# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## EXPERIMENTAL INVESTIGATION OF STAINLESS STEEL BY USING ELECTRICAL DISCHARGE MACHINE (EDM)

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Process)(Hons.)

by

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# APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process) (Hons.). The member of the supervisory is as follow:

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(DR LIEW PAY JUN)

# ABSTRAK

*Electrical Discharge Machining* (EDM) adalah salah satu proses pemesinan termaju, berdasarkan termo tenaga elektrik di antara bahan kerja dan elektrod. Biasanya, EDM digunakan untuk memesin bahan yang mempunyai kekerasan yang tinggi dan bentuk yang kompleks. Dalam kajian ini, kesan saiz mikro dan nano bagi serbuk karbon yang ditambah kedalam bendalir dielektrik pada keluli tahan karat telah disiasat dengan menggunakan proses EDM. Dalam eksperimen ini, SODICK AQ35L adalah model mesin EDM yang digunakan untuk memesin bahan keluli tahan karat dengan menggunakan elektrod tembaga. Berat bahan kerja dan elektrod telah direkodkan sebelum dan selepas eksperimen dengan menggunakan *Precise Digital Balance* untuk mendapatkan *material removal rate* (MRR*)* dan *tool wear rate* (TWR). Manakala bagi kekasaran permukaan bagi bahan kerja (keluli tahan karat) telah diperiksa dengan menggunakan Mitutoyo SJ-301 *surface roughness tester* dan sela bunga api itu diperiksa dengan menggunakan *stereo microscopic*. Ia mendapati bahawa apabila saiz nano bagi serbuk karbon yang dicampur kedalam cecair dielektrik dan menghasilkan nilai *material removal rate* (MRR*)* yang lebih tinggi, *tool wear rate* (TWR) yang lebih rendah, dan kekasaran permukaan yang lebih licin yang boleh didapati berbanding dengan saiz mikro bagi serbuk karbon yang dicampurkan kedalam cecair dielektrik. Penambahan saiz nano serbuk juga, boleh mengurangkan kekuatan penebat cecair dielektrik dan menghasilkan sela bunga api yang lebih besar.

# ABSTRACT

Electrical Discharge Machining (EDM) is one of the advanced machining processes, based on thermo electric energy between the workpiece and tool. Normally, EDM used to machine high hardness materials and complex shape. In this research, the effect of the micro and nano size of carbon powder additive into dielectric fluid on the stainless steel was investigated by using EDM process. In the experiment, EDM machine model SODICK AQ35L was used to machine stainless steel material by using copper electrode. The weight of the workpiece and electrode were recorded before and after the experiment by using Precise Digital Balance in order to obtain Material Removal Rate (MRR) and Tool Wear Rate (TWR). While, the surface roughness of the workpiece (stainless steel) was examined using Mitutoyo SJ-301 surface roughness tester and the spark gap was examined using stereo microscopic. It was found that when nano size of carbon powder was mixed into the dielectric fluid, higher material removal rate (MRR), lower tool wear rate (TWR), and smoother surface roughness can be obtained compared to the micro size of carbon powder. Addition of nano size of powder also can reduce insulating strength of dielectric fluid and result to a bigger spark gap.

# DEDICATION

*First and foremost, I would like to express my greatest appreciation to Universiti Teknikal Malaysia Melaka for giving me the opportunity to undergo my final year "Projek Sarjana Muda". A special thank you also goes to my supervisor Dr. Liew Pay Jun for her dedication and guidance during the period of undergoing my project and also to technician En Hanafiah for his guidance. Last but not least, I want to thank my mom and dad for their support as well as to all my friends Fazreena Binti Mohamad Noor Adami and Muhammad Nur Syafiq bin abdul Rahman who never give up encouraging me to complete this report.*

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Firstly, I am thankful to ALLAH S.W.T for blessing me in finishing this final year project (FYP) with successful complete and in achieving the objectives of this project. Hopefully, this project will be benefit to all.

In this opportunity, I would like to give my sincere gratitude to my family, Mohmad Daud bin masro, my father, Masriah binti Abu, my mother and all of family members for morale support, motivation and encouragement in completing this final year project and in finishing my study in UTeM with successful

I also would like to convey my full appreciation and thankful to my supervisor, Dr Liew Pay Jun for her guidance, supervising, and continuous support to complete my final year project for these two semesters. She has been very helpful and always advices me whenever there are problem in complete this project. I really appreciate every advice and without her support, critics I could not finish this thesis as presented here.

My sincere thanks go to vocational advisor, Mr Hanafiah for his guidance for in operating the Electrical Discharge Machine.

My special thanks to the friend that gives support and always company me in making and complete this project.

