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TO STUDY THE EFFECT OF ELECTRODE ROTATIONAL SPEED AND MACHINING PARAMETERS ON MRR AND SR USING EDM

Engineering

KEYWORDS: Electrical Discharge Machining (EDM), Material Removal Rate (MRR), Electrode wear rate (EWR), Surface roughness (SR), Analysis of variance (ANOVA) and I(Pulse current), Revolutions per minute (RPM)

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ABSTRACT

In this work an attempt has been made to compare the effect of rotating copper electrode for machining of HCHCr D2 steel at different sets of rotation i.e. 60,100 and 200 rpm. The intent of the present study is to observe the effects of input parameters such as peak current, on time, duty cycle, rotational speed of electrode on the material removal rate (MRR) and surface roughness (SR). It is observed that material removal rate of Cu electrode at lower RPM is higher at lower value of duty cycle and depends directly on values of current. The electrode wear rate is lower at higher RPM and increase with increase in current. Surface roughness holds a higher value at increased rotational speed and at greater values of duty cycle but lower at reduced duty cycle. The result shows that at higher speed of rotating electrode the MRR decrease whereas the surface roughness increases, at different levels of peak current and duty cycle. Percentage contribution of parameters like current, duty cycle and on time is calculated, on each set of RPM, through ANOVA and it's found that current has the greatest effect on MRR followed by duty cycle and on time.

INTRODUCTION

Electrical Discharge Machining (EDM) is the process of machining electrically conductive materials by using precisely controlled sparks [1]. This machine produces tools with complex-shapes and being used extensively in industries [2]. It is already established that electric discharge machining can be performed all sorts of electrically conductive materials irrespective of their hardness [3]. MRR, tool wear rate (TWR) and surface roughness increases, by increasing open circuit voltage, because electric field strength increases [4]. The objective of this study is to conduct EDM machining on HCHCr D2 steel at various set of machining parameters using rotary electrode at different speeds i.e. 60,100,200 rpm.

APPLICATIONS OF ROTARY ELECTRODE IN EDM

Research on rotary electrode for EDM has been carried out for many years in order to analyze the effect of rotation on MRR and SR. It is found that MRR and Surface roughness improve with rotary EDM due to effective flushing of eroded debris. Addition of additives in dielectric a latest approach in EDM machining is also reported. This section deals with the experimental materials and experimental set up.

EXPERIMENTAL MATERIALS

Workpiece Material

The workpiece material was an HCHCr D2 steel. The electrode materials were copper at different RPM.

Figure 1: Workpiece material

TABLE – 1
CHEMICAL COMPOSITIO OF HCHCR D2

Element	C	Si	Mn	Mo	Cr	Ni	V	Co
Weight%	1.5	0.3	0.3	1.0	12.0	0.3	0.8	1.0

Source: ttp://www.varoonsteels.com/index.php?content_id=1271&title=Alloys%20Steels&menu_id=977&option=cms#HCHCrD2WSP

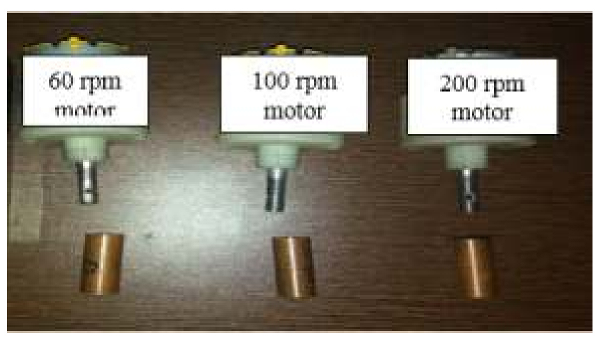

Figure 2: Electrode material

EXPERIMENTAL SET UP

An electrical discharge machine (Electra SE-35) with servo control system was used to conduct the experiments.Figure 1 displays experimetal set up of the EDM process in which different electrodes with different rotational speed i.e. 60,100,200 rpm are used on machining table. A DC geared motor is used for rotating mechanism. MRR for each condition were evaluated by dividing measured amount of material by the density and machining time.Table 3 represents machining conditions. The pulsed current, pulse on time and duty cycle are controlled varialbles.Meanwhile, the tool electrodes used have internal diameter 6mm, outside diameter 12mm and length 30mm.The specimen was HCHCr D2 steel which is widely used in mould industry.The chemical composition of the material is given in Table 1.

