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COMPARATIVE STUDIES OF EDM MACHINING USING ALUMINIUM, BRASS AND COPPER

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Abstract— - **Electrical discharge machining (EDM) is also called as spark erosion and it is a non-traditional machining process which is based on the thermoelectric energy between the electrode and work specimen. In this procedure, the material removal is happened electro thermally by a progression of progressive discrete releases among anode and the workpiece [1]. In the EDM process, different electrode materials are used for comparative studied. EDM researchers are invented many ways to improve the sparking efficiency with including someone of a kind test ideas experimental concepts that depart from the EDM traditional sparking phenomenon [2]. The Material Removal Rate (MRR), Macro Graph (MG), Surface Roughness (SR), Signal to noise ratio (SN) is measured and recorded for detailed analysis. In the experimental process, different electrode materials are used like Aluminum, Brass, Copper kind of materials employed in the set of experiments and spo oil is used as the dielectric [3]. This experiment is to investigate the best material characteristic in terms of higher Material Removal Rate (MRR), low signal to noise ratio, excellent surface finish and the Macro Graphs after machining. Various machining parameters used to conduct an experiment are depth of cut, time pulse, current, frequency, lift time on materials like copper, brass, aluminium.**

Keywords— **Electrical discharge machining, Copper, Brass, Aluminum, Material removal rate, Electrodes, Metal removal**.

I. INTRODUCTION

Electrical Discharge Machining (EDM) is the non-conventional electro thermal machining process. EDM is the process to generate the electrical spark to remove the material due to thermal energy by using electrical energy. The high voltages are used between the two electrodes by the using of electric field and the space between two electrodes has a good strength allow to break the materials [4]. The EDM is invented in the year of 1940 and it is developed, and many documents are published to present the results for in specific cases and made a lot of experiments on different materials with certain operating conditions.

Nowadays EDM process is highly using in the large-scale industries for the precision machine of all kind of conductive materials like graphite, ceramic materials, alloys regarding hardness and EDM is used to machine the high complex shapes [5]. This process is largely applied on mould making and in construction prototypes. The objective of this paper to study the characteristic behaviour of copper, brass and aluminium using constant speed and feed by calculating the metal removal rate with different depths of cuts through electric discharge machining.

II. LITERATURE REVIEW

In non-traditional machining, an extensive measure of material is expelled from the raw material to get the ideal profile. The metal removal process is a highly expensive process by comparing other manufacturing processes. So, cost awareness it is highly expected to produce the product. There is no logical and financial approach ways to deal with decrease the non-productive occasions however there are extensive conceivable outcomes in reducing the machining time without reducing the nature of the machined product [6]. In recent days more priority is given in MRR, dimensional accuracy for products by the industry and they need to select the parameters to satisfy the customer requirements. Because of high speculation and machining cost of nonconventional machines, there is an effective need to work the machines as productively as conceivable to get the necessary compensation. The expense of machining is a kind of sensitive to select of machining factors [7].

With the advancement and developments in new technologies, low weight- high strength and high hardness and temperature resistant materials have been developed for special applications like aerospace, automobile, medical etc. Since the presentation of the Wire Electric Discharge Machining (WEDM) process, it has developed from a straightforward method for making apparatuses and bites the dust to the best option of delivering smaller scale leaves behind the most noteworthy level of dimensional precision and surface completion [8]. WEDM is a complex machining process constrained by an enormous number of procedure parameters, for example, the beat length release recurrence and releases current force, wire electrode speed, dielectric flow rate etc. and small variations can be effective in the matching performance [9]. From the detailed information, WEDM parameters influence on output characteristics are available before shaping the material and it is a useful application. This literature reviews the research work with an attempt to understand and interpret the previous work on different aspects related to EDM/WEDM. The literature subsequently reviewed under different categories

III. EXPERIMENTAL SETUP AND PROCESS

The machining is carried out on Electronica C-425 EDM setup. Brass, Copper and Mild steel are used as work material with the copper electrode and spo oil as dielectric oil [10]. Experiments were performed using Electronica C-425 EDM. Copper material is used as an electrode. Spo oil is used as a dielectric fluid in this experiment. The experiment is conducted using different process parameters like peak current and pulse on time, pulse off time, gap, sensitivity, resistance, duty cycle, impulse current, bi pulse current, spark time, lift time [11].

The different work materials used to find out the material removal rate are Brass, Copper and Mild steel. The MRR is evaluated for each removal condition by evaluating the amount of material specimen removed and the time taken to remove the material [12].

Machining experiments for determining the metal removal rate will be carried out by setting voltage in the range of 120-200v, the discharge current in the range of 6.0 to 18.0A, the pulse duration in the range of 30-90μs, and the gap between the electrode and workpiece in the range of 1-20 [13].

Once when the required parameters are chosen and set, the machining starts [14]. Either the machining time or the depth of cut is made as a fixed parameter and accordingly, the readings are noted down. if the depth of cut is made fixed, then the time taken is noted and if the time is made fixed, the depth of cut is fixed. Spo oil is a combination of hydrated water, kerosene and glycerine. As the electrode moves up and down, due to the contact of the workpiece and electrode, the current flows and material are removed which is called pulse on time [15]. When the electrode moves away from metal, the current doesn't flow and the removed material is washed away with the help of dielectric fluid, this stage is called the pulse of time. In this way the removal of the metal takes place [16].

