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Effect of Machining Characteristics on EN24 Alloy Steel using Different Electrodes

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***Abstract*—In Electric Discharge Machining (spark erosion machining) metal is removed by producing a powerful electric spark between the tool and the work piece. Basically, improper choice of electrode material may result in poor machining performance and it will decrease the accuracy of the products. This work presents a fundamental study of the characteristic of electric discharge machine such as electrode wear ratio (EWR), metal removal rate (MRR) and surface roughness. The experiment is done by selecting three different electrodes (copper, brass and aluminum) for machining EN24 alloy steel, collecting data's like MRR, EWR and surface roughness, finally analyzing the results and to choose the best electrode.**

Keywords- MRR; EWR; dielectric; depth of cut; spark gap

I. INTRODUCTION

In electrical energy based processes, electrical energy is directly used to cut the material to get the final shape and size. The main components are the DC power supply, dielectric medium, work piece, tool and servo control mechanism. The work piece is connected to positive terminal and acts as anode and the electrode is connected to negative supply and acts as cathode. The complete machining occurs inside a dielectric medium having poor electrical conductivity. The function of servo control mechanism is to maintain a very small gap known as spark gap, ranges from 0.005 to 0.05mm.

When the supply is given spark is produced across the gap, dielectric break down occurs and electrons are emitted from the tool. At high temperature and pressure metal is melted, eroded and some of it is vaporized. The MRR and EWR characteristics depends on the spark gap maintained. If anode and cathode are made of same material then greatest erosion takes place at the anode so that in order to remove maximum metal and have minimum wear the tool is made as cathode and the work piece as anode.

In electrical discharge machining improper choice of the electrode material may cause poor machining rate. If the chosen electrode is not suitable for a particular work piece then it cannot satisfy the requirements, therefore the accuracy of the product will decrease. Furthermore, electrode wear imposes high cost and to substitute the eroded electrodes by new ones is a major challenge for the manufacturers. The aim of this study is to determine the suitable electrode material for machining EN24 alloy steel (work piece). The parameters taken for study are Metal Removal Rate, Electrode Wear Ratio and Surface Roughness the electrodes chosen are copper brass and aluminium and the dielectric medium chosen is EDM oil. Machining the work piece with different electrodes and determining their electrode wear ratio (EWR), metal removal rate (MRR), and surface roughness and comparing each results will help selecting the best electrode and good accuracy can be achieved.

II. METHODOLOGY

A. Work piece- EN24 alloy steel

Material selection is the most important step in this experiment because different materials have different working parameters based on their properties. The right selection of the machining material is the most important aspect to take into consideration in the processes related to the EDM.

EN24 is a high quality, high tensile, alloy steel. Usually supplied readily machinable in 'T' condition, it combines high tensile strength, shock resistance, good ductility and resistance to wear. EN24 / 817m40 has a high tensile strength of 850/1000 N/mm2.

TABLE I: CHEMICAL COMPOSITION OF EN24 ALLOY STEEL

Alloyant	Percentage
Carbon	0.36-0.44
Silicon	0.1-0.35
Manganese	0.45-0.70
Sulphur	0.04 max
Phosphorous	0.035 max
Chromium	1-1.40
Molybdenum	0.2-0.35
Nickel	1.3-1.7

B. Procedure

1. Measure the diameter and the length of the electrode and work piece material.
2. Measure the initial mass of the electrode and work piece using a digital weighing machine.

3. Clamp the electrode and the work piece, fill the tank with EDM oil and start machining.
4. Set the parameters like current, voltage, pulse on time, pulse off time, depth of cut.
5. Note down the time taken for each electrode.
6. After sparking, measure the final mass of the both electrode and work piece using the same digital weighing machine.
7. Calculate MRR and EWR using the formula.

$$MRR = \frac{\text{Weight of work piece material removed}}{\text{Time}}$$

The unit is grams/minute.

$$EWR = \frac{\text{Weight of electrode or tool removed}}{\text{Time}}$$

The unit is grams/minute.

8. Calculate surface roughness on the work piece using surface roughness testing instrument.
9. Compare all the results and choose the suitable electrode.

