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JUDUL: EFFECTS OF SURFACE ROUGHNESS USING DIFFERENT ELECTRODES ON ELECTRICAL DISCHARGE MACHINING (EDM).

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EFFECTS OF SURFACE ROUGHNESS USING DIFFERENT ELECTRODES ON ELECTRICAL DISCHARGE MACHINING (EDM)

MOHD ABD LATIF BIN ABD GHANI

A project report submitted in partial fulfillment
of the requirements for the award of the degree of
Bachelor of Mechanical Engineering with Manufacturing Engineering

Faculty of Mechanical Engineering
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November 2008

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing.

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STUDENT DECLARATION

I declare that this thesis entitled effects of surface roughness using different electrodes on electrical discharge machining (EDM) is the result of my own project except as cited in references. The thesis has not accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :………………………........................
Name : MOHD ABD LATIF BIN ABD GHANI
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Dedicated to my beloved

“family“

For their endless support in term of motivation,

supportive and caring as well throughout the whole project

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ABSTRACT

The electrical discharge machining (EDM), is one of the processing based on non-traditional manufacturing procedures, is gaining increased popularity, since it does not require cutting tools and allows machining involving hard, brittle, thin and complex geometry. The objective of the project is to predict the surface roughness on the workpiece using different electrode such copper, aluminum and brass. There must be a different on surface roughness produce in tool steel workpiece. Results obtained from this study will be compared among each other and similar studies in the literature. The problem of this project is to predict the best electrode among copper, brass and aluminum electros that can give the smoothes surface roughness on the tool steel workpiece. The problem face in this project is to choose and set the parameters before running the experiment. The EDM parameters such as current, pulse on-time, pulse off-time, arc voltage, also can affect the R_a, surface roughness on the workpiece. This is because the parameters are different between the electrodes each electrode has their own characteristics. The tool steel workpiece is machined by EDM using copper, brass, and aluminum electrodes. After machining, the workpiece will be measured using perthometer. Data collected will be analyzed before deciding the best electrode. The best electrode for the EDM between copper, aluminum, and brass is copper electrodes.

ABSTRAK

Electrical discharge machining (EDM) adalah salah satu cara memproses berdasarkan prosedur bukan tradisional. Electrical discharge machining tidak memerlukan mata alat dan membenarkan memproses bahan-bahan kuat, rapuh dan mempunyai bentuk yang compleks. Projek ini adalah bertujuan untuk meramalkan kekasaran permukaan pada bahan dengan mengunakan electrode yang berbeza seperti copper aluminium dan brass. Keputusan yang diperolehi daripada experiment ini akan dibandingkan antara satu sama lain untuk menentukan electrode mana adalah yang terbaik. Permasalahan projek ini adalah untuk menentukan menentukan electrode terbaik yang akan digunakan dalam EDM dan akan memberikan permukaan paling licin pada bahan yang dimesin. Masalah yang dihadapi dalam projek ini adalah untuk menentukan parameter pada EDM seblum menjalankan experimen. Parameter EDM seperti current, pulse on-time, pulse off-time, arc voltage boleh memberi kesan kepada permukan bahan. Ini kerana setiap electrode yang berbeza mempunyai karekter yang berbeza. EDM akan memesin bahan mengunakan electrode copper, brass dan aluminium dan setelah selesai, sampel akan diukur dengan menggunakan perthometer. Data akan dianalisis sebelum menentukan electrode mana adalah terbaik. Berdasarkan experiment ini electrode copper adalah electrode terbaik bebanding aluminium dan brass.

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LIST OF ABBREVIATIONS

ABBREVIATION	MEANING
EDM	Electrical discharge machining
RMS	Root means square
R_q	Root means square
L	Evaluation length
Z	Height
X	Distance along measurement
AA	Arithmetic average
CLA	Center-line average
R_a	Average roughness

CHAPTER 1

INTRODUCTION

1.1 Project title

The title of the project is the effects of surface roughness using different electrodes on electrical discharge machining (EDM).

1.2 Project background

This project background is to predict the effect on the surface roughness on electrical discharge machining (EDM) by using different type of electrodes.

The EDM machining process is a thermal process that involves melting and vaporisation of the workpiece electrode. In this machining process, it uses an electrical discharge to remove material from the workpiece, each spark jump from the electrode to the work piece and its cause the material to be removed from the workpiece. This is how the machining process works in the EDM. The knowledge about the EDM is required before running the process.

The objective of the project is to predict which material of the electrodes will give the best surface roughness on the tool steel workpiece either aluminum, copper or brass.

Another equipment use in the project is perthometer. It is use in this project to measure the surface roughness on each sample machined by each electrode. All the data will be collect and will be analyze.

1.3 Problem statement

The problem of this project is to predict the surface roughness on the tool steel workpiece using different type of the tool in the EDM machining and choosing wrong material will affect the surface on the workpiece. It is because each type of tool has its own characteristic such as conductivity and the strength of the tool. The application of this experiment is to predict which electrode is the best of machining the cavity on the mold. Some of the product that want to be produce by injection molding need very smooth surface.

In the EDM machine, the parameter will affect the surface roughness on the tool steel workpiece is the EDM machine parameter itself. There are two type of the parameter on the EDM machine; it is non electrical and electrical parameter. Electrical parameter may affect the surface roughness is pulsed current and pulse time, higher or lower values of these parameters may decrease or increased the surface roughness on the tool steel workpiece. Each value of this parameter in the process will ensure that the surface roughness produce on the tool steel will be in an acceptable range or not.

1.4 Objective of the project

The objective for this project is to investigate which tool among the aluminum, brass and copper can give the best surface roughness on the tool steel workpiece using EDM machine. The best value is of the surface roughness is 0.35µm.

