# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## ASSESSMENT OF EDM PARAMETERS ON ALUMINIUM 5083

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

by

**MUHAMMAD MUNAWWAR HASAN BIN ROHAIZAN**

FACULTY OF MANUFACTURING ENGINEERING

2009

## UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PSM

TAJUK: **"Assessment of EDM Parameters on Aluminium 5083"**

SESI PENGAJIAN: 2008/2009 Semester 2

Saya **MUHAMMAD MUNAWWAR HASAN BIN ROHAIZAN**
mengaku membenarkan laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM / tesis adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM / tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. *Sila tandakan (√)

| | | |
|---|---|---|
| ☐ | SULIT | (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972) |
| ☐ | TERHAD | (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan) |
| ☐ | TIDAK TERHAD | |

53, JLN. WIRAWATI 8,
TMN. MALURI
55100 KUALA LUMPUR,
W. PERSEKUTUAN (KL)

Cop Rasmi:
DR. BAGAS WARDONO
*Pensyarah Kanan*
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka

Tarikh: 15/5/09

Tarikh: 15 MAY 09

* Jika laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.

# DECLARATION

I hereby declared this report entitled "Assessment of EDM Parameters on Aluminium 5083" is the result of my own research except as cited in the references.

Signature : ……………………………………………………..

Author's Name : MUHAMMAD MUNAWWAR HASAN

Date : 15/5/09

# 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) with Honours. The members of the supervisory committee are as follow:

(Signature of Supervisor)

DR. BAGAS WARDONO
*Pensyarah Kanan*
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka

...............................................

(Official Stamp of Supervisor)

# ABSTRACT

This research presents the machining of Aluminium 5083 using electrical discharge machining (EDM) Die-Sinking with a graphite electrode. The effectiveness of the EDM process is evaluated in terms of material removal rate (MRR), electrode wear (EW) and Surface Roughness. In this work, a study was carried out on the influence of peak current (Ip), voltage (V), pulse on-time ($t_i$) and pulse off-time ($t_o$). The technique of design of experiments (DOE) has been used for the planning of the experiments. The experimental results reveal that the most significant factor that influence MRR is peak current, followed by voltage, interaction between voltage and peak current, pulse on-time and interaction between peak current and on-time. Furthermore, in order to obtain low values of electrode wear, low values of peak current and voltage should be used. The results also indicate that the value of surface roughness tends to increase when the pulse on-time, peak current and voltage are increased. Interpretation of this result will be used for further reference for checking suitable condition parameter on various conditions of operations.

# ABSTRAK

Penyelidikan ini membentangkan pemesinan ke atas Aluminium 5083 menggunakan elektrik nyahcas mesin *(EDM) Die-Sinking* dengan elektrod grafit. Keberkesanan proses *EDM* dinilai dalam sesuatu terma bagi bahan kadar penyingkiran, kehausan elektrod dan kekasaran permukaan. Dalam kerja ini, satu kajian telah dijalankan pada pengaruh arus puncak (Ip), voltan (V), denyut tepat pada masa ($t_i$) dan denyut di luar masa ($t_o$). Teknik reka bentuk bagi eksperimen (DOE) telah digunakan untuk perancangan bagi eksperimen ini. Hasil percubaan mendedahkan faktor yang terpenting yang menpengaruhi *MRR* ialah arus puncak, diikuti oleh voltan, interaksi antara voltan dan arus puncak, denyut tepat pada masa dan interaksi antara puncak semasa dan tepat pada masa. Tambahan pula, dengan tujuan mendapatkan nilai yang rendah bagi kehausan elektrod, nilai rendah bagi arus puncak dan voltan harus digunakan. Keputusan-keputusan itu juga menunjukkan bahawa nilai untuk kekasaran permukaan cenderung untuk meningkat apabila denyut tepat pada masa, arus puncak dan voltan bertambah. Tafsiran yang dicapai adalah berguna sebagai rujukan lanjut dalam memilih kesesuaian parameter di dalam pelbagai operasi.

# DEDICATION

*Specially dedicated for my beloved father, Rohaizan bin Hj. Rokambol and my mother, Norlida binti Hj. Mohd who are very concerns, understanding patient and supporting. Thank you for everything to my supervisor, Dr. Bagas Wardono, my sisters, my brothers and all my friends. The work and success will never be achieved without all of you*

# ACKNOWLEDGEMENTS

First and foremost, thanks to ALLAH S.W.T. for His blessings and for the strength given to complete this Project Sarjana Muda (PSM) – I and II. A special thanks to my supervisor, Dr. Bagas Wardono for the supervision along the time I was doing this project. I greatly appreciate his consistent encouragement, advice and invaluable guidance throughout the course of this project. I wish to extend my special appreciation to Mr. Khairul Effendy bin Mansor and Mr. Fauzi for their patience, support, comments and valuable time to complete this project. I would also like to express my deepest appreciation and gratitude to my family members for their love, sacrifice, motivation and support given during the course of this project. Last but not least, I would like to thanks those who have contributed directly or indirectly towards the sucess of this project.