TABLE – 2
TECHNICAL SPECIFICATION

Make	ELEKTRA SE-35
Dielectric capacity	150 Litres
Dielectric Medium	Kerosene
Current	1 A to 40 A
Pulse On Time	2 µs to 1600 µs
Duty Cycle	1 to 12

Source: EDM ELECKTRA SE-35 manual

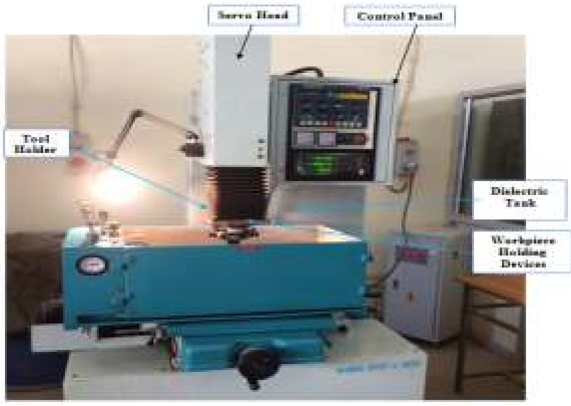

Figure 3 Experiment set up

TABLE – 3
EXPERIMENTAL CONDITIONS

Dielectric	Keroscene
Work material	HCHCr D2 steel
Tool material	copper at 60,100 &200 RPM
Pulse current(IP)	10,20 ,30A
Pulse on time	50,100,150 usec
Duty cycle	3,6,9

ROTARY ATTACHMENT

It is used to generate rotary motion for the electrode and is fixed with the quill of the machine. It is operated with 12 volts at 60,100 and 200 rpm. DC motor is attached with the clamp and further with its main spindle. The input voltage is supplied to the rotary arrangement by the12V DC power supply. A schematic drawing illustrating the fixing of rotary arrangement with the main spindle of the machine is shown in the figure 4. Rotary motion is transferred from horizontal plane to the vertical plane. Electrode holder is fixed in the vertical plane and holds the clamp which further electrode. Electrode rpm 60,100 and 200 are used which is obtained by geared motor conned with 12V battery.

Figure 4: Electrode holder

CASE STUDY

In the present an attempt has been made to compare the effect of rotating copper electrode for machining of HCHCr D2 steel at different sets of rotation i.e. 60,100 and 200 rpm. The intent of the present study is to observe the effects of input parameters such as peak current, on time, duty cycle, rotational speed of electrode on the material removal rate (MRR) and surface roughness (SR).

Material removal rate

MRR is expressed as the ratio of the difference of weight of the workpiece before and after machining to the machining time and density of the material.

$$MRR = \frac{W_i - W_f}{\rho \times t} \times 1000\ mm^3/min$$

Where,
W_i is Initial weight of workpiece material in gms
W_f is Final weight of workpiece material in gms
t is Time period of trials in minutes
ρ is Density of workpiece in gms/mm³

Figure 5: Machined work piece

RESULTS & DISCUSSION

TABLE – 4
FACTORS WITH LEVEL VALUES OF ELECTRODE

Factors	Level 1	Level 2	Level 3
Peak current (A)	10	20	30
Pulse on-time (µs)	50	100	150
Duty Cycle	3	6	9

TABLE – 5
RESULT OF ANOVA ANALYSIS AT DIFFERENT ELECTRODE RPM

Electrode Rotation	Input Parameters	% Contribution for MRR	% Contribution for SR
Copper 60rpm	Current On time Duty cycle Error	63.93165 10.30498 21.13014 4.633230	28.06956 21.09113 49.58802 1.251290
Copper 100rpm	Current On time Duty cycle Error	66.16200 12.24664 16.70486 4.886500	46.31034 15.85039 34.82458 3.014690
Copper 200rpm	Current On time Duty cycle Error	54.99911 16.56194 22.05739 6.381560	29.087440 15.287690 52.317779 3.3070910

MATERIAL REMOVAL RATE (MRR)

Experiments were done using a solid copper electrode varying RPM. The main machining parameter whose effect have been studied here are Current and Duty Cycle.