1.5 Scope of project

The scope of the project is to focus on the investigation of surface roughness on the tool steel workpiece using different types of electrode. The electrodes used is copper, brass and aluminum.

1.6 Thesis organization

Chapter 1: Introduction

In this chapter, its elaborate the main idea of the project and it is including the title of the project, objective of the project, problem statement, scope of the project and the project background. This chapter briefly explains about the guidance and information of the project.

Chapter 2: Literature review

This chapter elaborate the meaning and the information of the project where its inform the detail about the project and where the ideas, data and information of the project area collect from various article and journal as a reference in order to understand the concept of the project.

This chapter includes the introduction of the surface roughness in the EDM machining, the parameter affecting the surface roughness on the workpiece. This chapter also discusses about the machine itself or in other word what is the EDM machine all about and what are the electrical and non electrical parameter in this machine. It also includes the briefly explanation of the parameter in this machine.

This chapter is very important in order to understand the parameter of the EDM and the tool that lead to the better surface roughness on the workpiece. The information and knowledge gain in this chapter advanced to elaborate to the next chapter.

Chapter 3; Research methodology

This chapter discuss on the method that will be use in this project. All the quantity, equipment, method and machine which use in this project will be inform and list in this chapter. The step of the experiment on surface roughness using different electrodes is design before the experiment run.

Chapter 4; result and discussion

In this chapter, all the result generates from the experiment will be analyze. The result of the experiment is evaluated and discussed to know what have been learned.

Chapter 5; Conclusion

These chapters are concluded and decide which material will give the surface roughness. This chapter also concludes if the project is successful and the result is the same as the previous result done as state in the journal and article.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

EDM is no longer a “non-conventional” machining method. It is claimed that EDM is now the fourth most popular machining method, leading behind milling, turning and grinding. One of the major reasons for the turnaround is that in today’s context, EDM machines have dramatically increased their cutting speeds, surface finishes and accuracies with unattended operations. As a result, the sale of these machines has increased dramatically with the growth of EDM technologies.

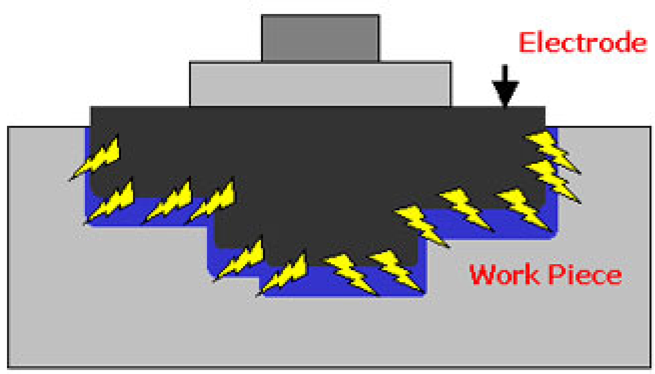

Figure 1: EDM process on workpiece

In this process, the desired shape is formed when sparks jump from the electrode to the work piece and cause material to be removed from the workpiece. Ram EDM is generally used to produce the blind cavities such as Mobile phone cavities, Speaker grill cavities etc [1].

2.2 Fundamental principles of EDM and surface roughness

One of the most important features of the EDM method is its ability to work independently of the mechanical properties of the machined material. Once voltage is applied to the electrode and the work piece, electrons detached from the electrode (cathode) move accelerated towards the work piece. At the destination, they hit neutral dielectric molecules, removing more electrons. These electrons, in turn, accelerate the electron flow towards the anode by similar collisions. This motion of electrons creates a leakage current in the dielectric, evaporating the dielectric fluid in this region. The current increases in the evaporating fluid. At the end, a "plasma" channel is created between the electrode and the work piece. Due to its high temperature, this channel melts or evaporates a "crater" on both the work piece and the electrode. After the plasma channel extinguishes, all of the evaporated and a part of the melted material is flushed away by the flow of dielectric fluid. A small "crater" is created on the surface of the electrode and the work piece. Craters created by a multitude of plasma channels allow the surface machining [7].

2.3 Electro discharge machining process

Electro discharge machining (EDM) is a thermo-electrical material removal process, in which the tool electrode shape is reproduced mirror wise into a work material, with the shape of the electrode defining the area in which the spark erosion will occur. The machine tool holds a shaped electrode, which advances into the work material and produces a high frequency series of electrical spark discharges. The sparks are generated by a pulse generator, between the tool electrode and the work material, submerged in a liquid dielectric, leading to metal removal from the work material by thermal erosion or vaporization. Melting and vaporization of the work material dominates the material removal process in EDM, leaving tiny craters on the surface of the work material. EDM has no contact and no cutting force process, and therefore does not makes direct contact between tool electrode and the work material.

This eliminates the chances of mechanical stress, chatter and vibration problems, as is prominent in traditional machining [13].

