An Experimental Investigation of Electrode Wear Rate (EWR) on EDM of SS-202 using Different Electrodes

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Abstract: **Electrical Discharge Machining is one of the most efficiently employed non-traditional machining process to produce dies, punches, mould, finishing parts for aerospace and automotive industry. Electrode Material selection plays a very important factor for machining of hard to cut materials in Electrical Discharge Machining. During machining process in proper selection of the electrode material may cause poor machining rate or performance. The objective of this is to determine the proper electrode material for Stainless Steel-202. Material Removal Rate and Electrode Wear Rate will be considered as performance factor for this experimental procedure.**

Keywords **– Electrical Discharge Machining (EDM), Copper Tungsten, Copper, Brass Electrode, SS-202**

I. INTRODUCTION

At present EDM is widespread technique used in industry for high-precision machining of all types of conductive materials such as metals, metallic alloys, graphite or even some ceramic materials of any hardness[1]. During EDM the main output parameters are the MRR, EW and surface finish. It is desirable to obtain the maximum MRR with minimum EW common electrode materials are graphite, brass, and copper-tungsten alloys. Efforts have been done to minimize EW. A.A. Khan found that electrode wear increases with an increase in both current and voltage, but wear along the cross-section of the electrode is more compared to the same along its length. It was also found that the wear ratio increases with an increase in current [2]. The working principle of EDM process is based on the thermoelectric energy. This energy is created between a workpiece and an electrode submerged in a dielectric fluid with the passage of electric current. The workpiece and the electrode are separated by a specific small gap called spark gap. Pulsed arc discharges occur in this gap filled with an insulating medium, preferably a dielectric liquid like hydrocarbon oil or de-ionized (de-mineralized) water [3-6]. In EDM process the Electrode and Work Piece does not make any direct contact, there will be no chatter, vibration and mechanical stresses during Electrical Discharge Machining of work piece [7]. With the application of rapid and repetitive spark discharge, removal of electrically conductive material takes place [8]. Now is research is going on to develop some suitable tool material for EDM in order to maximize MRR and to reduce EWR for better performance. The objective of this research is to study the performance of different electrode materials on Stainless Steel-202 workpiece with EDM process.

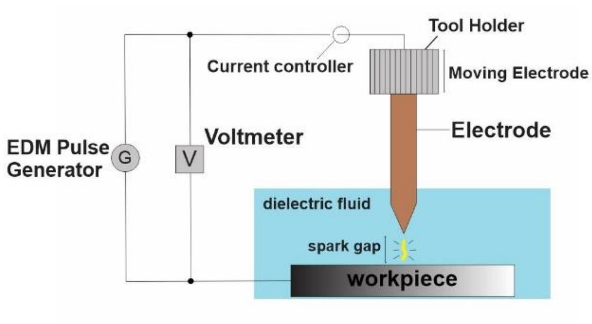

Fig.1 Working Principle of EDM Process

I. EXPERIMENTAL PROCEDURE

Pulse current is generally selected in such a way to increase Material Removal Rate and to decrease electrode wear rate. The experiments were carried out for 4 mm depth of cut. In this experiments 3 pulse current settings of 5A, 8A and 11A is used with the application of Copper, Brass and Copper Tungsten electrode.

a) Design of Experiments

Three parameters namely current, pulse on time and pulse off time is selected for the experimental work. There are three level in this experiment as shown in Table.1

Table 1. Machining parameters.

	Parameters	Unit	Level 1	Level 2	Level 3
A	Pulse Current	A	5	8	11
B	T_{on}	µs	130	220	380
C	T_{of}	µs	07	09	10

b) Work Piece Material

The work material used in this experiment is stainless steel 202. Work piece is 76 mm in diameter and 4 mm is thickness. Table.2 shows the mechanical properties of SS-202

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c) Electrode Material

In this experiment Copper, Brass and Copper Tungsten are selected as electrode material. Fig.2 explains about the work piece and electrode material.