Fig.1 EDM machine

IV. MATERIAL SELECTION

In this case, we selected the three different materials with different parameters like brass, aluminium and copper. The materials selected because of in recent days the large-scale industries are using these kind materials because these materials are almost using in the composition of every material and so many researches are investigation on about their physical and mechanical properties to make the new composition of the materials. The physical properties of the materials shown in the below:

Table 1. Physical properties of brass

Density g/cm^3	8.470 g/cm^3
Melting range ^{0}c	900 to 940 °C
Specific heat J/gm. K	0.380
Resistivity ohm.m	5.9 x 10^{-8}
Temperature coefficient (1/^{0}C)	1.5 x 10^{-3}

Table 2. Physical properties of copper

Density g/cm^3	8.96 g/cm^3
Melting range ^{0}c	1,085 °C
Specific heat J/gm. C	0.385

Resistivity ohm.m	1.724×10^{-8}
Temperature coefficient ($1/^{0}C$)	4.29×10^{-3}

Table 3. Physical properties of aluminium

Density g/cm^3	2.75 g/cm^3
Melting range ^{0}c	660.3°C
Specific heat J/gm. C	0.900
Resistivity ohm.m	2.82×10^{-8}
Temperature coefficient ($1/^{0}C$)	0.00427

V. EXPERIMENTAL CONDITIONS

In the experimental conditions, two different stages are used with 6 experiments. In each stage, 3 experiments are made and those are shown in the below figure:

Fig 2. Brass as specimen and copper, brass, aluminium as electrodes

Stage-1

Experiment 1: Brass as a specimen
1. Copper as Electrode
2. Brass as Electrode
3. Aluminium as Electrode

Experiment 2: Copper as a specimen
1. Copper as electrode
2. Brass as electrode
3. Aluminium as electrode

Fig 3. Copper as specimen and copper, brass, aluminum as electrodes

Experiment 3: Aluminium as Specimen
1. Copper as Electrode
2. Brass as Electrode
3. Aluminum as Electrode

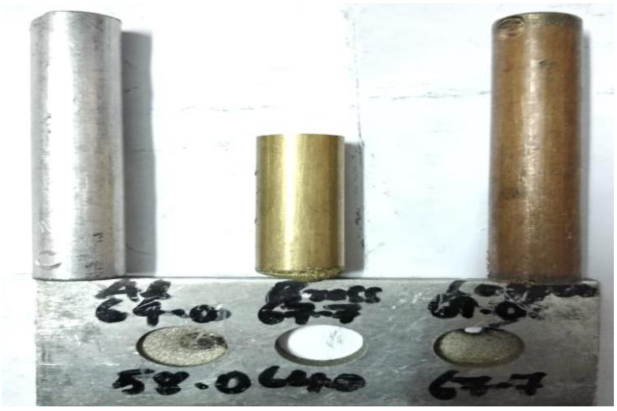

Figure 4. Aluminium as specimen and copper, brass, aluminium as electrodes

Table 4. Stage 1 parameters for machining

Resistance (Ω)	63
Duty cycle (τ)	9
Impulse (amps)	10
Bi impulse (amps)	3
Sparking time(secs)	2
Lift time (secs)	2
Gap (v)	10
Sensation	20

Stage-2

Experiment -4: Brass as specimen
1. Copper as Electrode
2. Brass as Electrode
3. Aluminum as Electrode

Fig 5. Brass as specimen copper, brass, aluminum as electrodes

Experiment-5: Copper as Specimen
1. Copper as Electrode
2. Brass as Electrode
3. Aluminum as Electrode

Fig 6. Copper as Specimen and copper, brass, aluminum as electrodes

Experiment-6: Aluminium as Specimen
1. Copper as Electrode
2. Brass as Electrode
3. Aluminum as Electrode

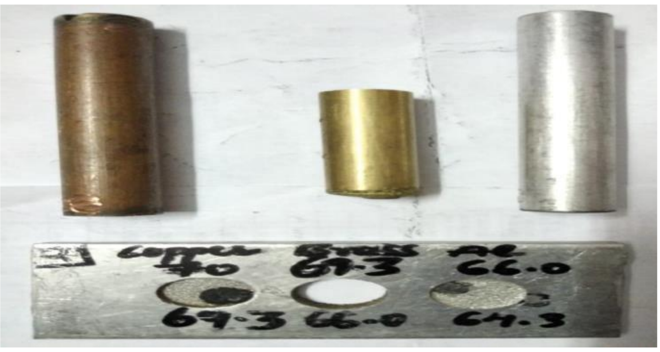

Fig 7. Aluminium as Specimen and copper, brass, aluminium as electrodes

Table 5. Stage 2 parameters for machining

Resistance (Ω)	63
Duty cycle (τ)	9
Impulse (amps)	19
Bi impulse (amps)	3
Sparking time(secs)	5
Lift time (secs)	2
Gap (v)	15
Sensation	20

From the above table, some parameters are changed like impulse and sparking time.

Specifications:
Electrode Diameter-16mm.
Length-100mm.
Specimen length100mm*Width50mm*Thickness5mm.

Grades of materials used:
Copper-C106/CW024A.
Aluminium-Alloy 2024.
Brass C38500.

VI. RESULTS AND DISCUSSION

A conclusion, In this case, the different parameters are used in stage 1 and stage 2 as shown in table 4 and 5 and each specimen is used to make the results for each electrode and results are compared. In each stage, each material is calculated with each electrode to make a proper comparison.