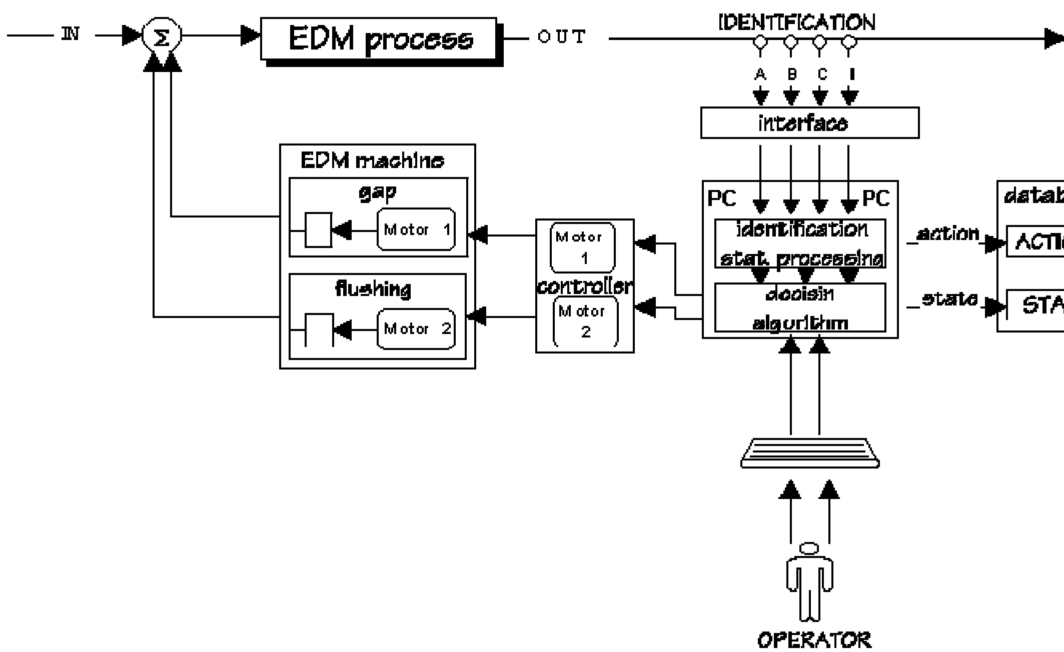

Figure2: Adaptive control system for EDM process control

2.4 Literature survey on surface roughness

2.4.1 Surface roughness (surface quality)

Surface roughness is harder to attain and track than physical dimensions are, because relatively many factors affect surface roughness. Some of these factors can be controlled and some cannot. Controllable process parameters include feed, cutting speed, tool geometry, and tool setup. Other factors, such as tool, workpiece and machine vibration, tool wear and degradation and workpiece and tool material variability cannot be controlled as easily [3].

The closed-form solutions of surface roughness parameters for a theoretical profile consisting of elliptical arcs are presented. Parabolic and simplified approximation methods are commonly used to estimate the surface roughness parameters for such machined surface profiles. The closed-form solution presented in this study reveals the range of errors of approximation methods for any elliptical arc size. Using both implicit and parametric methods, the closed-form solutions of three surface roughness parameters, Peak-to-Valley Roughness, Rt, Arithmetic Average Roughness Ra, and Root-Mean-Square Roughness Rq, were derived [6].

In other work surface roughness or surface quality, also known as surface texture are terms used to describe the general quality of machined surface, which is concerned with the geometric irregularities and the quality of a surface. The ideal surface roughness may be specified in various ways, but two common methods are the peak to valley height (h) and the arithmetic average, Ra (µm). The Ra value, also known as centre line average (CLA) and arithmetic average (AA) is obtained by averaging the height of the surface above and below the centre line [11].

In EDM process, the surface produced consists of a large number of craters that are formed from the discharge energy. The roughness of surface mainly depends upon the energy per spark. If the energy content is high, deeper craters will be attained, leading to poor surface. The surface roughness has also been found to be inversely proportional to the frequency of discharge. Assuming that each spark leads to a spherical crater formation on the surface of workpiece, the volume of metal removed per crater will be proportional to the cube of the crater depth [10].

2.4.2 Root mean square (RMS)

RMS roughness was defined as follows: [3], [4]

$$R_q = \sqrt{\frac{1}{L}\int_0^L Z^2\,(x)dx} \qquad \text{(Eq 2)}$$

Where,

L = evaluation length

z = height

x = distance along measurement

2.4.3 AA (arithmetic average) or center-line average (CLA) roughness

AA (arithmetic average) or center-line average (CLA) roughness: [3], [4].

$$R_a = \frac{1}{L}\int_0^L |z(x)|\,dx \qquad \text{(Eq 2.1)}$$

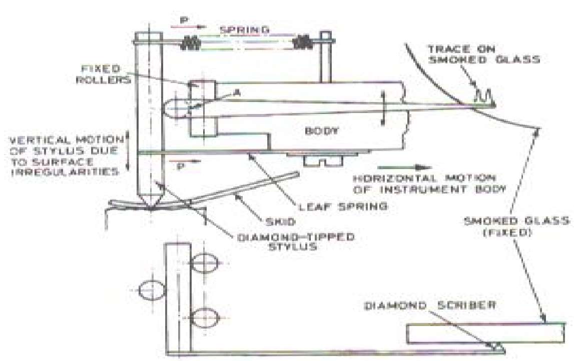

Figure 3: Tomlinson Roughness Meter [3]

Result of EDM done by copper electrode [7]

