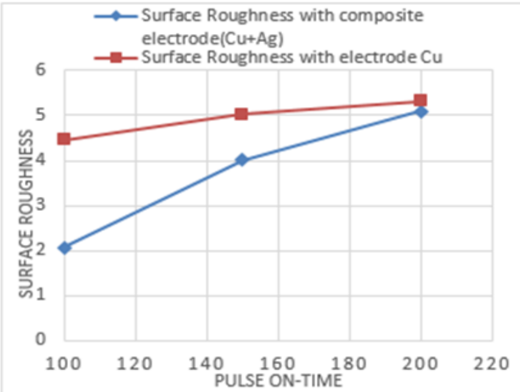

Figure 9: Effect Plus (Time - On) on SR

Table 3: Calculation result of MRR, TWR and SR for Copper -Silver tool (70:30) and Copper tool with variation in pules on –time (100 µs,150 µs,200 µs) at current 14 Amps and pulse off 25 µs.

Copper –Silver electrode			**Copper electrode**		
MRR (gm/min)	TWR (gm/min)	SR (µm)	MRR (gm/min)	TWR (gm/min)	SR (µm)
0.109	0.011	2.07	0.101	0.077	4.45
0.127	0.0046	4.01	0.107	0.026	5.03
0.255	0.0001	5.10	0.153	0.015	5.31

5. Conclusions

From the experimental results, the following points are concluded:

i. The Copper - sliver (70:30) composite material electrode has been developed the performance of EDM process.

ii. Higher MRR with lower TWR was obtained for the copper-silver electrode as compared to copper electrode.

iii. Lower value of surface roughness can be obtained by using composite electrode (Cu-Ag) less than copper electrode.

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