In stage 2 experiments some experimental parameters are changed and from these results, MRR is little high value in stage 2 by comparing the results from stage 1. From all results, MRR is high in both stage 1 and sate2.

Stage-1: Brass as specimen
Experiment-1: (A)Copper as electrode

Table 6. Results for copper as electrode

The initial weight of workpiece before machining	268gms
The final weight of workpiece before machining	264.4gms
Time is taken for the machining to be done	2
MRR	30mm^3/min
Surface roughness (Ra)	2.5 µm
Signal to Noise Ratio	0.3174

(B)Brass as electrode

Table 7. Results for brass as electrode

The initial weight of workpiece before machining	258gms
The final weight of workpiece before machining	255gms
Time is taken for the machining to be done	2
MRR	$25mm^3/min$
Surface roughness (Ra)	5.70 µm
Signal to Noise Ratio	0.3174

(C)Aluminum as electrode

Table 8. Results for aluminum as electrode

The initial weight of workpiece before machining	264.4gms
The final weight of workpiece before machining	258gms
Time is taken for the machining to be done	2
MRR	$53.3mm^3/min$
Surface roughness (Ra)	2.75 µm
Signal to Noise Ratio	0.3174

Experiment-2: Copper as specimen

(A)Copper as electrode

Table 9. Results for copper as electrode

The initial weight of workpiece before machining	239.8gms
The final weight of workpiece before machining	239gms
Time is taken for the machining to be done	2
MRR	$6.6mm^3/min$
Surface roughness (Ra)	2.24 µm
Signal to Noise Ratio	3.15

B)Brass as electrode

Table 10. Results for brass as electrode

The initial weight of workpiece before machining	238.6gms
The final weight of workpiece before machining	238gms
Time is taken for the machining to be done	2
MRR	$5mm^3/min$
Surface roughness (Ra)	0.7175 µm
Signal to Noise Ratio	0.3174

(C)Aluminium as electrode

Table 11. Results for aluminium as electrode

The initial weight of workpiece before machining	239gms
The final weight of workpiece before machining	238.6gms
Time is taken for the machining to be done	2
MRR	$3.3mm^3/min$
Surface roughness (Ra)	1.121µm
Signal to Noise Ratio	0.3174

Experiment-3: Aluminum as a specimen

(A)Copper as electrode

Table 12. Results for copper as an electrode

The initial weight of workpiece before machining	69gms
The final weight of workpiece before machining	67.7gms
Time is taken for the machining to be done	2
MRR	$10mm^3/min$
Surface roughness (Ra)	2.935 µm
Signal to Noise Ratio	3.15

(B)Brass as electrode

Table 13. Results for brass as electrode

The initial weight of workpiece before machining	268gms
The final weight of workpiece before machining	264.4gms
Time is taken for the machining to be done	2
MRR	$30mm^3/min$
Surface roughness (Ra)	2.5 µm
Signal to Noise Ratio	0.3174

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(C)Aluminium as electrode

Table 14. Results for aluminium as electrode

The initial weight of workpiece before machining	64gms
The final weight of workpiece before machining	58gms
Time is taken for the machining to be done	2
MRR	50mm^3/min
Surface roughness (Ra)	2.234 µm
Signal to Noise Ratio	0.3174

Stage-2:
It is observed that signal to noise ratio and surface roughness is constant although the parameters have been changed. By the changing of properties and it will variant in stage 2 results.

Experiment- 4: Brass as the specimen

(A)Copper as electrode

Table 15. Results for copper as an electrode

The initial weight of workpiece before machining	272gms
The final weight of workpiece before machining	262gms
Time is taken for the machining to be done	30min
MRR	333.33mm^3/min
Surface roughness (Ra)	2.24 µm
Signal to Noise Ratio	3.15

(B)Brass as electrode

Table 16. Results for brass as electrode

The initial weight of workpiece before machining	262gms
The final weight of workpiece before machining	253gms
Time is taken for the machining to be done	30min
MRR	300mm^3/min
Surface roughness (Ra)	2.24 µm
Signal to Noise Ratio	3.15

(C)Aluminium as electrode

Table 17. Results for aluminium as electrode

The initial weight of workpiece before machining	253gms
The final weight of workpiece before machining	246gms
Time is taken for the machining to be done	30min
MRR	233.3mm^3/min
Surface roughness (Ra)	1.121µm
Signal to Noise Ratio	0.3174

Experiment- 5: Copper as a specimen

(A)Copper as electrode

Table 18. Results for copper as an electrode

The initial weight of workpiece before machining	243gms
The final weight of workpiece before machining	242gms
Time is taken for the machining to be done	30min
MRR	33.33mm^3/min
Surface roughness (Ra)	1.121µm
Signal to Noise Ratio	0.3174

(B)Brass as electrode

Table 19. Results for brass as electrode

The initial weight of workpiece before machining	242gms
The final weight of workpiece before machining	241.3gms
Time is taken for the machining to be done	30min
MRR	25.33mm^3/ min
Surface roughness (Ra)	1.121µm
Signal to Noise Ratio	0.3174

(C)Aluminium as electrode

Table 20. Results for aluminium as electrode

The initial weight of workpiece before machining	241.3gms
The final weight of workpiece before machining	241gms
Time is taken for the machining to be done	30min
MRR	10mm^3/min
Surface roughness (Ra)	1.121μm
Signal to Noise Ratio	0.3174