Table 3 – Results of the EDM experiment done by copper electrodes

I (A)	t_{on} (μs)	t_{off} (μs)	V (V)	R_a (μm)	I (A)	t_{on} (μs)	t_{off} (μs)	V (V)	R_a (μm)	I (A)	t_{on} (μs)	t_{off} (μs)	V (V)	R_a (μm)
7	6	12	40	1.7	7	12	25	40	1.68	12	12	12	100	2.85
7	12	12	40	1.85	7	25	25	40	1.93	12	25	12	100	3.2
7	25	12	40	2.14	7	50	25	40	2.28	12	100	12	100	4.03
7	50	12	40	2.43	7	100	25	40	2.68	22	6	12	40	2.76
7	100	12	40	2.64	7	12	25	60	1.85	22	12	12	40	3.31
7	12	12	60	1.94	7	25	25	60	2.1	22	50	12	40	4.65
7	25	12	60	2.4	12	100	25	60	3.77	22	100	12	40	4.8
7	100	12	60	2.9	12	6	25	80	2.12	22	6	12	60	3.06
7	6	12	80	1.9	12	12	25	80	2.46	22	12	12	60	3.61
7	12	12	80	2.1	12	50	25	80	3.21	22	50	12	60	4.8
7	50	12	80	2.69	12	100	25	80	3.82	42	50	12	40	5.6
12	12	12	80	2.67	12	6	25	100	2.26	42	100	12	40	5.83
12	25	12	80	2.88	12	12	25	100	2.63	42	12	12	60	4.5
12	50	12	80	3.3	12	25	25	100	2.77	42	25	12	60	5.14
12	1	12	80	3.96	12	100	25	100	3.94	42	50	12	60	5.73
12	12	12	100	2.85	22	6	25	40	2.7	7	100	12	80	3.0
12	25	12	100	3.2	22	12	25	40	3.15	7	6	12	100	2.0
42	12	25	60	4.43	22	100	50	40	4.3	22	12	100	40	2.86
42	50	25	60	5.56	22	12	50	60	3.26	22	50	100	40	3.6
⋮														
42	100	25	60	5.9	22	25	50	60	3.53	22	100	100	40	4.0
42	6	25	80	4.33	22	50	50	60	3.86	22	12	100	60	3.1
7	50	25	80	2.41	22	12	50	100	3.58	22	100	100	80	4.23
7	100	25	80	2.92	42	25	50	60	4.46	22	6	100	100	3.03
7	6	25	100	1.7	42	50	50	60	4.91	22	12	100	100	3.39
7	12	25	100	1.96	42	100	50	60	5.64	22	50	100	100	3.9
7	25	25	100	2.14	42	12	50	80	4.48	22	100	100	100	4.43
7	100	25	100	3.05	42	25	50	80	4.7	42	6	100	40	3.61
12	6	25	40	2.01	42	50	50	80	4.97	42	12	100	40	3.76
12	12	25	40	2.16	42	100	50	80	5.72	42	25	100	40	3.96
7	25	100	40	1.79	42	100	100	80	5.01	7	100	50	100	2.97
7	100	100	40	2.35	42	12	100	100	4.45	12	6	50	40	1.8
7	6	100	60	1.4	42	25	100	100	4.65	12	25	50	40	2.26
7	12	100	60	1.67	42	100	100	100	5.16	12	50	50	40	2.6
7	50	100	60	2.2	12	100	50	40	3.24	12	6	50	60	1.98
7	100	100	60	2.42	22	6	50	80	2.9	22	100	12	60	5.29
7	6	100	80	1.44	22	25	50	100	3.87	22	6	12	80	3.23
7	12	100	80	1.74	22	50	50	100	4.3	22	12	12	80	3.61
7	25	100	80	2.14	22	100	50	100	4.87	22	25	12	80	4.34
7	50	100	80	2.32	42	12	50	40	4.06	22	100	12	80	5.53
42	25	50	40	4.41	42	60	12	40	4.1	22	6	12	100	3.4
42	50	50	40	4.78	42	12	12	40	4.2	22	25	12	100	4.67
42	100	50	40	5.3	22	100	12	100	5.9					
42	6	50	60	3.93	22	50	12	100	5.12					

Figure 4: Table of Result done by copper electrode

2.5 Machining Parameter Selection

In the EDM, the variables parameters are have great effects to the machining performances results especially to the material removal rate (MRR), electrode wear rate and surface quality. There are two major groups of parameters that have been discovered and categorized [2]:

1) Non-electrical Parameters
    a. Injection flushing pressure
    b. Rotational of speed electrode

2) Electrical Parameters

a. Peak current
b. Polarity
c. Pulse duration
d. Power supply voltage

It was observed that surface roughness of workpiece and electrode were influenced by pulsed current and pulse time, higher values of these parameters increased surface roughness. Lower current, lower pulse time and relatively higher pulse pause time produced a better surface finish.[5] To determine the most optimum material removal time, it should be ensured that the surface roughness stays within an acceptable range [7].

Another performance indicator of the EDM process is the roughness formed on the surface of the work piece. One of the areas among studies involving the EDM most researches have been made on is the effort to decrease the surface roughness. While depending on the machining parameters during the EDM, the surface roughness is also greatly affected by the material properties of the workpiece and the electrode [7].

2.6 Basic parameters affecting the manufacture process

1) Discharge current (*I*): value of the current applied to the electrode during pulse on-time in the EDM. Discharge current is one of the primary input parameters of an EDM process and together with discharge duration and relatively constant voltage for given tool and work piece materials
2) Gap voltage (V): voltage applied between the electrode and the work piece during the EDM.

3) Pulse on-time (T_{on}): time for which current is applied to the electrode during each EDM cycle. The material removed is directly proportional to the quantity of energy applied during pulse on time. This energy is controlled by the current and the on-time.
4) Off-time (T_{off}): waiting interval during two pulse on-time periods. Melted and solidified particles are removed from the setting during this period [7].

2.7 Flushing

Flushing is used to remove eroded particles from the gap for efficient cutting. Flushing also enables fresh dielectric oil flow into the gap and cools both the electrode and the workpiece. Improper flushing can causes erratic cutting, thus prevents the electrode from cutting efficiently. It is then necessary to remove the attached particles by cleaning the workpiece. Dielectric fluid is used as flushing to assist in the removal process of particles from the work area hence giving better surface finish [8].

There are five types of flushing fluid system in EDM [9]:

1) Pressure flushing
    a. Through electrode
    b. Through workpiece
2) Suction flushing
3) Combined pressure and suction flushing
4) Jet flushing
5) Pulse flushing
    a. Vertical flushing
    b. Rotary flushing
6) Orbiting Flushing

2.8 Dielectric fluid

Basic characteristics required for dielectric used in EDM are high dielectric strength and quick recovery after breakdown [8].

Dielectric fluid performs three important functions.