# TABLE OF CONTENT

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| ANOVA | - | Analysis of Variance |
| BP | - | Belief propagation |
| CNC | - | Computer Numerical Control |
| DOE | - | Design of experiments |
| EDM | - | Electric discharge machining |
| EDG | - | Electrical discharge grinding |
| EW | - | Electrode wear |
| GA | - | Genetic algorithm |
| HV | - | Hardness Vickers |
| K | - | Kurtosis |
| MRR | - | Material removal rate |
| NTM | - | Non-traditional manufacturing |
| Rms | - | Root-mean-square |
| $R_a$ | - | Average roughness |
| $R_v$ | - | The maximum valley height |
| $R_q$ | - | Root mean square roughness |
| $R_y$ or $R_{max}$ | - | Maximum peak-to-valley roughness |
| $R_p$ | - | Maximum peak height |
| $S_k$ | - | Skewness |
| TFM | - | Total Form Machining |
| UTeM | - | Universiti Teknikal Malaysia Melaka |
| WEDM | - | Wire Electric discharge machining |
| $\eta$ | - | Duty cycle |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Electric discharge machining (EDM) is among the earliest of non-traditional manufacturing (NTM) process, having had its inception 50 years ago in a simple die-sinking application. The two principal types of EDM are die-sinking EDM and wire EDM (WEDM). Die-sinking EDM is traditionally performed vertically, but it may also be conducted horizontally. Die-sinking EDM has been greatly refined since the 1940s with the advent of transistorized pulse generators, planetary and orbital motion techniques, CNC and adaptive control. Orbital motion was introduced to EDM during the early 1970s. Orbital motion is composed of simultaneous electrode movement along the vertical axis with a lateral movement out of the work piece center. Thus the electrode center describes a horizontal circular orbit. This orbit is characterized by the eccentricity and the angular speed of the translation. The former is controlled by the servo system just like the vertical speed feed, while the angular speed of the translation can be chosen freely. Another application of electrical discharges machining (EDM) is electrical discharge grinding (EDG), which is used for precision machining of electrically conductive workpieces. The EDM state-of-the-art practice achieved significant technological breakthroughs during the late 1980s owing to two major advances: improvement in the performance of the EDM process and advancements in the level of automation for EDM. The EDM process has been improved by reduced damage from arcing, lowered tool wear ratio and less frequent wire rupture in WEDM. The level of automation has increased through on-line adaptive control strategies.

## 1.2 Project Background

The main focus of this research is to determine the dependency of the surface roughness, electrode wear (EW) and material removal rate (MRR) obtained on the Die-Sinking electric discharge machining (EDM) parameters. The material that is used in this project is Aluminium 5083 and will be cut with different parameters toward the results in term of the surface roughness, electrode wear (EW) and material removal rate (MRR). The parameters considered are the current, voltage, pulse on time and pulse off time. This was done using the technique of design of experiments (DOE) to select the optimal machining conditions for finishing stages and good surface roughness. The main machine used is EDM Die-Sinking (MODEL: AQ35L SODICK).


**Figure 1.1**: Die-Sinking EDM (MODEL: AQ35L SODICK)

## 1.3 Problem Statement

In electrical discharge machining (EDM) work material is removed using an electrical spark erosion process. Common methods of evaluating machining performance in the EDM operation are based on the following performance characteristics: material removal rate, surface roughness, and electrode wear ratio. These output responses are directly correlated with machining parameters such as pulse-on time, duty factor, discharge current, etc. These controllable parameters are usually adjusted to get the fine quality of surface roughness. Hence, proper selection of the machining parameters will result in better response which here is higher material removal rate. Previously, there has been no significance study on Die-sinker EDM using Aluminium 5083 with graphite as the electrode. In this study, the investigation is focused on effect of various parameters on Die-sinker EDM machining on Aluminium 5083 using graphite electrode. This experiment also tries to get which parameter that affects the most in cutting Aluminium 5083.

## 1.4 Objectives

The main objectives of this study are as the following:

(a) To gain basic knowledge on advance machining.

(b) To know basic principles of Die-Sinking EDM.

(c) To determine basic machining characteristic of Die-Sinking EDM.