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| | | |
|---|---|---|
| EDM | - | Electrical Discharge Machining |
| WEDM | - | Wire Electrical Discharge Machining |
| CNC | - | Computer Numerical Controlled |
| BeCu | - | Beryllium Copper |
| CNT | - | Carbon nanotubes |
| Al | - | Aluminum |
| Si | - | Silicon |
| MRR | - | Material Removal rate |
| TWR | - | Tool Wear Rate |
| Ra | - | Surface roughness |
| $W_a$ | - | Material weight before machining |
| $W_b$ | - | Material weight after machining |
| tm | - | Machining time |
| $E_b$ | - | Tool (electrode) Weight before machining |
| $E_b$ | - | Tool (electrode) Weight after machining |
| n | - | Number of readings |
| $D_i$ | - | The diameter of the hole |
| $D_o$ | - | Electrodes after machining |
| DC | - | Direct current |
| Ra | - | Surface roughness |
| DA | - | Dimensional accuracy |
| SR | - | Surface finish |
| V | - | Voltage |
| A | - | Ampere |

| | | |
|---|---|---|
| $T_{on}$ | - | Pulse on time |
| $T_{off}$ | - | Pulse off time |
| µsec | - | Micro second |
| µm | - | Micrometer |
| g/min | - | Gram per minute |
| mm | - | Millimeter |
| g/l | - | Gram per liter |
| % | - | Percentage |
| E | | Young modulus |

# CHAPTER 1
# INTRODUCTION

This chapter describes the introduction of the experiment. In this experiment, the effect of micro and nano size of carbon powder as an additive into dielectric fluid were compared by using Electrical Discharge Machining (EDM). This chapter includes the background, problem statement, objective and scope of this study.

## 1.1 Background

Electrical Discharge Machine (EDM) is most important acknowledge technologies in manufacturing industries since many complex shapes can be machining by using a simple shaped of the tool electrode. Electrical Discharge Machining (EDM) is an advance manufacturing process. This process used to remove the material by controlled erosion from a series of electric sparks between an electrode and workpiece with the existence of dielectric fluid. The electrode may be considered as the cutting tool (Nikhil et al, 2012). Currently, EDM is an extensive technique used in the industry for machine electrically conductive and difficult materials for manufacturing of mould, die, automotive, aerospace and surgical components. (Soumyakant et al, 2012).

The latest developments in the field of EDM have progressed due to the growing application of EDM process. other than that, the challenges being faced in the modern manufacturing industries, from the development of new materials that are hard and difficult to machine such as tool steels, composites, ceramics, stainless steels, super alloys, carbides, heat resistant steel and other being widely used in die

and mould making industries need the high precision, complex shapes and high surface finish (Ayush, 2012).

The material used in this experiment is stainless steel due to its widely used in industrial applications. It has excellent material properties primarily by their corrosion resistance, high strength and ductility (Sidda et al, 2010). At the present, applications of stainless steel are widespread in industries such as food processing equipment, cryogenic vessels, gutters, brewing equipment, downspout and flushing and components for chemical environment.

Additive powder into dielectric fluid is one of the new innovations in EDM process. According Ahsan *et al.* (2012), when the powder additive into dielectric fluid, charge powder are speeded up by the electric field and act as conductors and powder gather in clusters. The chain formation by interlocking which help to form bridging networks between workpiece and tool which caused early explosion or spark. The good electrical conductivity of powder helps to increase the discharge gap between the workpiece and tool and can be increase the insulating strength of the electric fluid and also improved EDM machibility (Soumyakant et al, 2012). In this situation may be occur multiple discharges, it can lead to reduce of the crater size on the surface of workpiece. In turn, might be obtain a better surface finish compare than without powder additive powder into dielectric fluid (Liew et al, 2013).

## 1.2 Problem statement

Electrical Discharge Machining (EDM) is a machining method used for hard metals or those that would be impossible to machine with traditional techniques. Previously, powder has been mixed into the dielectric fluid to improve the machining efficiency of EDM. However, to date a comparison between the sizes of carbon powder on the stainless steel has not been carried out yet. Therefore the main aim of this study is to compare the effect of sizes of carbon powder on the material removal rate (MRR), tool wear rate (TWR), surface roughness (Ra), and spark gap.

## 1.3 Objective

The objectives of this project are:

1 To compare the effect of micro and nano powders additive by using conventional electrical discharge machine.

2 To investigate the effect of carbon powder concentration on material removal rate (MRR), tool wear rate (TWR), surface roughness and spark gap of stainless steel by using EDM.

## 1.4 Scope of Project

This project was focused on the comparison between the sizes of carbon powder on the stainless steel by using EDM. The sizes of the carbon powder were micro and nano (200-300µm and 40nm). In this process, the material that has been used is conductive material, which is stainless steel. The material for the tool is copper. Carbon powder was added into the dielectric fluid. The effect of micro and nano of carbon powder on the material removal rate (MRR), tool wear rate (TWR), surface roughness (Ra) and spark gap was investigated.