Table.2 Mechanical properties of Stainless Steel-202

Properties	Metric
Tensile strength	515 MPa
Yield strength	275 MPa
Elastic modulus	207 GPa
Poisson's ratio	0.27-0.30
Elongation at break	40%

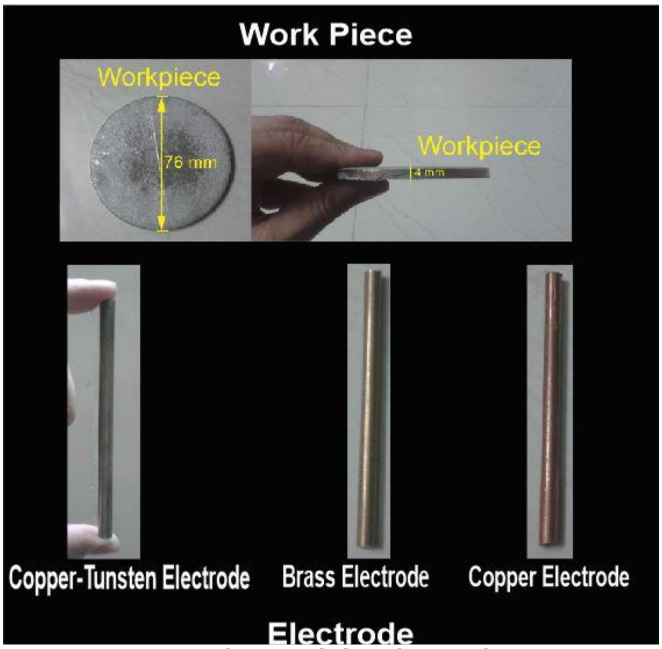


Fig.2 Work Piece and Electrode Material

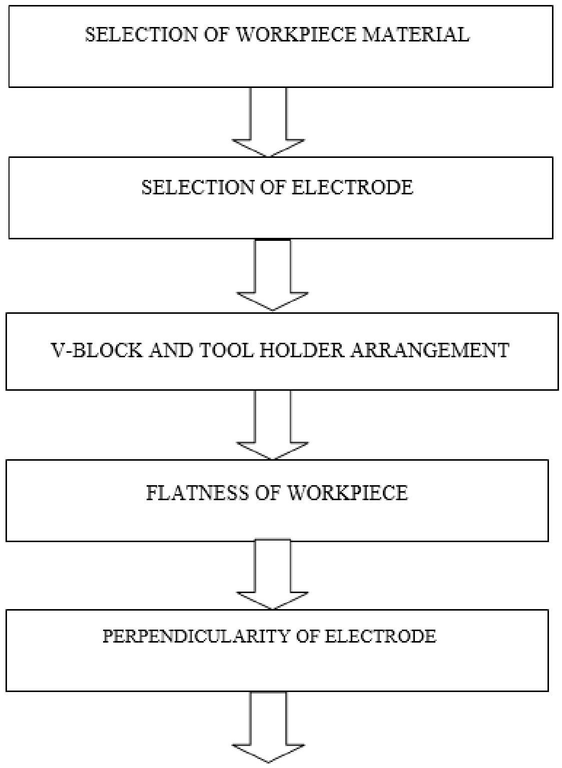
d) Machine Tool

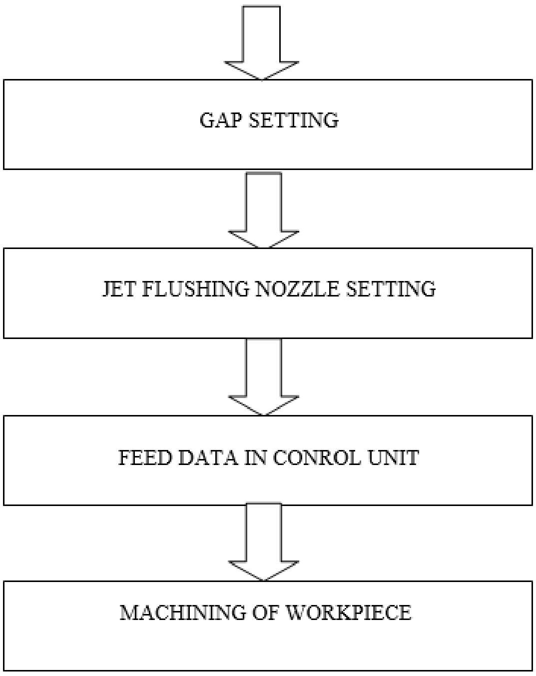
The experiments were performed on ELECTROLUX EDM Machine (Model No.: D7130) shown in Fig.3.