1) The fluid forms a dielectric barrier for the spark between the workpiece and the electrode.
2) The fluid cools the eroded particles between the workpiece and the electrode.
3) The pressurized fluid flushes out the eroded gap particles and removes the particles from the fluid by causing the fluid to pass through a filter system

Most dielectric media uses are hydrocarbon compounds and water. The hydrocarbon compounds are in the form of refined oil or known as kerosene. While the fluid properties are essential, the correct fluid circulating methodology is also important. The selection of suitable dielectric is based on the type of materials and the processes that are used. The performance of the dielectric may vary from one workpiece to another [9].

2.9 Previous study

There are some research exists which study the effect on the surface roughness for EDM using different parameter as the control variables. O¨ zlem Salman et al study the using of different EDM parameters (current, pulse on-time, pulse off-time, arc voltage), the Ra (µm) roughness value as a result of application of a number of copper electrode-hardened powder metals (cold work tool steel) to a work piece has been investigated, in this study. At the same time, roughness values obtained from the experiments that have been modeled by using the genetic expression programming (GEP) method and a mathematical relationship has been suggested between the GEP model and surface roughness and parameters affecting it. Moreover, EDM has been used by applying copper, copper–tungsten (W–Cu) and graphite electrodes to the same material with experimental parameters designed in accordance with the Taguchi method.

Results from this study reveal that among tool steels undergoing the EDM with similar parameters.

Shankar Singh et al study some investigations into the electric discharge machining of hardened tool steel using different electrode materials. This paper reports the results of an experimental investigation carried out to study the effects of machining parameters such as pulsed current on material removal rate, diameter overcut, electrode wear, and surface roughness in electric discharge machining of En-31 tool steel (IS designation: T105 Cr 1 Mn 60) hardened and tempered to 55 HRc. The work material was ED machined with copper, copper tungsten, brass and aluminium electrodes by varying the pulsed current at reverse polarity. Investigations indicate that the output parameters of EDM increase with the increase in pulsed current and the best machining rates are achieved with copper and aluminum electrodes.

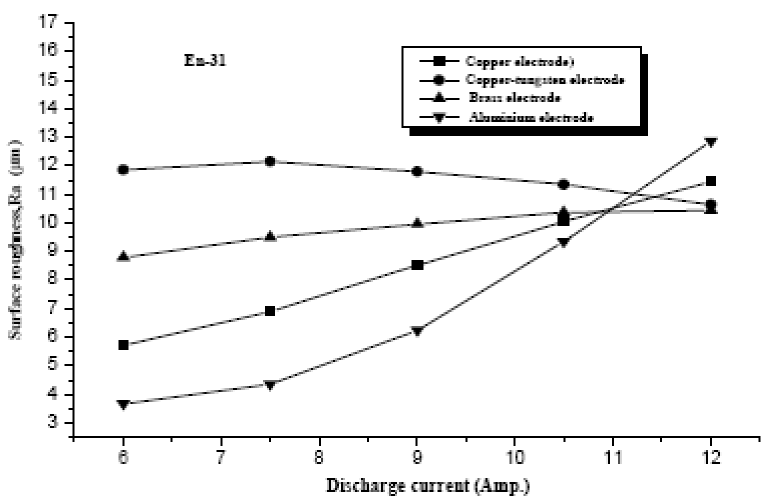

Figure 5: Graph of previous study

Results from this study reveal that the four tested electrode materials, Cu and Al electrodes produce comparatively high surface roughness for the tested work material at high values of currents. Copper–tungsten electrode offers comparatively low values of surface roughness at high discharge currents giving good surface finish for tested work material [13].

CHAPTER 3

METHODOLOGY

3.1 Introduction

In the electrical discharge machining (EDM) one of the most important features of the method is its ability to work independently on the mechanical properties of the machined material. Once voltage is applied to the electrode and the workpiece, electrons detached from the electrode (cathode) move accelerated towards the work piece. At the destination, they hit neutral dielectric molecules, removing more electrons. These electrons, in turn, accelerate the electron flow towards the anode by similar collisions. This motion of electrons creates a leakage current in the dielectric, evaporating the dielectric fluid in this region. The current increases in the evaporating fluid. At the end, a "plasma" channel is created between the electrode and the work piece. Due to its high temperature, this channel melts or evaporates a "crater" on both the work piece and the electrode. After the plasma channel extinguishes, all of the evaporated and a part of the melted material is flushed away by the flow of dielectric fluid. A small "crater" is created on the surface of the electrode and the work piece. Craters created by a multitude of plasma channels allow the surface machining **[**8**].**

3.2 Machining parameter

EDM machine has two parameters that need to be pay attention. This parameters could affect the surface roughness on the tool steel workpiece which is electrical and non electrical parameter. The electrical parameter is known as discharge current (I), Gap voltage (V), Pulse on-time (T_{on}) and pulse off-time (T_{off}) and flushing as non electrical parameter.

3.3 Material

The material used as a subject on this project are aluminum, brass and copper as an electrodes and tool steel as a workpiece.

3.4 Electrodes

Each electrode has their own characteristic such as conductivity and the strength. But for this experiment it is not to investigate the effect of the parameters to the surface roughness. The parameter of all electrodes will be constant and this parameter will be set base on the copper electrode.