The relationship between the current and metal removal rate (MRR) by solid Cu electrode at three different Duty Cycle durations are shown below:

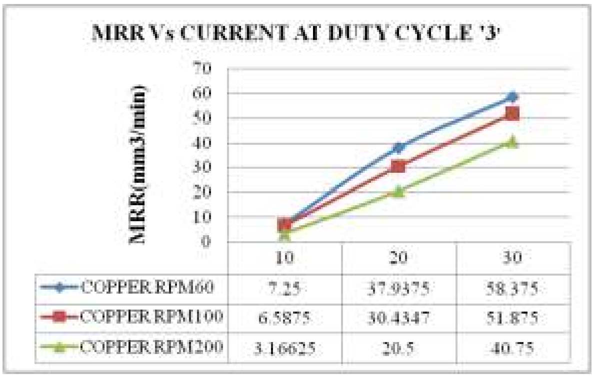

Figure 6: MRR(mm3/min) Vs Current(A) when Duty cycle is 3

Figure 6 indicates that MRR varies in direct proportion to current. As current varies from 10A to 30A, the MRR increases. At higher values of current MRR holds a high value than at lower value of current.

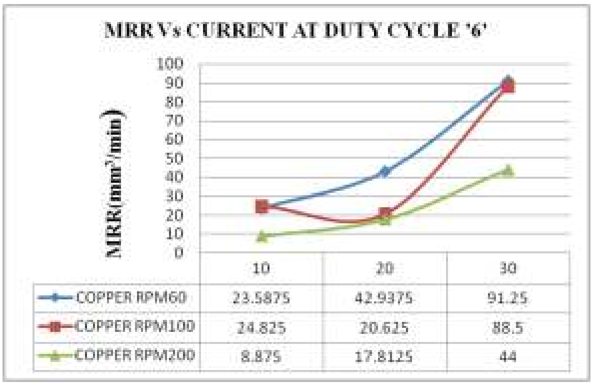

Figure 7: MRR(mm3/min) Vs Current(A) when Duty cycle is 6

From Fig 7 it is found that copper has better MRR when rotating at 60rpm as compared to when rotating at 100 and 200rpm.

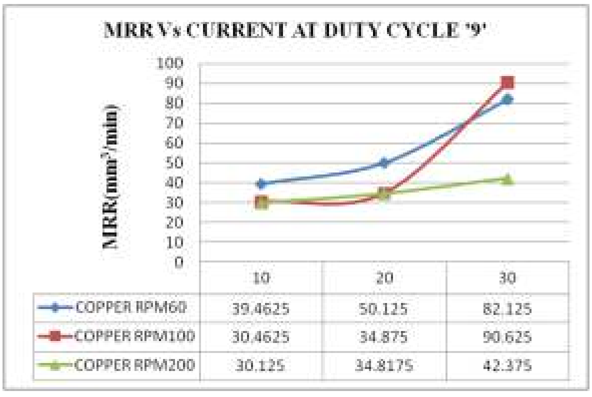

Figure 8: MRR(mm3/min) With Current(A) when Duty cycle is 9

The relationship between metal removal rate and peak current for different set of duty cycle and rotation of electrode is shown in figures 6-8. They show that MRR increases with increase of peak current in all the machining conditions. It is concluded from the graph that at maximum value of current which is 30A MRR holds a minimum value when rotating at 200 rpm whereas, maximum value of MRR at 30A occurs when electrode rotation is 60 rpm. So, it is concluded that when the rotational speed of the electrode is increased the MRR decreases or lower the speed of electrode better the MRR.

