UNIVERSITI TEKNIKAL MALAYSIA MELAKA

The Effects of Cutting Parameter on Workpiece Surface Layers in the Die Sinking Electrical Discharge Machine (EDM)

Thesis submitted in accordance with the partial requirements of the Universiti Teknikal Malaysia Melaka for the Bachelor of Manufacturing Engineering (Manufacturing Process)

By

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APPROVAL

This thesis submitted to the senate of UTeM and has been accepted as partial fulfilment of the requirements for the degree of Bachelor of Manufacturing (Manufacturing Process). The members of the supervisory committee are as follow:

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Main Supervisor
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ABSTRACT

The electrical discharge machining removes workpiece by an electrical spark erosion process. The variations in the machining parameters, such as polarity, pulse-on time, open discharge voltage, discharge current and dielectric fluid greatly affect the measures of the machining performance, for example surface roughness, EWR and MRR. Therefore, proper selection of the machining parameters can result in better machining performance. The surface phenomena that occur by EDMed were studied under different machining parameter. The machining parameters selected are current, voltage and jump speed. Experimental result indicate that the higher the discharge energy, the faster the machining time which will influences the resolidified surface layer and worsens the surface roughness.

ABSTRAK

Permesinan Nyahcas Elektrik membuang benda kerja melalui proses hakisan percikkan bunga api. Variasi parameter dalam permesinan adalah, kekutuban laksana, nadi masa, voltan pemberhentian terbuka, arus elektrik dan dielektrik bendalir dimana menjejaskan prestasi permesinan, seperti kekasaran permukaan untuk EWR dan MRR. Oleh itu, pemilihan parameter yang sesuai dapat menghasilkan prestasi permesinan yang baik. Fenomena permukaan yang disebabkan oleh permesinan EDM telah dipelajari di bawah parameter yang berbeza. Parameter permesinan terpilih adalah arus elektrik, voltan dan lompatan kelajuan. Hasil percubaan menunjukkan bahawa lebih tinggi tenaga luahan, lebih cepat masa permesinan dan mempengaruhi penyejukkan lapisan permukaan. Ini memberi kesan kerosakkan permesinan pada lapisan penyejukkan dan merosakkan kekasaran permukaan.

DEDICATION

For my beloved mother and father

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TABLE OF CONTENTS

Abstract……………………………………………………………………..……...…i

Abstrak………………………………………………………………………………...ii

Dedication …………………………………………………………………………....iii

Acknowledgement ………………………………………………………………………iv

Table of Contents ………………………………………………………………………..v

List of Figures …………………………………………………………………....viii

List of Tables ……………………………………………………………………………x

Sign and Symbols ………………………………………………………………………xi

List of Appendices ……………………………………………………………………..xii

1.0 INTRODUCTION…………………………………………………………………..1

1.1 Statement of the Problem…………………………………………………………...2

1.2 Objectives…………………………………………………………………………...3

1.3 Scope……………………………………………………………………………….3

2.0 LITERATURES REVIEW……………………………………………………....4

2.1 Electrical Discharge Machine (EDM)……………………………………………4

2.2 Die-Sinking EDM…………………………………………………………………...6

2.3 Principle of Die sinking EDM………………………………………………………7

2.4 Die Electric Fluid…………………………………………………………………...8

2.5 Flushing……………………………………………………………………………..9

2.6 Material of Workpiece: (Mild Steel -AISI 1020 steel)...……………………….....11

2.7 Electrode………………………………………………………………………….....13

2.7.1 Copper Electrode…………………………………………………………......13

2.8 Surface Texture……………………………………………………………………15

2.9 Surface Roughness (R_a)………………………..……………………………….16

2.9.1 Symbols for Surface Roughness………………………………………….....18

2.9.2 Surface Effect and Accuracy……………………..……………………….21
2.10 Parameter……………………………………………………………………25
2.10.1 Current………………………………………………………………..25
2.10.2 Voltage……………………………………………………………….26
2.10.3 Jump Speed…………………………………………………………...26
2.11 Overview of DOE…………………………………………………………..27
2.11.1 The Role and Implication of DOE………………………………...….28
2.11.2 Orthogonal Array (OA) Experiment……………………………………29
2.12 Conclusion of Literature Review.……………………………….……….…31

3.0 METHODOLOGY………………………………………………………...33
3.1 Introduction…………………………………………………………..........33
3.2 Design of Factor (DOE) Methodology………………………………………….35
3.2.1 Stage 1: Objective of Experiment………………………….............35
3.2.2 Stage 2: Identification of the Control Factors and Their Levels……...35
3.2.3 Stage 3: Identify Suitable Noise Factor/Response……………………36
3.2.4 Stage 4: Select the Appropriate Orthogonal Array (OA)……………..37
3.2.5 Stage 5: Preparation of the Experiment……………………………….39
3.2.6 Stage 6: Analyzed and Interpret Results of Experiment Trials……....43
3.2.7 Stage 7: Conclusion and Recommendation………………..………....44