3.5 Machines

The machine use in this research is Sodick AQ55L

Figure 6: EDM machine

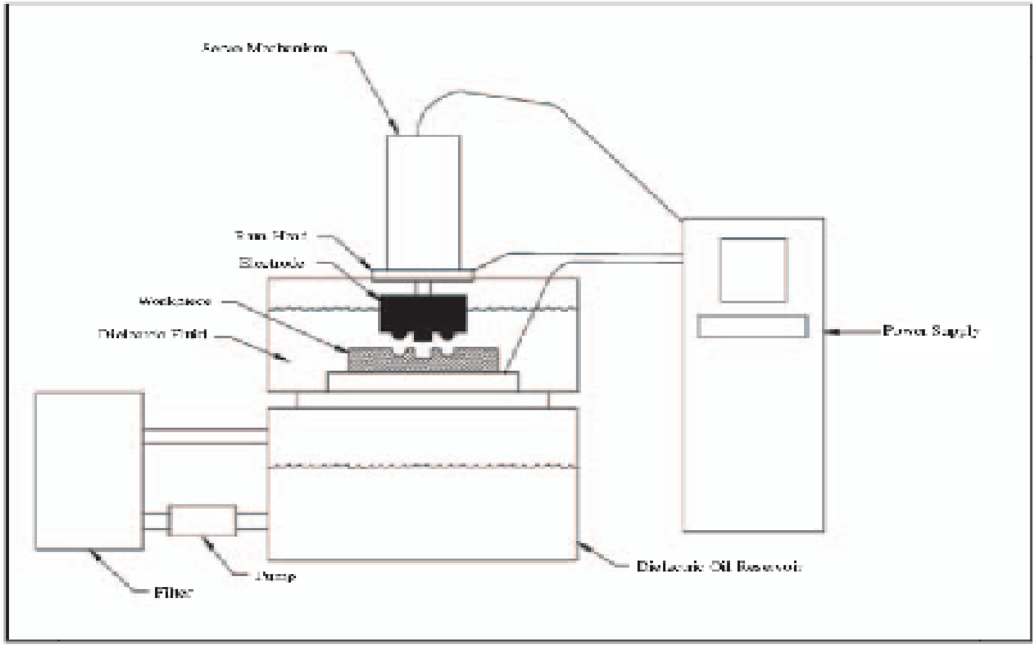

Figure 7: **The ram EDM process [12]**

Figure 8: **Perthometer**

Perthometer is an equipment use to measure the surface roughness on the tool steel workpiece after the machining finish.

3.6 Experiment method

The experiment is run by using EDM model sodick AQ55L. Before run the experiment the parameter such discharge current (I), Gap voltage (V), Pulse on-time (T_{on}) and off-time (T_{off}) will be set. All this value will be set base on copper electrode parameters.

Another value that had been set up constantly for this experiment is cutting depth of the workpiece and the surface roughness.

- Cutting depth = 1mm
- Surface roughness= 2µm

The electrodes used on this experiment have the same size.

- Diameter of electrodes = 6.5mm

For the determination of the surface roughness the travel length of the perthometer also had been set as a constant for each specimen.

- Travel length of perthometer= 1.75mm

Figure 9: Determination of surface roughness

Table 3: Experimental parameters setup for each electrode

Material	Pulse on (μs)	Pulse on (μs)	Current(A)	Voltage (V)
Copper	1	30	0.4	35
Aluminum	1	30	0.4	35
Brass	1	30	0.4	35

3.7 Flow chart

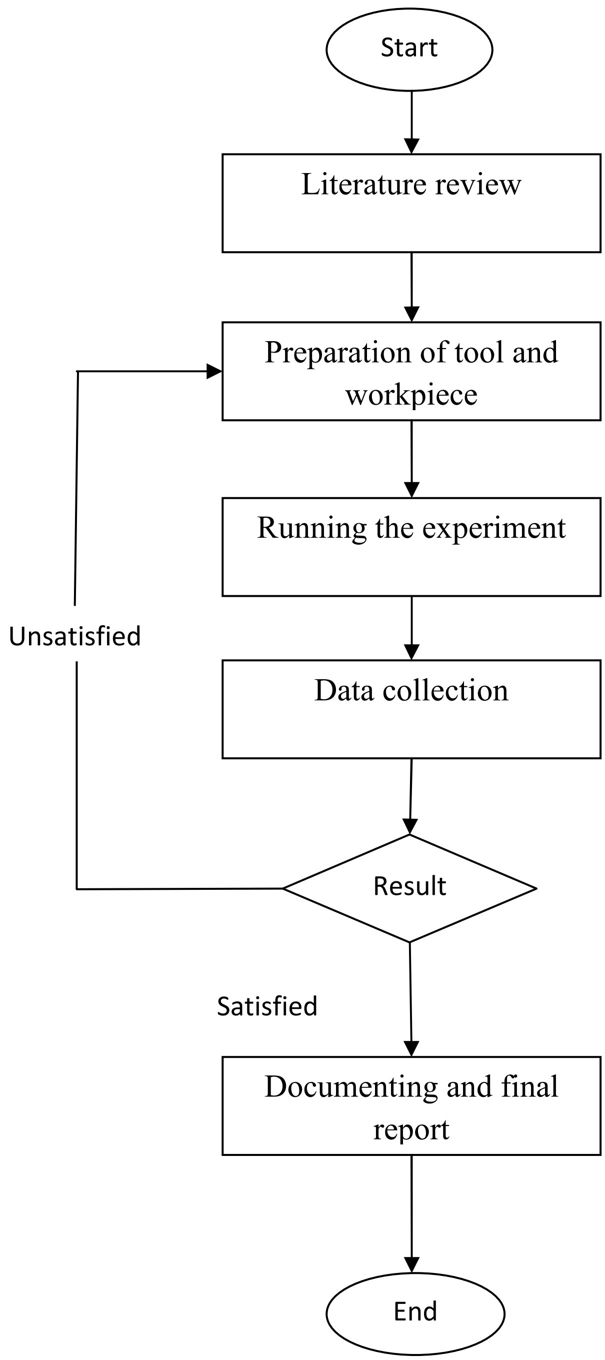

Figure 10: flow chart.

