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EXPERIMENTAL INVESTIGATION OF MACHINING PARAMETERS USING ROTARY ELECTRODE FOR EDM OF HCHCR D2 STEEL

Engineering

KEYWORDS: Electrical Discharge Machining (EDM), Material Removal Rate (MRR), Surface roughness (SR), Analysis of variance(ANOVA) and IP(Pulse current).

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ABSTRACT

In this work an attempt has been made to correlate usefulness of electrodes during rotary motion. Experiments are conducted to study the effect of different parameter such as peak current and duty cycle on material removal rate and surface finish while using different rotary electrode such as Copper, Brass and Aluminium. It is observed that using rotary copper electrode for electric discharge machining at low and intermediate values of peak current i.e. 10 and 20A to provide better MRR than that of aluminium and brass at duty cycle 3 and 9 whereas, for high value of peak current i.e. 30A aluminium to be used. At duty cycle 6 aluminium has better MRR at low and intermediate value of peak current i.e. 10 and 20A whereas, copper is used for high value of current i.e. 30A and brass is not acceptable at any value of current and duty cycle because of its poor MRR. SR has lowest value when we use brass electrode for every set of duty cycle. The percentage contribution of input parameter has been calculated using ANOVA table. It showed that current has the maximum effect on all parameter followed by duty cycle and on time

INTRODUCTION

Electrical Discharge Machining (EDM) is a machine that is used as non-traditional manufacturing and this machine is continually developing further technology that would be impossible to produce with faster and conventional [1]. In EDM, the electrode does not contact the work piece. The electrode must always be spaced away from the work piece by the distance required for sparking, known as the sparking gap [2].

MRR, tool wear rate (TWR) and surface roughness increases, by increasing open circuit voltage, because electric field strength increases [3]. The material erosion mechanism primarily makes use of electrical energy and turns it into thermal energy through a series of discrete electrical discharges occurring between the electrode and workpiece immersed in a dielectric fluid [4]. The EDM process does not involve mechanical energy, thus hardness, strength, or toughness of the work piece does not affect the material removal rate(MRR) [5].

EDM process has gained popularity as a most successful and profitable machining method, for machining materials with a high degree of dimensional accuracy and economical cost of production [6]. This paper describes the effect of different electrode material and machining parameters on HCHCr D2 steel using EDM.

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 pulse time, tool electrode diameter on MRR and SR. It is found that with rotary EDM, material removal rate (MRR) increases along with improvement in out of roundness in comparisons to hole made by sinking EDM. Also there is increase in MRR to improved flushing of eroded debris due to tool rotation. 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, brass and aluminium.

Figure 1: Workpiece material

TABLE – 1: CHEMICAL COMPOSITION OF WORKPIECE MATERIAL

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

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

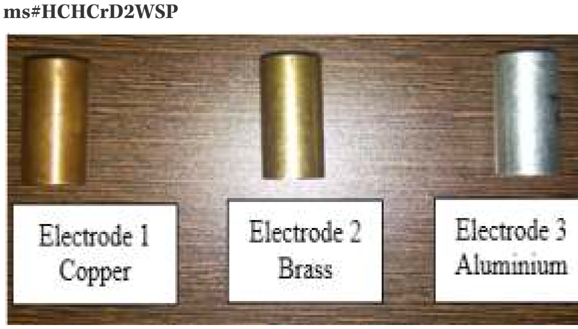

Figure 2: Electrode materials

EXPERIMENTAL SET UP

An electrical discharge machine (Electra SE-35) with servo control system was used to conduct the experiments.Figure 3 displays experimetal set up of the EDM process in which different electrodes are used on machining table. A DC geared motor is used for rotating mechanism. Three electrodes are used for the experiment i.e. copper, brass and aluminium. 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 2.