Fig.3Electrolux EDM Machine

e) Steps of Experiment

In order to run the experiment successfully we have to plan the experimental work as given in the following flow chart.





1. Selection of workpiece material

The circular work piece is 76 mm in diameter and 4 mm is thickness. Electrical Discharge Machining will be done on this work piece. Fig. 4 explain about the work piece of this experiment. In this experiment the electrode wear rate of SS-202will be determined.

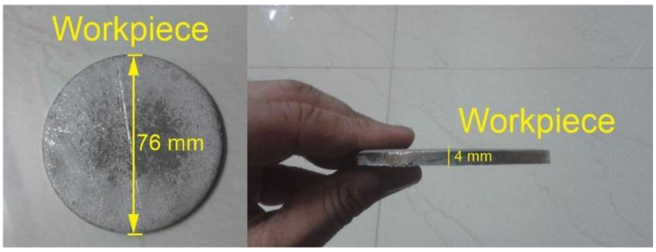


Fig.4Workpiece of SS - 202

2. Selection of Electrode

In this experiment Copper, Brass and Copper Tungsten are selected as electrode material. Fig.5 shows the tool electrode for electrical discharge machining.

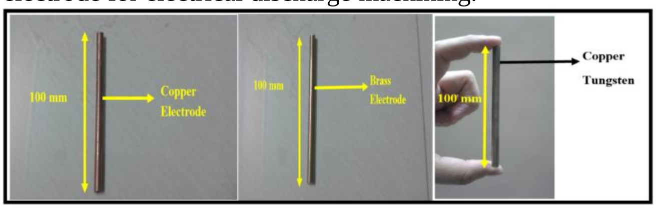


Fig.5Electrode Materials

3. V-block and Tool holder arrangement

Tool holder and V-Block is arranged in such a manner that machining process should be in desired direction. Fig. 6 explains about the V-block and Tool holder arrangement.

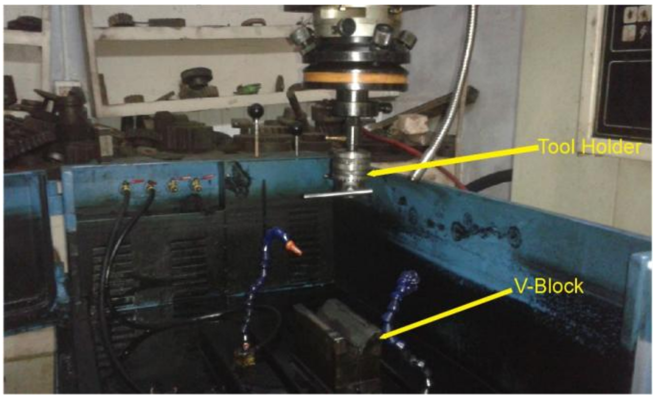


Fig.6 V-Block and Tool Holder arrangement

4. Flatness of Work Piece

Circular workpiece of SS-202 is put on V-block in a flat position so that the desired hole will be in a proper direction. This will also maintain the circularity of the hole. Fig.7 shows the workpiece position on V-block.

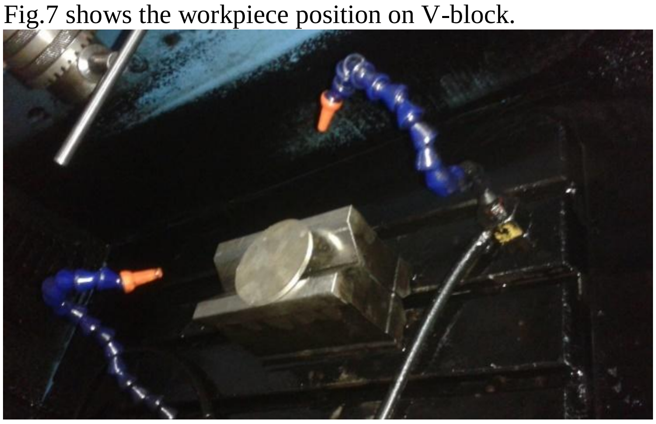


Fig.7Flatness of Work Piece

5. Perpendicularity of electrode

Perpendicularity of electrode should be maintain before performing the machining operation on EDM machine. Fig.8 explains about the Perpendicularity of the electrode.