3.8 Gantt chart

Table 3.1: Gantt chart for final year project 1

Progression of task/ week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1)Project proposal																
2)Literature Review																
3) Methodology																
4)Submit draft for correction																
5) Write report & Submit																
6)preparation for Presentation																
7) Presentation																

Table 3.2: Gantt chart for final year project 2

Progression of task/ week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1) Experiment															
2) Analysis data															
3) Final result															
4) Submit draft for correction															
5) Writing and submit report															
6) Presentation															

CHEPTER 4

RESULT AND DISCUSSION

4.1 Introduction

In this chapter the result collected from the experiment will be analyzed. The result are interpreted base on the table and will be calculate and compared to each other to carry out the best result among electrode which is copper, aluminum and brass electrode. The best result is decided in which electrode give the smoothes surface roughness base on the product that want to be produce by the electrical discharge machine (EDM).

4.2 Data collection

Table 4: Result for copper as electrode

No of specimen	1st reading	2nd reading	3rd reading	Average
1	0.345	0.348	0.352	0.348
2	0.555	0.332	0.312	0.399
3	0.314	0.312	0.355	0.327
4	0.334	0.323	0.345	0.334
5	0.356	0.312	0.337	0.335
6	0.346	0.367	0.354	0.355

Table 4.1: Result for brass as electrode

No of specimen	1st reading	2nd reading	3rd reading	Average
1	0.665	0.520	0.657	0.614
2	0.672	0.617	0.648	0.645
3	0.544	0.438	0.624	0.535
4	0.549	0.532	0.587	0.556
5	0.612	0.574	0.569	0.585
6	0.619	0.543	0.587	0.583

Table 4.2: Result for aluminum as electrode

No of specimen	1^{st} reading	2^{nd} reading	3^{rd} reading	average
1	0.372	0.337	0.348	0.352
2	0.393	0.322	0.354	0.356
3	0.518	0.404	0.432	0.451
4	0.398	0.376	0.387	0.387
5	0.356	0.365	0.349	0.356
6	0.434	0.384	0.395	0.404

Table 4.3: Surface roughness done by each electrode

No of specimen	copper	aluminum	brass
1	0.348	0.352	0.614
2	0.399	0.356	0.645
3	0.327	0.451	0.535
4	0.334	0.387	0.556
5	0.335	0.356	0.585
6	0.356	0.404	0.583

4.3 Result

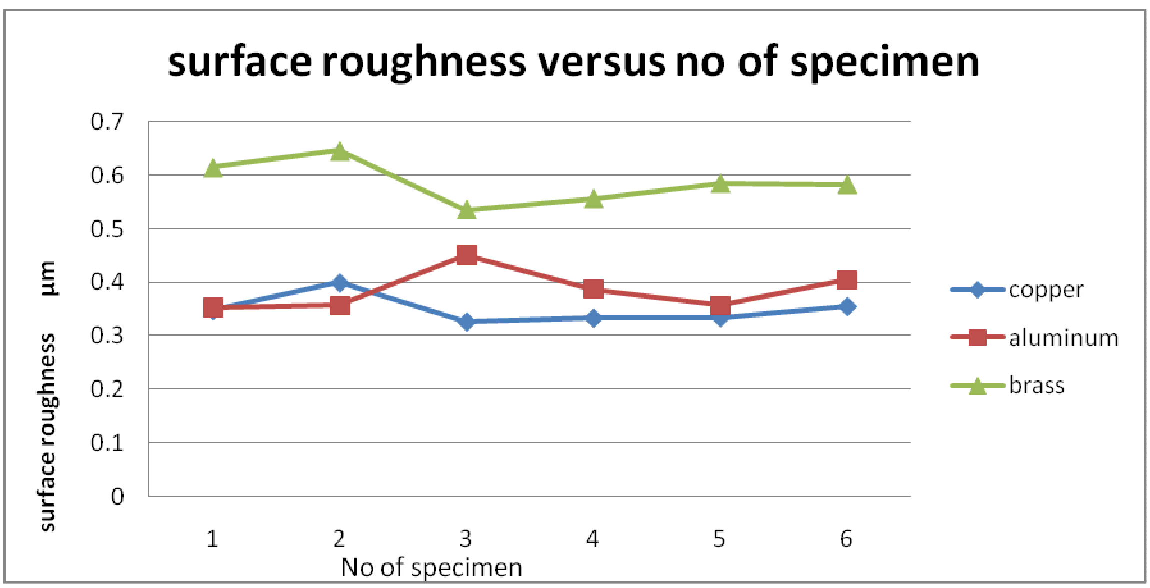

Figure 11: Graph of surface roughness versus no of specimen

Table 4.4: **Average surface roughness done by each electrode**

Material	Ra(average)µm
Copper	0.350
Aluminum	0.385
Brass	0.586

4.4 Discussion

From the graph 1 the different in surface roughness done by copper, brass and aluminum electrode can be seen. The copper electrode gives the smoothest surface roughness compare to the other electrodes. The copper electrodes give the value of surface roughness between ranges of 0.3µm to 0.4µm and the average value of the surface roughness done by copper is 0.35µm. For the aluminum and brass electrodes the value is slightly higher with the aluminum give second smoothes surface roughness which lay in range of 0.35µm to 0.45µm and give the average of surface roughness 0.385µm. As for the brass, the value lays in range of 0.5µm to 0.65µm and gives the average surface roughness of 0.586µm.

The difference in surface roughness done by these electrodes occurs even the parameter that had be set are same. This is because each electrode has their own characteristic and these characteristics are affecting the surface roughness on the tool steel workpiece.

One of the material properties of the electrode that affect the surface roughness is thermal conductivity. Thermal conductivity is an ability to allow the heat transfer through the electrode and higher of the value of this material properties will give the smoother surface roughness.