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

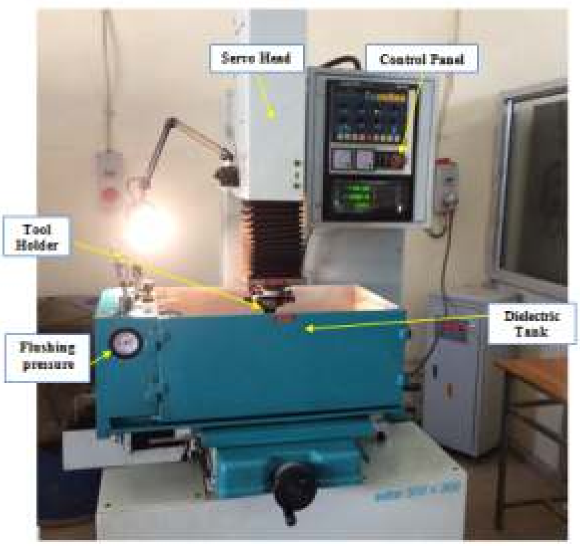

Figure 3: EDM used for experiment

TABLE - 3
EXPERIMENTAL CONDITIONS

Dielectric	Keroscene
Work material	HCHCr D2 steel
Tool material	copper,brass,aluminium
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 a 12 volts, 60 rpm DC motor attached with the clamp and further with its main spindle. The input voltage is supplied to the rotary arrangement by the12 V 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 is used which is obtained by geared motor conned with 12V battery.

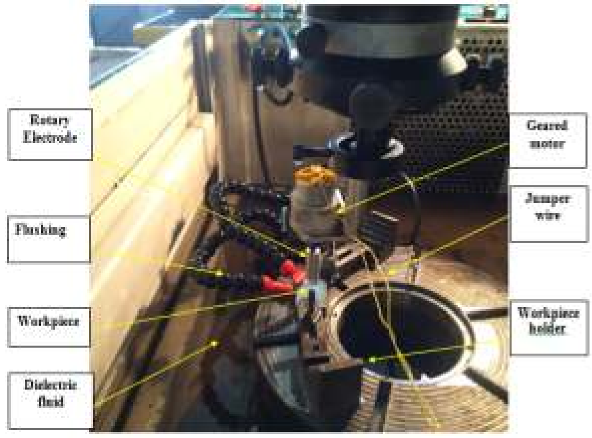

Figure 4: Work holding fixture

CASE STUDY

In the present study an attempt has been made to correlate usefulness of electrodes during rotary motion. Experiments are conducted to study the effect of different parameter such as peak current and duty cycle on material removal rate and surface finish while using different rotary electrodes such as Copper, Brass and Aluminium.

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.

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

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/mm^3

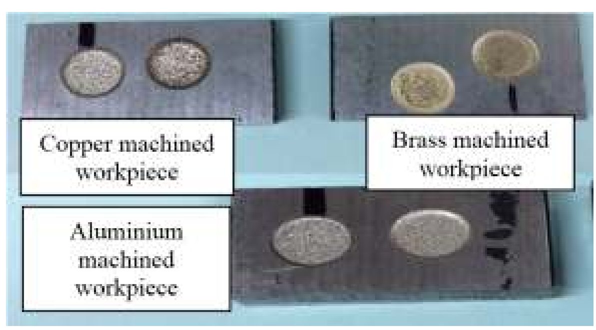

Figure 5: Machined work piece

RESULTS & DISCUSSION

TABLE - 4
FACTORS WITH LEVEL VALUES FOR EACH 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 FOR DIFFERENT ELECTRODE MATERIALS

Electrode Materials	Input Parameters	% Contribution for MRR	% Contribution for SR
Copper	Current	61.59976	37.0108484
	On time	10.97218	16.30546
	Duty cycle	25.95116	43.87759
	Error	1.476900	2.8061016
Brass	Current	42.69713	30.378800
	On time	21.07733	14.224514
	Duty cycle	31.53376	36.444570
	Error	4.791380	18.952116
Aluminium	Current	65.19342	57.46955
	On time	5.99935	12.01364
	Duty cycle	23.1177	13.95639
	Error	5.68953	16.56042

MATERIAL REMOVAL RATE (MRR)

As clearly it is shown that contribution of current and duty cycle is much better than that of on time. So, effect of current and duty cycle to be studied on MRR ,EWR and SR .Taking effect of current and duty cycle on MRR and surface roughness graphs are plotted between copper ,brass and aluminium to find out which one is comparatively better and to be used as electrode for rotary motion if to be used. The results are shown below