In experiment 5 the MRR value is low by comparing the materials electrodes copper is having the high MRR and aluminium is low MRR

Experiment- 6: Aluminum as a specimen

(A)Brass as electrode

Table 21. Results for brass as electrode

The initial weight of workpiece before machining	67.3gms
The final weight of workpiece before machining	62gms
Time is taken for the machining to be done	30min
MRR	176.66mm^3/min
Surface roughness (Ra)	1.121μm
Signal to Noise Ratio	0.3174

(B)Copper as electrode

Table 22. Results for copper as an electrode

The initial weight of workpiece before machining	70gms
The final weight of workpiece before machining	67.3gms
Time is taken for the machining to be done	30min
MRR	90mm^3/min
Surface roughness (Ra)	1.121μm
Signal to Noise Ratio	0.3174

(C)Aluminium as electrode

Table 23. Results for aluminium as electrode

The initial weight of workpiece before machining	62gms
The final weight of workpiece before machining	60.3gms
Time is taken for the machining to be done	30min
MRR	56.66mm^3/min
Surface roughness (Ra)	1.121μm
Signal to Noise Ratio	0.3174

From the above results in an aluminium, the specimen is taken the less time because pure form aluminium is the very soft material and less weight also. The aluminium is very is the very weak material when it is in the pure form. From these properties, aluminium is very easy to remove and when aluminium is mix with some other material then only it will become strong for this reason aluminium is easy to make a good composition with other materials.

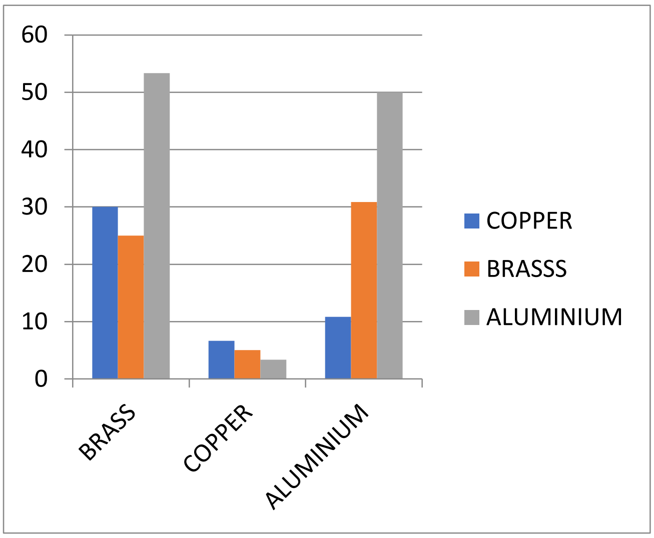

Fig 8. Graphical representation for brass, copper and aluminium in stage 1

Graph denoting Specimens on X-axis and MRR on Y-axis with respect to three different electrodes for a time duration of 2 hours as for stage-1 parameters.

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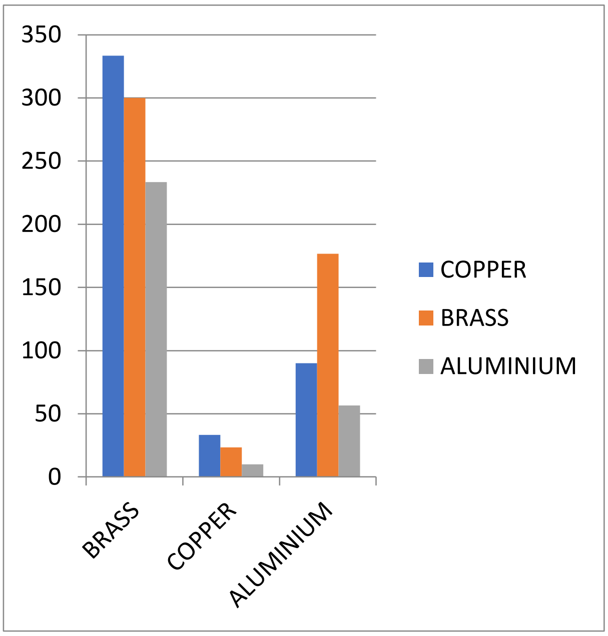

Fig 9. Graphical representation for brass, copper and aluminium in stage 2

Graph denoting Specimens on X-axis and MRR on Y-axis with respect to three different electrodes for a time duration of 30 minutes as for stage-2 parameters.

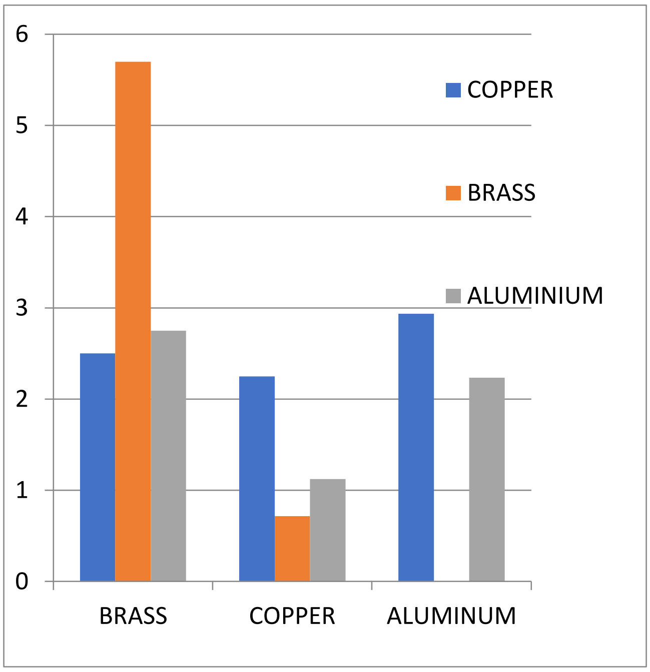

Fig 10. Graphical representation for brass, copper and aluminium in both stages.