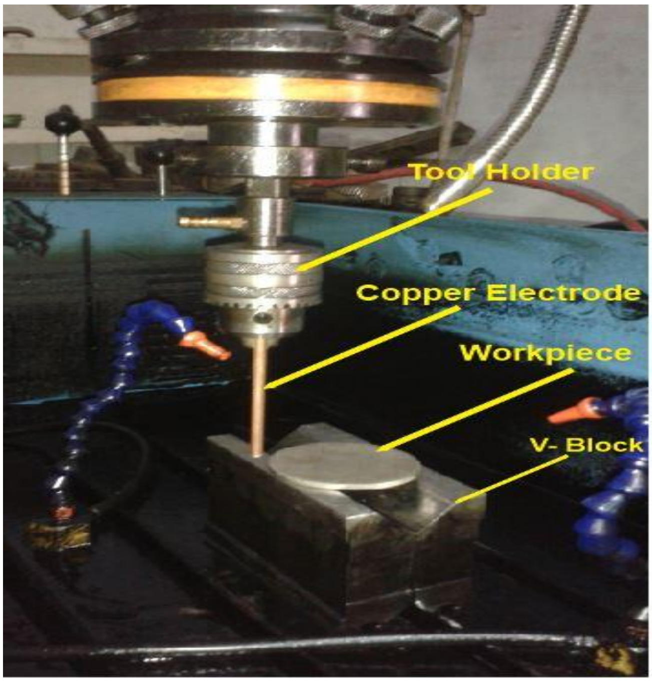


Fig.8Perpendicularity of electrode

6. Gap Setting

Gap between Tool electrode and Workpiece must be maintain before machining operation. This Gap is generally 0.025 mm. Fig.9shows the Gap setting of Tool electrode and Workpiece.

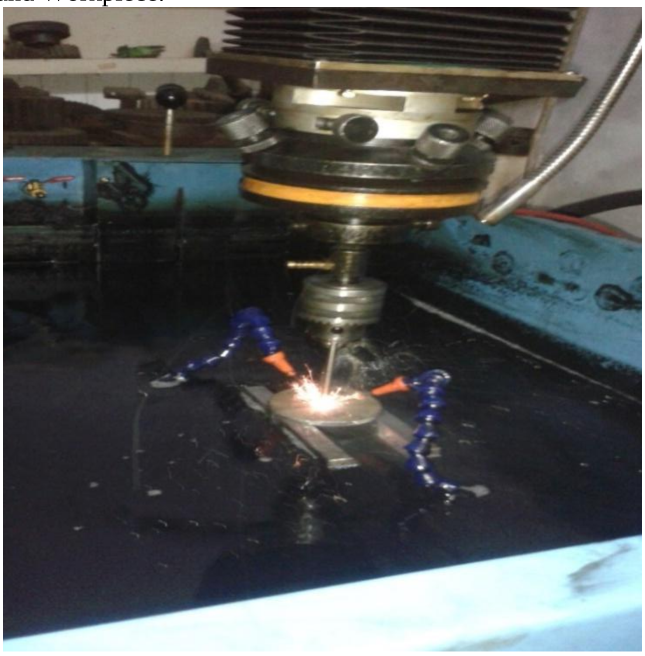


Fig.9Gap Setting

7. Jet Flushing Nozzle Setting

Position of Jet flushing nozzle should be maintain in such a way that eroded particles from workpiece removed properly. This helps to avoid carbon submission on Tool electrode and Workpiece. Fig.10 shows Jet flushing nozzle setting.

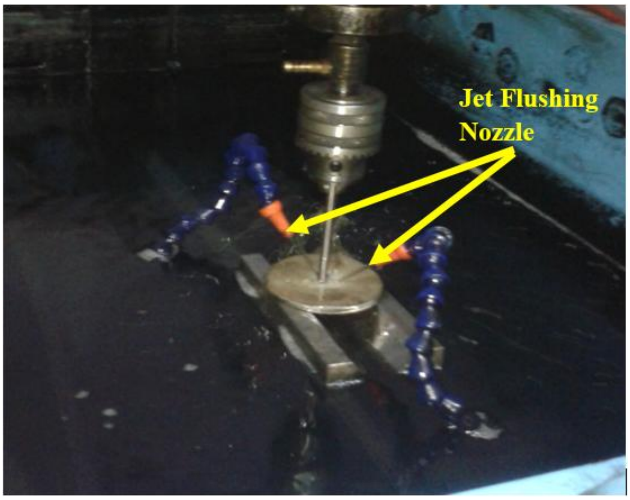


Fig.10Jet Flushing Nozzle Setting

8. Feed Data in Control Unit

When experiment is about to perform we have to put the values in control unit of machine. First we will set the value of pulse current and depth of cut in control unit. Fig.11 explains about the control unit of machine.