# CHAPTER 2
# LITERATURE REVIEW

Basically, literature review is one of the scope studies. Literature review serves as a guide to conduct this analysis. It will provide a variety of information about the electrical discharge machine. In addition, it also provides information to conduct all operations. Various references have been made in this literature review, which are research journals, books, conference online or printed article.

## 2.1 Electrical Discharge Machine (EDM)

Electrical discharge machining (EDM) is an advance manufacturing processes. EDM used most widely and successfully applied in manufacture geometrically the complex or process in fact to manufacture hard metals or those that would be very difficult in the machine with traditional techniques (Ojha et al, 2010, Soumyakant et al, 2012 and Sidda et al, 2010).

Mustafa *et al.* (2011) proved the EDM process also can be compared with other conventional machining processes like milling and turning as shown in Table 2.1. This comparison performed in terms of contact between workpiece and cutting tool, force, tool or workpiece rotation, tool or workpiece conductive and material removal method. EDM is the fourth most popular machining method at present, which is milling, turning, grinding, and drilling.

Table 2.1: Comparison between EDM process and conventional machining processes (milling/turning) (Mustafa et al, 2011).

| CHARACTERISTIC | MILLING/TURNNG | EDM |
|---|---|---|
| Contact between work piece and tool | Yes | No |
| Force | Yes | No |
| Tool or work piece rotation | Yes | Not Normal |
| Tools or work piece conductive | Not required | Required |
| Material removal rate | Shear | Melt or Vaporize |

Electrical discharge machining (EDM) is an advance manufacturing processes. EDM used most widely applied in manufacture geometrically the complex or process in fact to manufacture hard metals or those that would be very difficult in the machine with traditional techniques (Ojha et al, 2010, Soumyakant et al, 2012 and Sidda et al, 2010).

Mustafa *et al.* (2011) proved the EDM process also can be compared with other conventional machining processes like milling and turning as shown in Table 2.1. This comparison performed based on contact between workpiece and cutting tool, force, tool or workpiece rotation, tool or workpiece conductive and material removal method and others. At present, EDM is one of popular machining method from fourth machining method which is milling, turning and grinding.

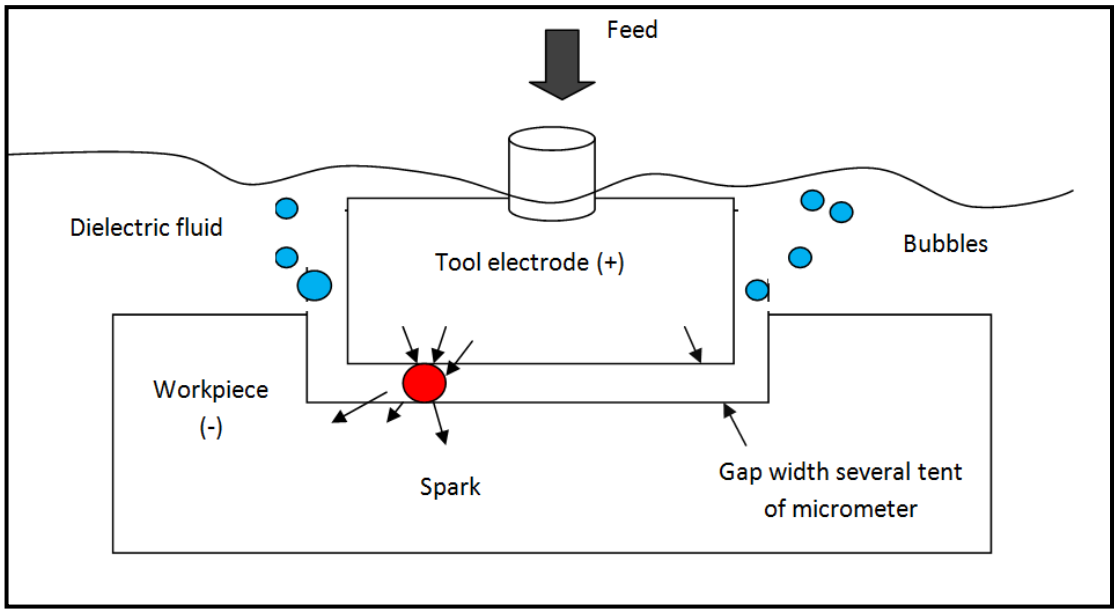


Figure 2.1: EDM process (Mahendran et al, 2010)

However, EDM has been replacing the traditional machining operations like milling, drilling, and other operations. Currently, EDM machining being a selection throughout the world in manufacturing industries. EDM is can do to machining geometrically complex or hard material components, high accuracy and difficult to machine such as heat resistant steels, composites, super alloys, ceramics, heat treated tool steels, carbides, heat resistant steels and others. According to Shailesh (2010), EDM was being used in application of die and mold, nuclear industries, aerospace, medical and surgical, aeronautics, sports, instruments, optical and others application.