Table 24. MRR in descending order for stage 1

S.no	Specimen	Electrode
1	Brass	Aluminium
2	Aluminium	Brass
3	Copper	Brass
4	Brass	Brass
5	Aluminium	Copper
6	Copper	Copper
7	Copper	Brass
8	Copper	Aluminium
9	Aluminium	Aluminium

Table 25. MRR in descending order for stage 2

S.no	Specimen	Electrode
1	Brass	Copper
2	Brass	Brass
3	Brass	Aluminium
4	Brass	Brass
5	Aluminium	Copper
6	Aluminium	Copper
7	Copper	Brass
8	Copper	Aluminium
9	Aluminium	Aluminium

From the above tables the comparison between the two stages of specimen and electrodes for the MRR descending order.

Microscope results for Stage-1

In this case, the metallurgical microscope is used for the inspection which is including the metals and ceramics. This microscope has capable of magnifying the image from the small object and there are some advanced techniques for the student use. The metallurgical microscope includes the total magnification and resolution.

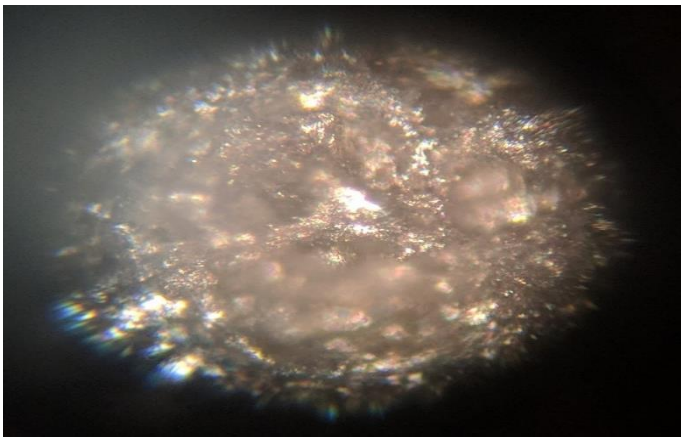

Fig 11. Aluminium specimen machined with Aluminum Electrode.