Fig.11Control Unit

9. Machining of Work Piece

Now the experiment will performed on machine. Fig.12 shows the electrical discharge machining of workpiece.

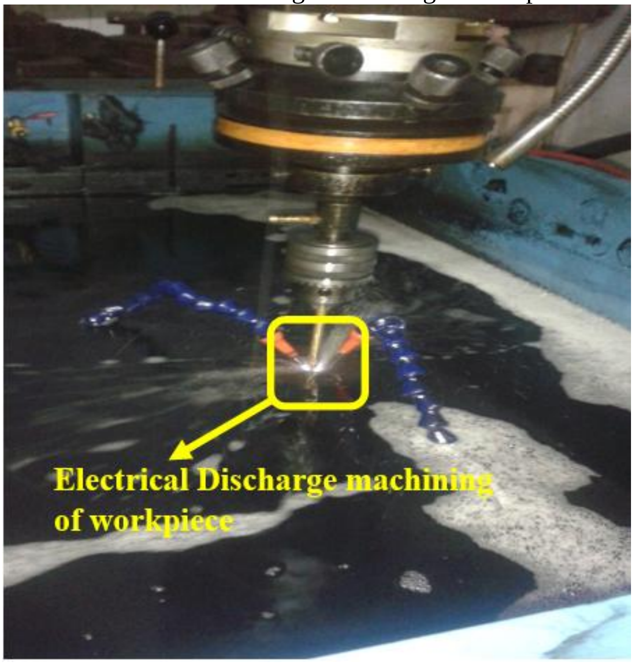


Fig.12Machining of Work Piece

II. DATA COLLECTION

The pulse current is normally selected on the basis of the maximum removal rate possible within the allowable mean current, electrode wear and surface integrity. The experiments were carried out for a depth of cut of 4 mm for Copper, Brass, Copper Tungsten electrode materials with three different pulse current settings of 5 A, 8 A and 11 A. Electrode Wear Rate (EWR) is expressed as the ratio of difference of mass of the electrode before and after machining to the machining time.

$$\text{EWR} = \frac{W_{eb} - W_{ea}}{T}$$

Where, EWR = Electrode Wear Rate (g/min)

Web = Mass of Electrode before machining (gram)

Wea = Mass of Electrode after machining (gram)

T = Machining time (minutes)

a) EWR with Copper Electrode at 5A

EWR of workpiece SS-202 with respect to 5A Pulse current is shown in the Table.3

Table.3 Data collection of EWR at 5A

Exp. No.	Weight of electrode before	Weight of electrode after	Time (Minutes)	Difference of Weight	Electrode Wear Rate
1	28.810	28.690	14.75	0.120	0.0081
2	28.690	28.560	14.67	0.130	0.0089
3	28.560	28.455	14.63	0.105	0.0072
4	28.455	28.350	14.17	0.105	0.0074
5	28.350	28.240	14.58	0.110	0.0075

b) EWR with Copper Electrode at 8A

EWR of workpiece SS-202 with respect to 8A Pulse current is shown in the Table.4

Table.4 Data collection of EWR at 8A

Exp. No.	Weight of electrode before	Weight of electrode after	Time (Minutes)	Difference of Weight	Electrode Wear Rate
1	28.810	28.720	8.50	0.090	0.0106
2	28.720	28.615	8.25	0.105	0.0127
3	28.615	28.510	8.75	0.105	0.0120
4	28.510	28.408	8.67	0.102	0.0118
5	28.408	28.290	8.25	0.118	0.0143

c) EWR with Copper Electrode at 11A

EWR of workpiece SS-202 with respect to 11A Pulse current is shown in the Table.5