C. *Specifications*

Length of the electrodes	-	50mm
Diameter of the electrodes	-	10mm
Length of the work piece	-	29mm
Diameter of the work piece	-	27mm
Depth of cut	-	1mm
Spark gap maintained	-	0.5mm

TABLE II: PARAMETER TABLE

Electrodes	Current (A)	Voltage (V)	Pulse on time (µs)	Pulse off time (µs)
1	12	30	8	5
2	10	30	7	5
3	8	30	6	5
4	6	30	5	5
5	4	30	4	5

TABLE III: EXPERIMENTAL DATA COLLECTION

Expt no.	Electrodes	Initial mass of electrode (g)	Final mass of electrode (g)	Initial mass of w/p (g)	Final mass of w/p (g)	Time (min)
1	Copper	35.86	35.85	131.64	130.85	5m9s
2	Copper	35.88	35.82	131.49	130.75	5m33s
3	Copper	35.92	35.83	131.07	130.37	5m50s
4	Copper	35.88	35.78	131.53	130.90	5m53s
5	Copper	35.94	35.66	130.59	130.00	6m43s
1	Brass	32.94	32.57	131.13	130.83	4m23s
2	Brass	32.92	32.52	131.32	131.00	4m42s
3	Brass	32.89	32.49	131.43	131.19	4m58s
4	Brass	32.89	32.45	131.29	131.09	5m30s
5	Brass	32.88	32.42	131.24	131.04	6m34s
1	Aluminium	10.46	10.43	131.75	131.18	6m21s
2	Aluminium	10.46	10.38	130.96	130.51	7m42s
3	Aluminium	10.45	10.36	131.12	130.72	8m19s
4	Aluminium	10.46	10.36	131.33	130.98	8m50s
5	Aluminium	10.45	10.31	131.58	131.28	9m28s

III. RESULTS

From the above datas, metal removal rate and electrode wear ratio is calculated using the formula. Surface roughness (Ra value) is tested in a surface roughness testing instrument. The nominal value of smooth finish is 8.314. The depth after sparking is calculated.

TABLE IV: RESULTS FOR COPPER

Copper electrode	1st	2nd	3rd	4th	5th	Average
EWR (g/min)	0.00194	0.01081	0.01544	0.01701	0.02678	0.014396
MRR (g/min)	0.15339	0.13333	0.12007	0.10714	0.08779	0.120344
Ra (µm)	8.217	8.851	8.860	6.946	5.982	7.7712
Depth after sparking (mm)	1.17	1.13	1.08	1.05	1.03	1.09

From the above table EWR and MRR is noted. The Ra value of copper is approximate to the nominal value. The approximate depth of cut (1.05mm) is achieved in the 5th electrode.

TABLE V: RESULTS FOR BRASS

Brass Electrode	1st	2nd	3rd	4th	5th	Average
EWR (g/min)	0.08447	0.08511	0.08048	0.08	0.07001	0.080014
MRR (g/min)	0.07078	0.06808	0.04829	0.03636	0.03044	0.05079
Ra (µm)	6.418	6.312	6.334	4.979	4.912	5.791
Depth after sparking (mm)	0.82	0.69	0.57	0.35	0.28	0.54

From the above table EWR and MRR is noted. The Ra value of brass is very less than the nominal value of aluminium. The 1mm depth of cut has not been achieved in any of the electrodes.

TABLE VI: RESULTS FOR ALUMINIUM

Aluminium electrode	1st	2nd	3rd	4th	5th	Average
EWR (g/min)	0.00472	0.01039	0.01202	0.01132	0.01478	0.010646
MRR (g/min)	0.08976	0.05844	0.04808	0.03964	0.03168	0.05352
Ra (µm)	5.173	5.713	5.225	4.982	4.211	5.0608
Depth after sparking (mm)	1.03	0.86	0.79	0.65	0.52	0.77

From the above table EWR and MRR is noted. The Ra value of aluminium is less than the nominal value and it is similar to brass. The approximate depth of cut is achieved only in the first electrode.

TABLE VII: FINAL RESULT

Electrodes	EWR (g/min)	MRR (g/min)	Ra (µm)
Copper	0.014396	0.120344	7.7712
Brass	0.080014	0.05079	5.791
Aluminium	0.010646	0.05352	5.0608

From the table, brass has the highest EWR and lowest MRR. The EWR aluminium is lower than brass and copper, the MRR value of aluminium is higher than brass but lesser than copper. Copper has better EWR and MRR characteristic compared to brass and aluminium. The nominal surface roughness value is achieved only in copper electrode. Therefore copper is the best electrode material than brass and aluminium.

VI. CONCLUSION

TABLE VIII: COMPARISON OF RESULTS

Electrodes	EWR (g/min)	MRR (g/min)	Ra (µm)	Depth of cut (mm)
Copper	Average	Best	Best	Best
Brass	Poor	Poor	Poor	Poor
Aluminium	Best	Poor	Poor	average

The material having lowest electrode wear ratio and highest metal removal rate is considered to be the best material. From the results it is clear that, copper has the best electrode wear ratio metal removal rate and surface roughness. Aluminium has best EWR but other parameters are lower than copper. Brass shows poor characteristics and it is not a suitable for machining in EDM.

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