(d) To apply statistical analysis of experiment (DOE) using suitable designs method to select the best parameter combination.

## 1.5 Scope of the Project

The scopes of the work in order to achieve the main objective are:

(a) Using Aluminium 5083 as a workpiece material.

(b) Using Graphite as an electrode.

(c) Study the parameters involve in this study such as current, voltage, pulse on time and pulse off time.

(d) Implementing design of experiment (DOE) method to analyze the results.

# CHAPTER 2

## LITERATURE REVIEW

The following sections present discussions on topics related with Die-sinking EDM process such as the concept of Die-sinking EDM technology, the machining parameters and the material used. At the end of the chapter, several results of previous study are presented.

### 2.1 Introduction

In the past fifty years, EDM and wire EDM have made tremendous increases in the manufacturing field. Puertas & Perez [9] state “EDM is a 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”. Also EDM process is used in various fields and industries such as the medical field, construction, automotive, and aeronautics and space. Puertas and Perez explain that there are two basic types of EDM: die-sinking and wire EDM. Die-sinking EDM reproduces the shape of the tool used (electrode) in the part being machined, whereas in wire EDM a metal wire (electrode) is used to cut a programmed outline into the piece being machined.

Electrical Discharge Machining, EDM is one of the most accurate manufacturing processes available for creating complex or simple shapes and geometries within parts and assemblies. The main limitation of EDM is that it can only cut materials that are electrically conductive. The EDM process is commonly used in the tool and dies industry for mold-making, however in recent years EDM has become an integral part for making prototype and production parts.

Besides, EDM (electrical discharge machining) is a machining method primarily used for hard metals or those that would be impossible to machine with traditional techniques. EDM can cut small or odd-shaped angles, intricate contours or cavities in extremely hard steel and exotic metals such as iconel, hastelloy, kovar, titanium and carbide. Sometimes referred to as spark eroding or spark machining, EDM is a method of removing material by a series of rapidly recurring electric arcing discharges between an electrode (the cutting tool) and the work piece, in the presence of an energetic electric field.

The EDM cutting tool is guided along the desired path very close to the work but it does not touch the piece. Rapidly occurring consecutive sparks produce a series of micro-craters on the work piece and remove material along the cutting path by melting and vaporization. The constantly flushing dielectric fluid washes away the particles. The EDM Machining process is becoming a common method of making production and prototype parts, though it has been most widely used by the mold-making tool and dies industries. Particularly in the aerospace and electronics industries in which production quantities are relatively low.

### 2.1.1 Principle of EDM

The basic principle behind EDM machines dates back to the fifty years ago. They basically work in one of two ways: "they cut metal with a special metal wire electrode that is programmed to travel along a preprogrammed path (in the case of wire EDM), or they form a required shape negatively in a metal using a three dimensional electrode in the case of die sinking EDM machines [4]. EDM uses a charged electrode, and then brings the electrode near a workpiece (oppositely charged). As the tool and the workpiece get close enough, a spark will occur in dielectric fluid. The sparks then create a hole in both the electrode and the workpiece.

Some of the different types of materials used for electrodes are: copper, tungsten, and graphite. Although all these materials are used as electrodes, graphite is the most commonly used material because it is less affected and warn from the process. Graphite also is machined very easily, conducts electricity, and does not vaporize. During the process, the discharges that reveal the “spark” create the crater-like surface on the workpiece [1].

When explaining the workpiece and the tool being used, the terms, anode and cathode are the proper vocabulary terms used. The tool during the EDM process is shaped to the detailed required. The positive electrode and the negative electrode never touch each other, and a small gap is maintained at all times between the two electrodes by a computer. Both electrodes are inundated into dielectric fluid and create a course for the electric discharge to be made. Dielectric fluid is normally a clear color, some manufacturers will slightly dye their brand to make it unique. All EDM fluids have a high dielectric strength. Dielectric strength is important while a high value of strength is required, too high of a value will force a smaller gap and could lead to a higher wear on the electrode. Most quality dielectric fluids will be odorless but there are some that do produce an odor which generally means the quality isn't as high. There are petroleum and sythetic oils for EDM [2]. The dielectric fluid allows the tool to cool and removes any waste products remaining. The dielectric fluid is critical in coming out with a good surface finish because it controls the discharge [3].

### 2.1.2 EDM Operation

Operating the EDM machine is not as difficult as the process itself. Puertas & Perez [9] explain: Electrical discharge machining (EDM) is a non-traditional manufacturing process based on removing material from a part by means of a series of repeated electrical discharges (created by electric pulse generators at short intervals) between a tool, called the electrode, and the part being machined in the presence of a dielectric fluid.