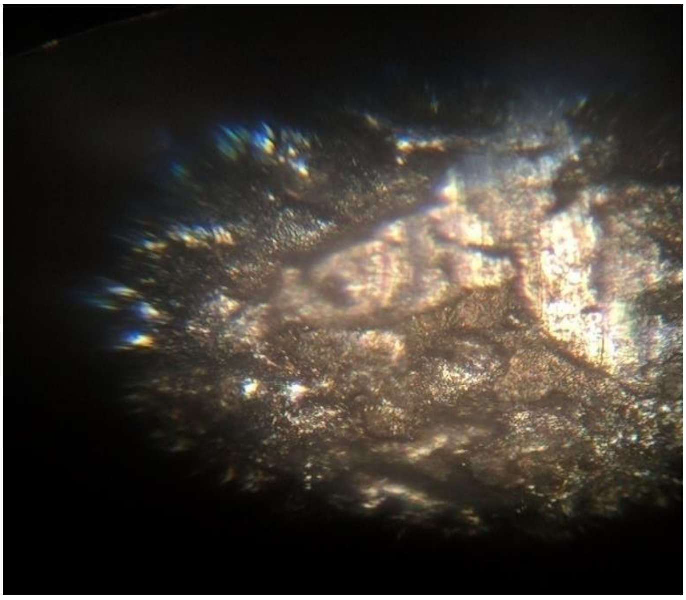

Fig 12. Aluminium specimen machined with Copper Electrode

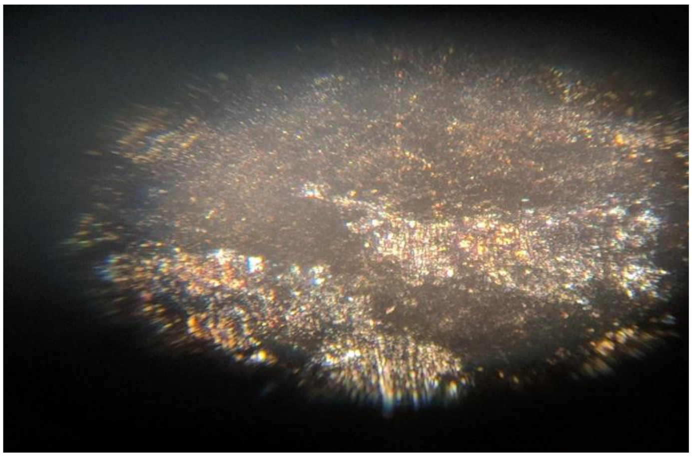

Fig 13. Copper specimen machined with Aluminium Electrode

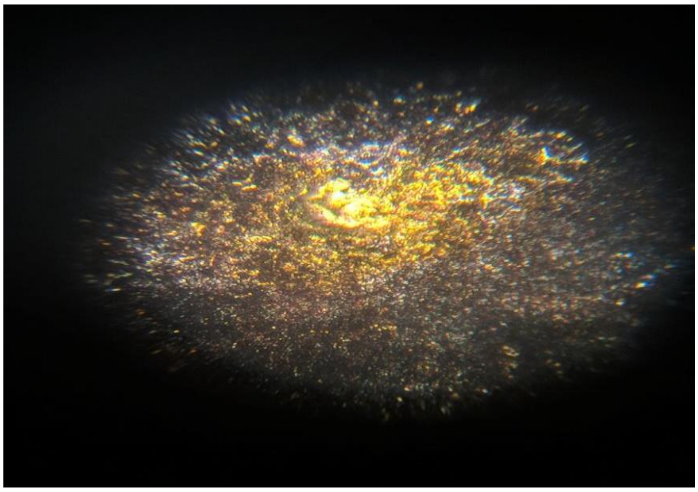

Fig 14. Copper specimen machined with Brass Electrode

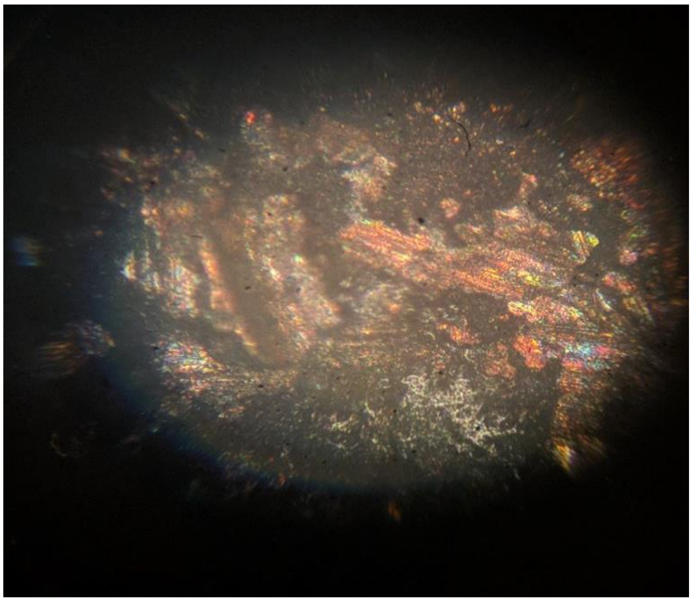

Fig 15. Copper specimen machined with Copper Electrode

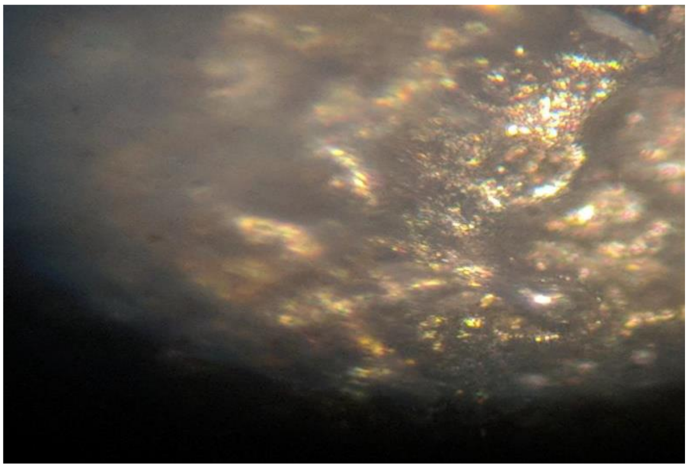

Fig 16. Brass specimen machined with Brass Electrode

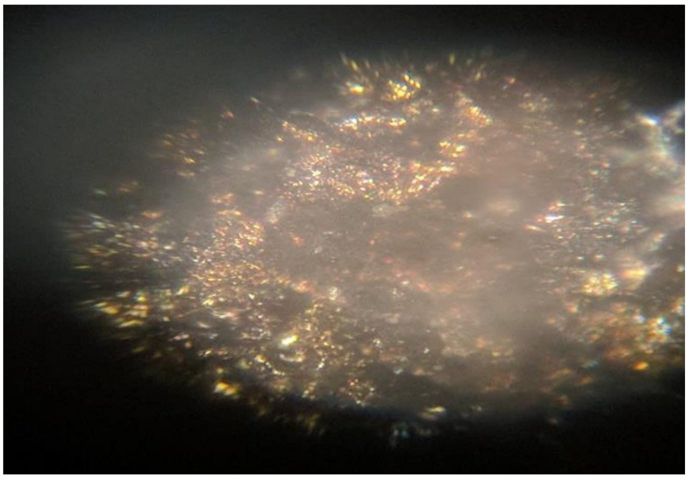