SURFACE ROUGHNESS(SR)

Taking effect of current and duty cycle on MRR graphs are plotted for 60,100 and 200rpm to find out at what speed it is comparatively better and to be used as electrode for rotary motion. The results are shown below:

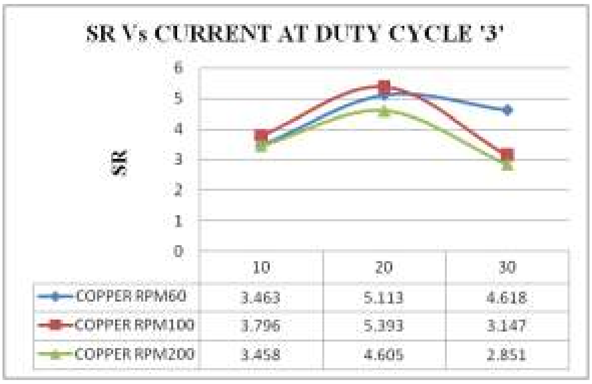

Figure 9: SR Vs Current when Duty cycle is 3

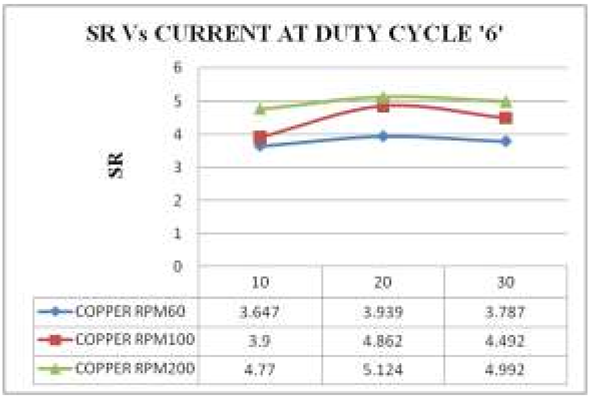

Figure 10: SR Vs Current when Duty cycle is 6

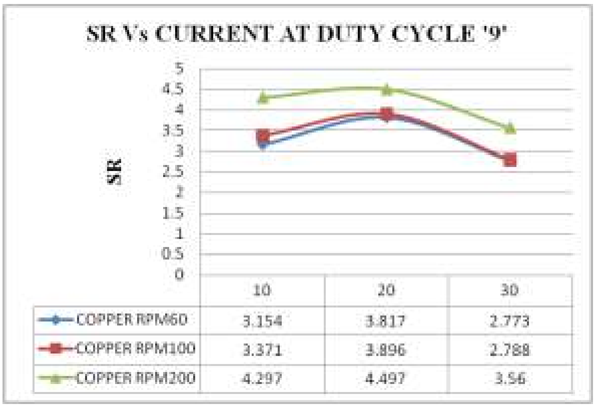

Figure 11: SR Vs Current when Duty cycle is 9

The relationship between surface roughness and peak current for different set of duty cycle and rotation of electrode is shown in figures 9-11. The graph clearly shows the trend of surface roughness varying with current at different sets of rpm. At higher value of current which is 30A the value of surface roughness for electrode rotating at 200 rpm is higher as compared to copper electrode at 60 rpm. So it is concluded that as we keep on increasing the rotational speed the surface roughness tends to decrease.

CONCLUSIONS

This present work evaluates the Material removal rate, Electrode wear rate, and Surface Roughness of a Cu electrode and HCHCr D2 steel at 3 sets of RPM i.e. 60, 100 & 200.

Based on the results and discussion presented in the previous chapter the following can be concluded:

- The results confirmed that the MRR is highest for copper electrode at 60 rpm.
- The electrical parameters more significantly affect the rotary electric discharge of machining process.
- The polarity of electrode and peak current largely affect the MRR and SR.
- The decrease in electrode rotation results in higher MRR and better SR.

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