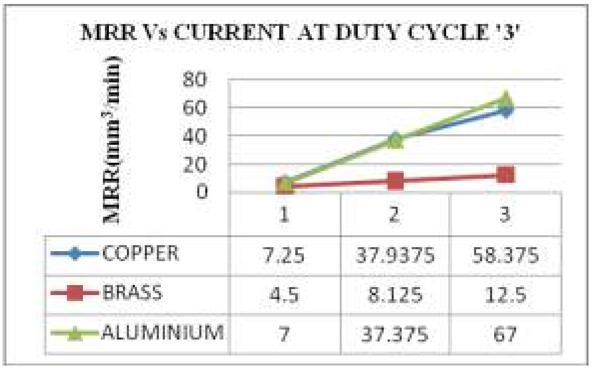

Figure 6: MRR (mm3/min) Vs Current (A) when Duty cycle is 3

From Fig 6 the maximum and minimum MRR is 67 and 4.5 which is in case of aluminium and brass. It is found that aluminium has better MRR among all at high value of current whereas copper has better MRR among all at other values of current when duty cycle is 3.

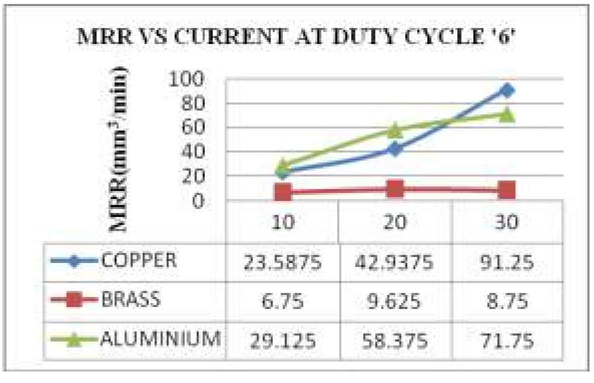

Figure 7: MRR (mm3/min) Vs Current (A) when Duty cycle is 6

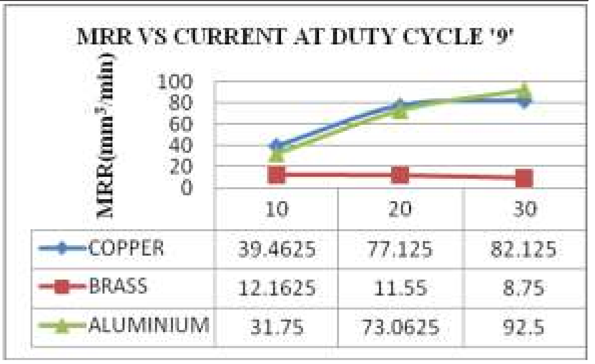

Figure 8:MRR (mm3/min) With Current (A) when Duty cycle is 9

From Fig 7 the maximum and minimum MRR is 91.25 and 6.75 which is in case of copper and brass. It is found that copper has better MRR among all at high value of current whereas aluminium has better MRR among all at other values of current when duty cycle is 6.

From Fig 8 the maximum and minimum MRR is 92.5 and 12.1625 which is in case of aluminium and brass. It is found that aluminium has better MRR among all at high value of current whereas copper has better MRR among all at other values of current when duty cycle is 9. The relationship between metal removal rate and pulse duration for current intensities at various rotation of electrode is shown in figures 6-8. They show that MRR increases with increase of peak current in all the machining conditions expect for brass decrease when duty cycle is 9.This may be due to higher input energy i.e. peak current at a particular pulse duration and electrode rotation. Figures 6-8 indicate the relationship between MRR and pulse current. It has been observed that MRR has a tendency to increase with the increase of duty cycle. In the end, figure 6-8 also shows the relation between MRR and electrode rotation during the electric discharge using different electrodes at different condition. Here, it has been observed that MRR of copper is best at low and intermediate level of current whereas MRR of aluminium is best at high level of current when duty cycle is 3 or 9. MRR of brass is worst at all values of current and duty cycle.

SURFACE ROUGHNESS (SR)

Taking effect of current and duty cycle on SR graphs are plotted between copper , brass and aluminium to find out which one is comparatively better and to be used as electrode for rotary motion. The results are shown below