Fig 17. Brass specimen machined with Aluminium Electrode

Macroscope results for Stage-2

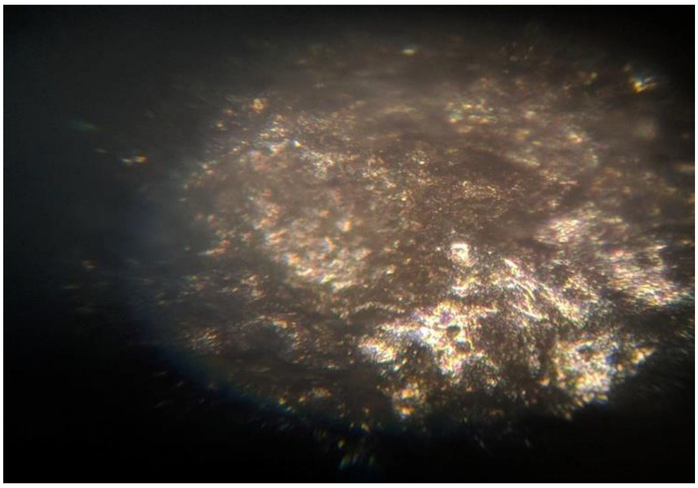

Fig 18. Aluminium specimen machined with Aluminium

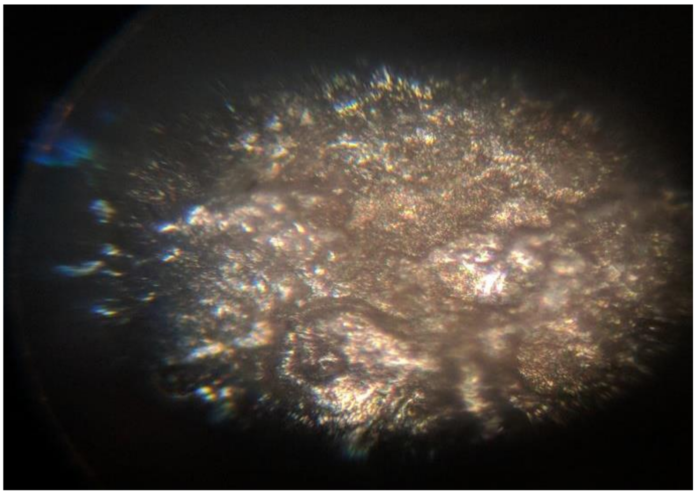

Fig 19. Aluminium specimen machined with Copper Electrode

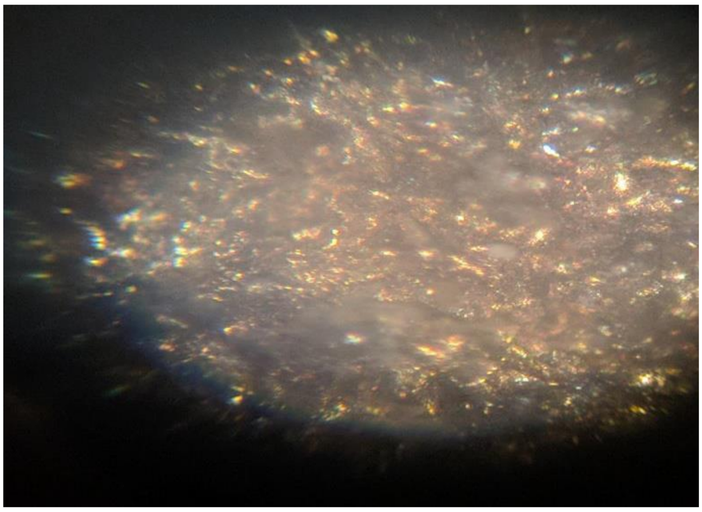

Fig 20. Brass specimen machined with Aluminium Electrode

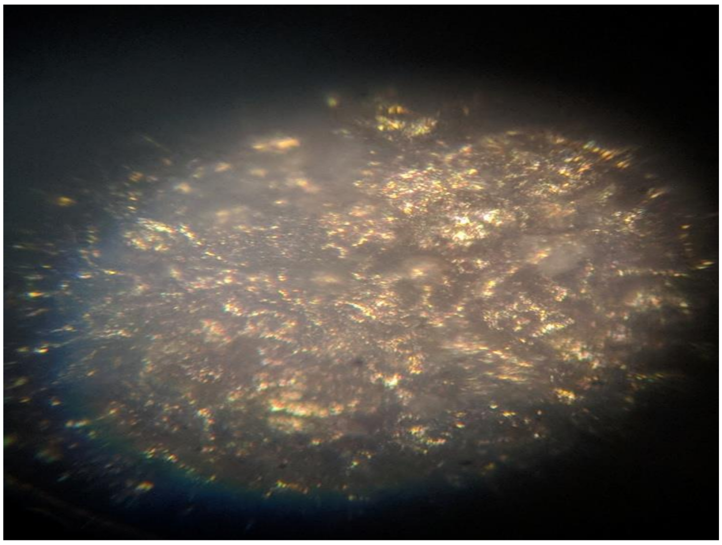

Fig 21. Brass specimen machined with Brass Electrode

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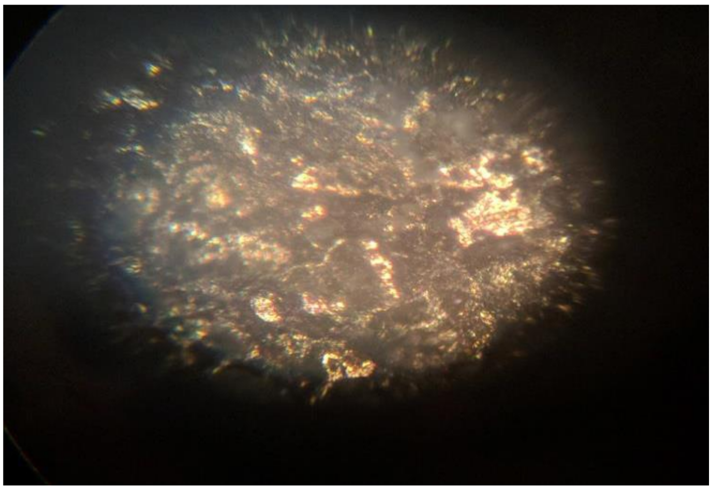