### 2.1.1 History of EDM

The history of EDM machining techniques discovered in early 1770s when it was discovered by an English Scientist is Joseph Priestly and found the erosive effect of electrical discharges or sparks. However, this technique is used but has some problems which is EDM Machining was very not accuracy and riddled with failures (Shailesh, 2010).

While in the 1949 at the Moscow University, be found two Russian scientists are Dr. B.R. Lazarenko and Dr. N.I. Lazarenko to develop a controlled process of machining

for difficult metals to machining by vaporizing material from the surface of metal. Then in the 1950's research about resistance capacitance type of power supply at EDM system.

According to Shailesh (2010), at mid 1970s, commercially developed Wire EDM is one of the techniques being selection in the industry to helped shape the metal working industry. At 1980's a computer numerical controlled (CNC) EDM was introduced in USA. Other than that many research have be done to improve in many aspect such as improve the quality on surface, material removal rate by using different cutting tool or parameters, improvement the spark gap by using different dielectric fluid and other research (Ho et al, 2003 and Pawade et al, 2013).

### 2.1.2 Types of EDM

There are two main types of EDM, which are Wire Electrical Discharge Machining (WEDM) and EDM die-sinking. Both of them are very suitable for applications in automotive stamping dies, tools, medical component and body aircraft components. This is caused by both of them can produce small size and high accuracy part well as large items.

#### 2.1.2.1 Wire Electrical Discharge Machining (WEDM)

WEDM is referring to wire electrical discharge machining. The WEDM used for complex shapes, which have sharp edges that are very difficult to machining processes. WEDM also used for high precision machining of all types of conductive materials. The suitable material in the WEDM process is metals, metallic alloys, graphite, or even some ceramic materials and other of any hardness.

Besides that, WEDM used a continuous wire as a substitute electrode. Spark generated from the electrode wire side surface to the workpiece (Figure 2.2). The wire is controlled by a computer numerical control (CNC). It is due allows

programming a path for the wire to travel along sort of like a super precision bandsaw. The diameter wire range from 0.0120 to 0.0008 inches (Singh et al, 2009 and Bo et al, 2009).

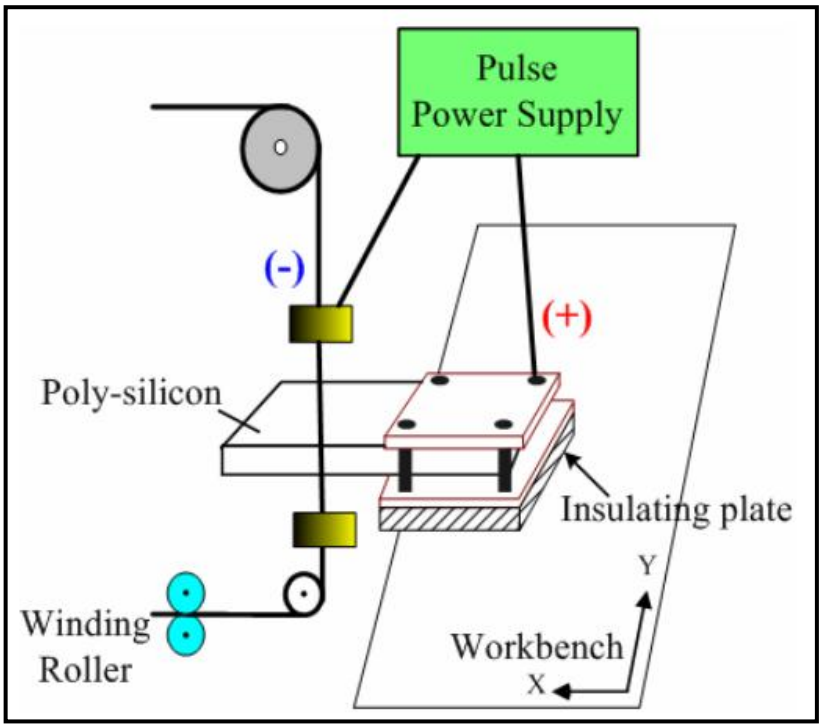


Figure 2.2: Schematic diagram of WEDM (Bo et al, 2009)

### 2.1.2.2 EDM die-sinking

The EDM die sinking is shown in Figure 2.3. According to Soumyakant *et al.* (2012), EDM die-sinking processes also know as nontraditional process where the tool does not contacts the workpiece. It is also refers to spark machining, spark eroding, burning, is a manufacturing process to make the profile shape of workpiece is obtain using electrical discharge. The material removal from the workpiece occurs by a series of rapidly repeated discharge between electrode and workpiece, separated by dielectric liquid and subjected to an electric voltage.