Table.5 Data collection of EWR at 11A

Exp. No.	Weight of electrode before	Weight of electrode after	Time (Minutes)	Difference of Weight	Electrode Wear Rate
1	28.810	28.790	5.50	0.020	0.0036
2	28.790	28.775	5.75	0.015	0.0026
3	28.775	28.755	5.25	0.020	0.0038
4	28.755	28.730	5.70	0.025	0.0044
5	28.730	28.715	5.50	0.015	0.0027

d) EWR with Brass Electrode at 5A

EWR of workpiece SS-202 with respect to 5A Pulse current is shown in the Table.6

Table.6 Data collection of EWR at 5A

Exp. No.	Weight of electrode before	Weight of electrode after	Time (Minutes)	Difference of weight	Electrode Wear Rate
1	27.410	24.878	24.67	2.532	0.1026
2	24.878	22.465	24.50	2.413	0.0985
3	22.465	20.015	24.42	2.450	0.1003
4	20.015	17.645	24.50	2.370	0.0967
5	17.645	15.230	24.58	2.415	0.0982

e) EWR with Brass Electrode at 8A

EWR of workpiece SS-202 with respect to 8A Pulse current is shown in the Table.7

Table.7 Data collection of EWR at 8A

Exp. No.	Weight of electrode before	Weight of electrode after	Time (Minutes)	Difference of weight	Electrode Wear Rate
1	27.410	25.722	23.67	1.688	0.0713
2	25.722	24.172	23.58	1.550	0.0657
3	24.172	22.878	23.67	1.294	0.0547
4	22.878	21.217	23.70	1.661	0.0701
5	21.217	19.978	23.25	1.239	0.0533

f) EWR with Brass Electrode at 11A

EWR of workpiece SS-202 with respect to 11A Pulse current is shown in the Table.8

Table.8 Data collection of EWR at 11A

Exp. No.	Weight of electrode before	Weight of electrode after	Time (Minutes)	Difference of weight	Electrode Wear Rate
1	27.410	25.035	18.58	2.375	0.1278
2	25.035	23.642	18.67	1.393	0.0746
3	23.642	21.820	18.42	1.822	0.0989
4	21.820	19.640	18.67	2.180	0.1168
5	19.640	17.385	18.70	2.255	0.1206

g) EWR with Cu-W Electrode at 5A

EWR of workpiece SS-202 with respect to 5A Pulse current is shown in the Table.9

Table.9 Data collection of EWR at 5A

Exp. No.	Weight of electrode before	Weight of electrode after	Time (Minutes)	Difference of weight	Electrode Wear Rate
1	39.960	39.905	18.67	0.055	0.0029
2	39.905	39.850	18.58	0.055	0.0030
3	39.850	39.790	18.72	0.060	0.0032
4	39.790	39.730	18.53	0.060	0.0032
5	39.730	39.665	18.40	0.065	0.0035

h) EWR with Cu-W Electrode at 8A

EWR of workpiece SS-202 with respect to 8A Pulse current is shown in the Table.10

Table.10 Data collection of EWR at 8A

Exp. No.	Weight of electrode before	Weight of electrode after	Time (Minutes)	Difference of weight	Electrode Wear Rate
1	39.960	39.915	8.50	0.045	0.0053
2	39.915	39.872	8.25	0.043	0.0052
3	39.870	39.827	8.75	0.043	0.0049
4	39.825	39.785	8.67	0.040	0.0046
5	39.780	39.738	8.25	0.042	0.0051

i) EWR with Cu-W Electrode at 11A

EWR of workpiece SS-202 with respect to 11A Pulse current is shown in the Table.11

Table.11 Data collection of EWR at 11A

Exp. No.	Mass of electrode before	Mass of electrode after	Time (Minutes)	Difference of Mass	Electrode Wear Rate
1	39.960	39.950	3.75	0.010	0.0027
2	39.950	39.942	3.53	0.008	0.0023
3	39.942	39.931	3.67	0.011	0.0030
4	39.931	39.923	3.80	0.008	0.0021
5	39.923	39.911	3.42	0.012	0.0035

III. RESULT AND DISCUSSION

Variation of electrode wear rate for Copper electrode with respect to Pulse current 5A, 8A and 11A are shown respectively in the following graph.