When operating EDM, there are two designs for the tool feed: ram and quill. The ram-feed machines are more heavy duty and less expensive than the quill-feed. The ram-feed uses a hydraulic cylinder for the movement of the head, whereas the quill-feed uses a hydraulic motor to drive a leadscrew. Both are controlled by "advancing and retracting the tool" [5]. Not only are the designs different, but there are also a large number of factors to consider within the EDM process, such as the level of generator intensity, the pulse time, and the duty cycle.

Puertas & Perez [9] clarify, "The level of generator intensity represents the maximum value of the discharge current intensity. The pulse time is the duration of time that the current is allowed to flow per cycle, and the duty cycle is the percentage of the pulse time relative to the total cycle time.

In addition, none of these processes within EDM require force, because the anode never touches the cathode. Another factor to consider in the EDM process is the speed of material removal. The speed of the material removal process as in most cases is measured by cubic inches per hour. The EDM process does not require force. There are several factors that control the material removal rate. The most important of these is the melting temperature of the workpiece material. The lower the melting temperature, the faster the removal rate. The rate of which the electrode is eroded is also considered. "Erosion rates are not affected by the material hardness but by the melting temperature of the material being used" [6].

### 2.1.3 Advantages and Disadvantages of EDM

EDM is a method of machining parts that cannot be done by conventional machines. "Since the tool does not touch the workpiece, there are no cutting forces generated; therefore, very fragile parts can be machined" [7]. The shape and also the hardness of the materials being used make EDM ideal. The EDM process leaves no burrs and the material is flushed away by the dielectric fluid, and by eliminating extra steps it also lowers costs. EDM makes it ideal for small, lots of parts, allowing reducing operating expenses, delivery dates, or reducing inventory. EDM can replace many types of contour grinding operations and eliminate secondary operations such as deburring and polishing. EDM is at an advantage when secondary operations are too labor intensive for traditional machines.

In addition, some of the advantages of EDM include machining of complex shapes that would otherwise be difficult to produce with conventional cutting tools, extremely hard material to very close tolerances, very small work pieces where conventional cutting tools may damage the part from excess cutting tool pressure. However EDM also have some disadvantages like inability to machine non-conductive materials, slow rate of material removal, additional time and cost used for creating electrodes for Die-Sinker EDM and reproducing sharp corners on the workpiece is difficult due to electrode wear.

## 2.2 Types of machines

There are two types of EDM processes namely wire and die sinker (also called Conventional EDM and Ram EDM). Wire EDM uses a metal wire as the tool electrode. It can generate two or three dimensional shapes on the workpiece for making punch dies and other mechanical parts. Die sinker are generally used for complex geometries where the EDM machine uses a machined graphite or copper electrode to erode the desired shape into the part or assembly.

### 2.2.1 Die-Sinking EDM

The Die-sinker EDM machining process uses an electrically charged electrode that is configured to a specific geometry to burn the geometry of the electrode into a metal component. The sinker EDM process is commonly used in the production of dies and molds. Over the past few years, advances in the field of EDM have allowed the manufacturing of ceramic materials. The main inconvenience with the die-sinking EDM is the electrical conductivity of the ceramic material. There are different variables when using the EDM for ceramic materials, such as: "surface roughness, material removal rate, and electrode wear" [6]. The following list shows the important input and output parameters with their general ranges:

**Table 2.1**: General Input and Output Parameter Die-Sinking EDM [8].

| **Input parameter** | **Range** |
|---|---|
| Voltage | 40-400V(DC) |
| Gap between electrode to workpiece | 0.0127-0.0508 mm |
| Current density | $10^3$ - $10^4$ A/mm$^2$ |
| Discharge time | $10^{-7}$-$10^{-3}$ s |
| Polarity | Plus to minus or minus to plus |

The concept of Die-Sinking EDM can be described as the following. Two metal parts submerged in an insulating liquid are connected to a source of current which is switched on and off automatically depending on the parameters set on the controller. When the current is switched on, an electric tension is created between the two metal parts. If the two parts are brought together to within a fraction of an inch, the electrical tension is discharged and a spark jumps across. Where it strikes, the metal is heated up so much that it melts. Innumerable such sparks spray, one after the other (never simultaneously) and gradually shape the desired form in the piece of metal, according to the shape of the electrode. Several hundred thousand sparks must fly per second before erosion takes place. In the case of die-sinking EDM, the required shape is formed negatively in the metal with a three-dimensional electrode. By superimposed movements in the main axes x, y, c, z, the most varied shapes, indentations and cavities are created, such as cannot in part be achieved by any other machining system.