Theoretically, there are parameters affecting the surface roughness in the EDM are found to be discharge current, gap voltage, pulse on-time and pulse off-time. Discharge current (*I*) is a value of the current applied to the electrode during pulse on-time in the EDM. Discharge current is one of the primary input parameters of an EDM process and together with discharge duration and relatively constant voltage for given tool and work piece materials. Increasing value of voltage is mean increasing in value of surface roughness. Gap voltage (V) is a voltage different applied between the electrode and the work piece during the EDM. Pulse on-time (t_{on}) time for which current is applied to the electrode during each EDM cycle. The material removed is directly proportional to the quantity of energy applied during pulse on-time. This energy is controlled by the current and the on-time. Pulse off-time (t_{off}) is waiting interval during two pulse on-time periods. Melted and solidified particles are removed from the setting during this period.

Table 4, 4.1 and 4.2 shows the data collection done by copper, brass and aluminum electrode. This recorded data was determined by using perthometer. The specimen will be measured three times each. All of this data will be calculated to obtain the average surface roughness.

The average of each specimen are collected and recorded in table 4.3. From table 4.3 the graph are plotted to show the different of the surface roughness among the copper, brass and aluminum electrode. From table 4.3 also the average of the surface roughness done by each electrode are calculated and recorded in table 4.4.

To decide which electrode is giving the best surface roughness is depends on the product that what to be produce. Die sinking electrical discharge machine (EDM) is generally used to produce the blind cavities such as Mobile phone cavities, Speaker grill cavities. So the lower value of surface roughness is the best.

CHAPTER 5

CONCLUSSION AND RECOMMENDATION

5.1 Introduction

In order to get the best electrodes that can give the smoothest surface roughness on the tool steel workpiece on electrical discharge machining (EDM), the combination of the knowledge about EDM and the material properties of electrodes are very crucial. This knowledge is useful in designing the experiment methodology and carries out the result of the experiment.

5.2 Conclusion

Base on the experiment copper electrode give the lowest surface roughness which is 0.350µm. Aluminum is 0.385µm and brass is 0.586µm. To decide the best electrode it's should depends on the product that want to be produce. For the die sinking electrical discharge machining, it is generally use to machine the cavities on the mold that should has the smooth surface.In conclusion the best electrode on this experiment is copper.

5.3 Recommendation

In order to prevent the best electrode on electrical discharge machining some recommendation could be implemented in future as below.

1) The studies should not investigate only on surface roughness. It is also can be investigate on the tool wear of each electrode.

2) The electrical discharge machining has plenty of factors that can affect the surface roughness on the especially electrical parameters such as current (I), gap voltage (V), pulse time on and pulse time off. The future experiment should have give more attention on the parameters of EDM in order to carry out the best electrode on EDM

References

[1] http: //www.makino.com.sg/edm.html.

[2] Electrical Discharge Machining-Die Sinking, 2008; Mr. Mohd Yussni Bin Yaakob, Universiti Tun Hussein Onn Malaysia (UTHM).

[3] Dr. Mandara D. Savage & Dr. Joseph C. Chen, Effects of Tool Diameter Variations in On-Line Surface Roughness Recognition System, journal of industrial technology Volume 15, Number 4.

[4] Dr. Mike S. Lou, Dr. Joseph C. Chen & Dr. Caleb M. Li, Surface Roughness Prediction Technique For CNC End-Milling, journal of industrial technology Volume 15, Number 1.

[5] M. Kiyak O. C¸ akır, Examination of machining parameters on surface roughness EDM of tool steel, Journal of Materials Processing Technology 191 (2007) 141–144.

[6] Jun Qu, Albert J. Shih, Analytical surface roughness parameters of an ideal profile consisting of elliptical or circular arcs.

[7] O¨ zlem Salman, M. Cengiz Kayacan. Evolutionary programming method for modeling the EDM parameters for roughness. Journal of materials processing technology 2 0 0 (2 0 0 8) 347–355.

[8]Wong, Y .S., Lim, L.C., and Lee, L.C. (1995). Effect of Flushing on Electro Discharge Machined Surface. J. of Materials Processing Technology. 48: 299-305.

[9] Sommer, C. (2000). Non-traditional machining handbook. First edition. Advance Publishing. Houston. Taguchi and Western methods of statistical experiment design. Chapman and Hall, New York.

[10] Pandey, P.C., and Shah, H.S. (1980). Modern Machining Processes. New Delhi. Tata Mcgraw-Hill.

[11] Armarego, E.J .A., and Brown, R.H. (1969). The Machining of Metals. Prentice Hall. New Jersey.

[12]Fundamentals of ram EDM, complete EDM handbook, compliment of www.ReliableEDM.com.

[13] Shankar Singh,S. Maheshwari ,Pandey Some investigations into the electric discharge machining of hardened tool steel using different electrode materials. Journal of Materials Processing Technology 149 (2004) 272–277.

1) Several sample of measuring profile done by brass electrode

2) Several sample of measuring profile done by aluminum electrode

3) Several sample of measuring profile done by copper electrode

4) Specification of AQ55L EDM

C axis	
Resolution (°)	0.001
Rotational speed(min. – max. rpm, continuous)	20 - 2000

Optional features
C axis (4 axes controlled)
C axis SES72 (4 axes controlled)
Electrode changer (4 - 50 positions)
RS232C interface
Uninterruptible power supply (UPS)
LAN facility
STP mode for carbide machining

- Ceramic table
- Linear glass scales
- Linear motor for the X, Y, and Z axes
- Automatic fire extinguisher
- Cooling system
- SVC Circuit
- SQ Circuit super quality finish
- LAN interface

Technical Data	
X / Y / Z axis travel (mm)	550 x 400 x 350
Table dimension (mm)	750 x 550
Worktank dims (mm)	950 x 725 x 410
Dielectric level (min - max, mm)	195 - 360
Max. workpiece weight (kg)	1,000
Max. electrode weight (kg)	50
Step resolution (mm)	0.0001
Max. positioning speed (mm/s)	5.0
Max. pulsation speed Z axis (m/min.)	36
Table - chuck distance (mm)	280 - 630
Controlled axes	4
Machine weight (kg)	6,000