Fig.13Electrode wear rate at 5A

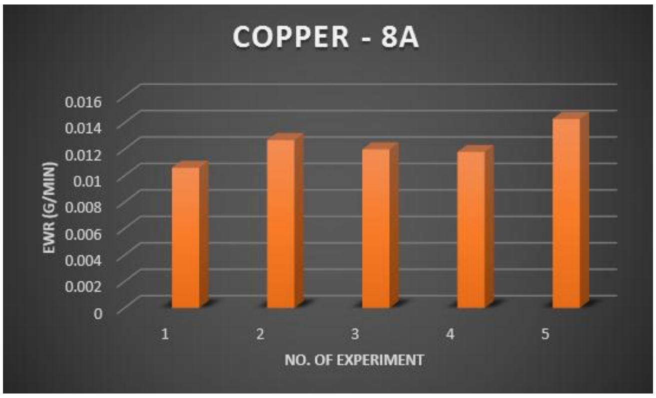


Fig.14Electrode wear rate at 8A

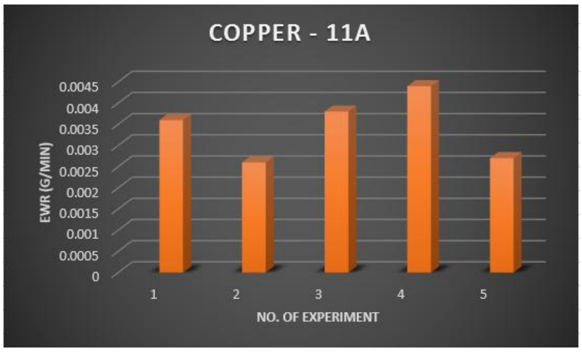


Fig.15Electrode wear rate at 11A

Variation of electrode wear rate for Brass electrode with respect to Pulse current 5A, 8A and 11A are shown respectively in the following graph.

Fig.16Electrode wear rate at 5A

Fig.17Electrode wear rate at 8A

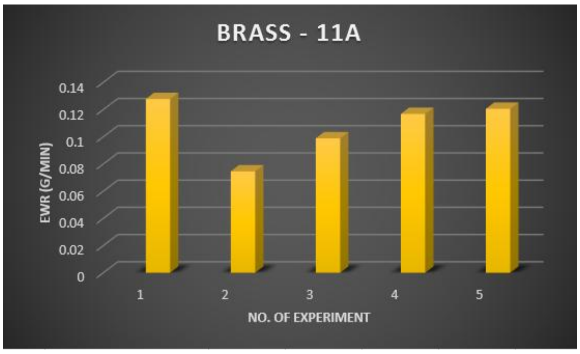


Fig.18Electrode wear rate at 11A

Variation of electrode wear rate for Copper Tungsten electrode with respect to Pulse current 5A, 8A and 11A are shown respectively in the following graph.

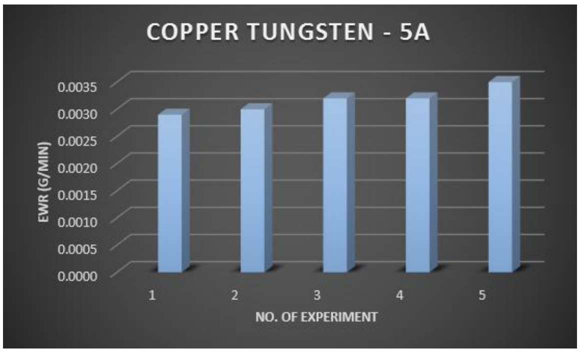


Fig.19Electrode wear rate at 5A

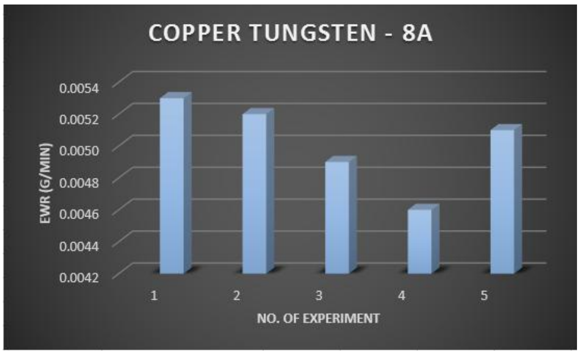


Fig.20Electrode wear rate at 8A

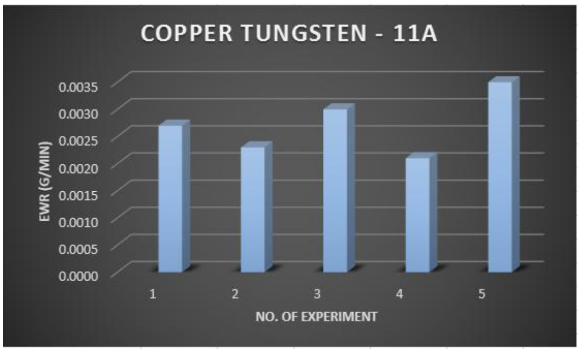


Fig.21Electrode wear rate at 11A

As the high density of electron impingement occurs at workpiece and electrode material during electrical discharge machining causes electrode wear. The electrode wear vs pulse current for SS- 202 material is shown in Fig.22