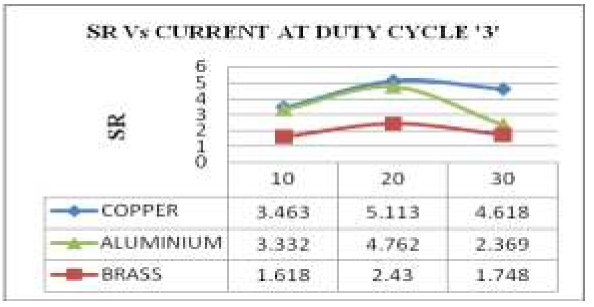

Figure 9: SR Vs Current when Duty cycle is 3

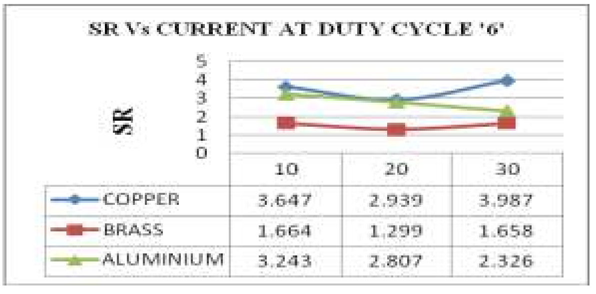

Figure 10: SR Vs Current when Duty cycle is 6

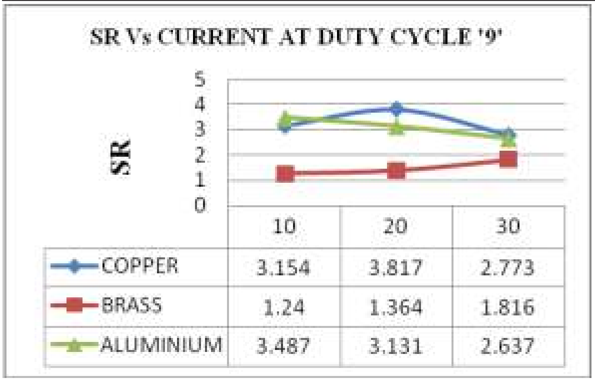

Figure 11: SR Vs Current when Duty cycle is 9

Figures 9-11 evaluate the surface roughness under various machining conditions. Surface roughness versus electrode rotation under different peak current conditions is shown in figures 9-11. It has been observed that brass has the least surface roughness among all for every set of duty cycle and peak current.

CONCLUSIONS

Based on the analysis and discussions of results presented in this paper along with the graphs, the following can be concluded: Experimental results confirm that the copper is used as rotary electrode for electrical discharge machining for low and intermediate values of current when duty cycle is 3 or 9 as it gives higher MRR as compared to aluminium and brass. Whereas aluminium is used as rotary electrode at high level of peak current for duty cycle 3 or 9 and brass is not acceptable for any value of current and duty cycle because of its low MRR whereas, phenomenon reverses for duty cycle 6. The Duty cycle and the peak current, largely affect the MRR and SR. Variation of Duty cycle has significant affect on MRR and SR. Based on the above points, it can be concluded that electrical discharge machining of HCHCr D2 steel by rotary copper electrode is highly useful to increase the productivity in industry when current is low or intermediate and aluminium for high value of current when duty cycle is 3 or 9 for achieving higher MRR. Brass has better SR among all for every set of duty cycle.

REFERENCE

[1] Prajapati, Hitesh B., Prajapati, Hiren R., "Parametric analysis of material removal rate and surface roughness of electro discharge machining on EN 9". Journal in modern engineering and emerging technology, Vol. 1, No. 1, 2013, pp:7-13. | [2] Singh, K., Kumar, D., "To study the effect of copper tungsten and cryogenic copper tungsten electrode on material removal rate during Electrical discharge machining of H11 tool steel at straight polarity". Journal in mechanical engineering and robotics, Vol. 4, No. 4, 2015, pp:224-233. | [3] Kumar, S., Singh, R., Singh, T.P., Sethi, B.L., "Surface modification by electrical discharge machining: A review". Journal in Materials Processing Technology, Vol.209, 2009, pp: 3675-3687. | [4] Thomson, P.F., "Surface damage in electro discharge machining". Journal in Material Science and Technology, Vol.5, 1989, pp: 1153–1157. | [5] Mohan, B., Rajadurai, A., Satyanarayana, K. G., "Electric discharge machining of Al-SiC metal matrix composites using rotary tube electrode". Journal of Materials Processing Technology, Vol. 153-154, No. 1–3, 2004, pp. 978–985. | [6] Chattopadhyay, K. D., Satsangi, P. S., Verma, S., Sharma, P. C., "Analysis of rotary electrical discharge machining characteristics in reversal magnetic field for copper-en8 steel system". International Journal of Advanced Manufacturing Technology, Vol. 38, No. 9-10, 2008, pp. 925–937.