Fig 22. Brass specimen machined with Copper Electrode

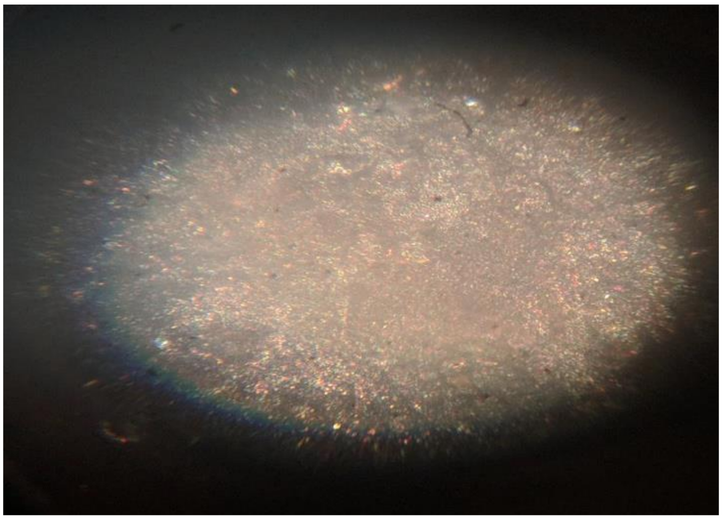

Fig 23. Copper specimen machined with Copper Electrode

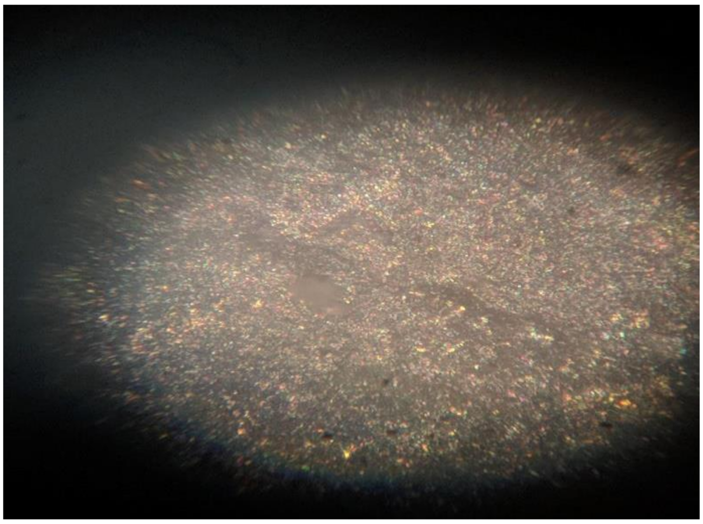

Fig 24. Copper specimen machined with Brass Electrode

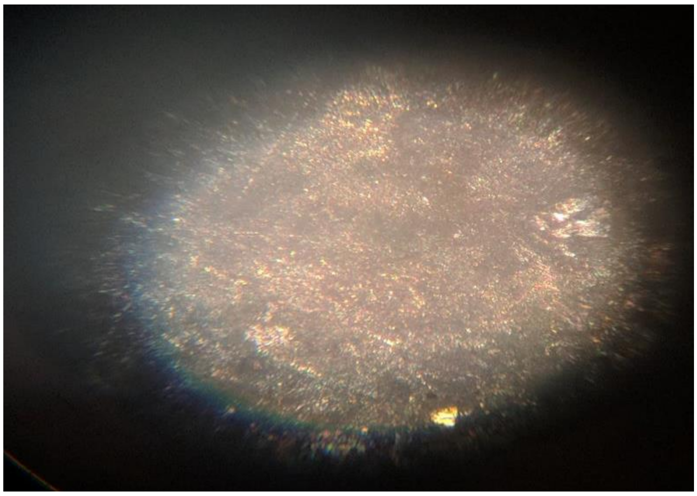

Fig 25. Copper specimen machined with Aluminum Electrode

From the results are shown for stage 1 and satge2. In both, the microscopic results are configured to compare the results.

VII. CONCLUSION

This work has been carried out to measure the metal removal rate, surface roughness, signal to noise ratio and macro graphs of the specimens by machining Brass, Copper and Aluminium with Electric Discharge Machining using a copper, brass and aluminium electrodes.
Based on the results presented herein, we can conclude that the impulse current and time affect the metal removal rate.

The material removal rate is determined with different depth of cuts for copper, brass and aluminium and found that MRR is high for the brass specimen to aluminium electrode in stage 1 and brass specimen to the copper electrode in stage 2. Aluminium specimen to aluminium electrode has the lowest material removal rate due to the formation of aluminium oxides. The MRR is indirectly proportional to the time to take for the machining process. It is found that Surface finish is higher in case of the copper specimen to the brass electrode with surface roughness value Ra =0.7175 And also the lowest surface finish is obtained for Brass specimen to the brass electrode. Macro graphs are taken using the metallurgical microscope and observed after the EDM machining.

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