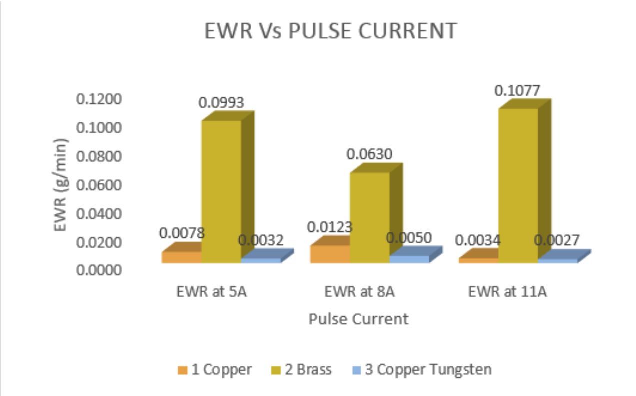


Fig.22Electrode Wear Rate Vs Pulse Current

Brass has the highest electrode wear. Copper tungsten shows least amount of electrode wear. As the melting point of Copper is low electrode wear increases as the pulse current increases. Copper tungsten has less electrode wear because of its high melting point.

Copper tungsten also has the property to resist spark which is responsible for less electrode wear as compare to Brass and Copper electrode.

IV. CONCLUSIONS

1. The less electrode wear ratio (EWR) will make the machining performance better. From this experiment, the best selection electrode for electrode wear ratio (EWR) is copper (0.0078) followed by copper tungsten (0.0036) and brass (0.0900). Fig.23 Represent the electrode wear rate for stainless steel – 202 using different electrode.

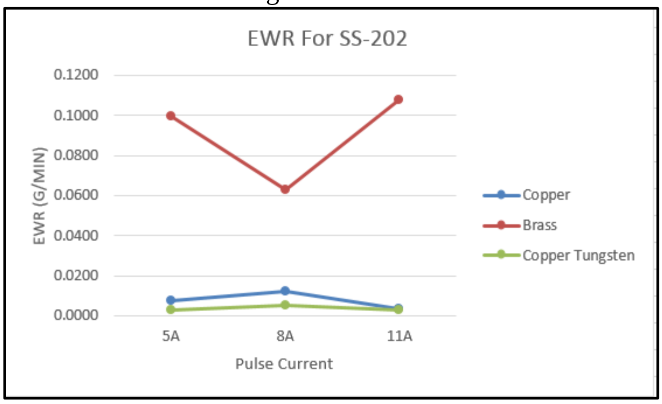


Fig.23Average Electrode Wear Rate for SS – 202

2. In copper tungsten electrode, least amount of electrode wear occurs and there is no corner wear in the electrode. Fig.24 explains about the electrode wear of copper tungsten tool electrode.

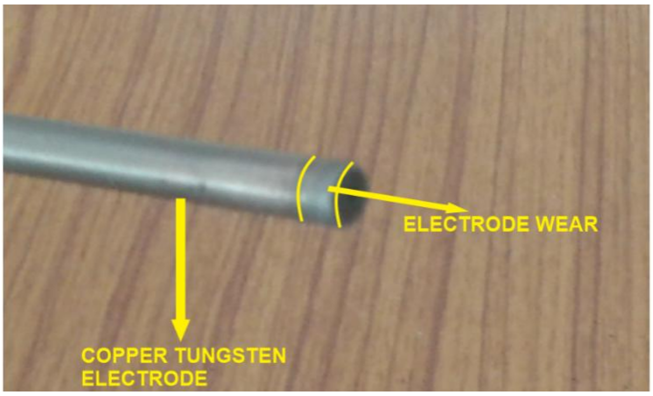


Fig.244 Electrode Wear in Copper Tungsten

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