4.0 RESULTS AND DISCUSSION……………………………………………...45
4.1 Finding of Surface Roughness………………………………………………..45
4.1.1 Factorial Design Analysis……………………………………………….46
4.1.2 Reduced Model…………………………………………………………47
4.1.3 ANOVA Balanced………………………………………………………48
4.1.4 Mathematical Model……………………………………………………50
4.2 EDM Surface Morphology ……………………………………………….....52

5.0 CONCLUSION AND RECOMMENDATIONS…………………………………...56

5.1 Conclusion………..…………………………………………………………..56

5.2 Recommendations……………………………………………………………57

REFERENCES …………….…………………………………………………………….58

APPENDICES

A Gantt chart for PSM 1

A Gantt chart for PSM 2

B EDMed set up

C Results of Surface Roughness

LIST OF FIGURES

2.1	Schematic illustration of the electrical-discharge machining process.	5
2.2	A controlled spark discharge removes a very small particle of metal during each electrical discharge.	5
2.3	Ram-type EDMs plunge a tool, shaped to the form of the cavity required, into a workpiece.	7
2.4a	Control spark removes metal during electrical discharge machine.	8
2.4b	Erosion process: ball-screw die-sinker.	8
2.5a	Down through the electrode.	10
2.5b	Up through the workpiece.	10
2.6a	By vacuum flow.	11
2.6b	By vibration.	11
2.7	Standard terminology and symbol to describe surface finish (Quantity is given in μin).	15
2.8	The Arimethic mean value.	17
2.9	Coordinate used for surface roughness measurement.	18
2.10	Standard lay symbols for engineering surface.	19
2.11	Comparison of surface roughness produced by common production process.	20
2.12	Heat-affected zones in EDM.	21
2.13	Effect of pulse length on surface roughness and wear.	23
2.14	Typical SEM micrographs of the recast layer on the cross-section.	23
2.15	SEM photomicrograph of the recast layer of the tool steel after EDM at 5 A.	24
2.16	Thickness of the recast layer at various EDM conditions.	24
3.1	Flow chart.	34

3.2 The 3 steps in designing Orthogonal Array. 37
3.3 Experiment layout preparation. 39
3.4a (a)Copper electrode (b) Mild steel AISI 1020. 40
3.4b Mild steel AISI1020. 40
3.5a Vertical position for electrode. 41
3.5b The tool and the workpiece were submerged in a dielectric fluid. 41
3.6 EDM die sinking Sodick LN2/LQ Series. 41
3.7a Portable Surface Roughness Tester (SJ 301) 42
3.7b The Scanning Electron Microscope (SEM) 42

4.1 Normal Probability Plot of the Effects 46
4.2 Mean Effects Plot (data means) for Ra 46
4.3 Pareto Chart of the Effects standardized (First model) 47
4.4 Pareto Chart of the effects (Second model) 47
4.5 Cube Plot (data means) for R_a 48
4.6 Data of an ANOVA: R_a versus IP 49
4.7 Estimated Coefficient for R_a 50
4.8 Exp. 1; R_a = 2.52μm 52
4.9 Exp. 2; R_a = 8.36μm 52
4.10 Exp. 3; R_a = 2.68μm 52
4.11 Exp. 4; R_a = 7.49μm 52
4.12 Exp. 5; R_a = 3.81μm 52
4.13 Exp. 6; R_a = 5.64μm 52
4.14 Exp. 7; R_a = 3.04μm 53
4.15 Exp. 8; R_a =6.78μm 53

LIST OF TABLES

2.1	AISI 1020 Steel Composition	12
2.2	Mechanical Properties	13
2.3	Thermal Properties	13
2.4	The Physical Properties of Copper Electrode	15
2.5	Orthogonal Array Designation	30
3.1	The Level of Process Parameter for Copper Electrode	36
3.2	The Setting of EDM Parameters	36
3.3	Orthogonal Array Table	38
3.4	Orthogonal Array Table for Experiment	38
4.1	Data of surface Roughness (R_a) Test	45
4.2	Analysis of Variance for R_a	49
4.3	Machining Time from DOE	54

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

%	-	percent
°C	-	Celsius
μ	-	micro
μin	-	micro inch
A	-	Ampere
ANOVA	-	analysis of variance
cm	-	centimeter
CNC	-	computer numerical control
DC	-	direct current
DOE	-	design of experiment
EDM	-	electrical discharge machine
EWR	-	electrode wear rate
in	-	inch
kHz	-	kilohertz
kPa	-	kilopascal
m	-	meter
mm	-	millimeter
MPa	-	mega Pascal
MRR	-	material removal rate
OA	-	orthogonal Array
Ra	-	arithmetic mean value
Rq	-	root mean square average
SEM	-	scanning electron microscope
V	-	Volt
Ω	-	ohm

LIST OF APPENDIX

A Gantt chart for PSM 1

A Gantt chart for PSM 2

B EDMed set up

C Results of Surface Roughness

CHAPTER 1

INTRODUCTION

1.0 Introduction

Electric discharge machining provides an effective manufacturing technique that enables the production of parts made of special materials with complicated geometry which is difficult to produce by conventional machining processes. Controlling the process parameters to achieve the required dimensional accuracy and finish placed this machining operation in a prominent position.

Electrical Discharge Machine (EDM) is a non traditional manufacturing process based on removing material from a part by means of a series of repeated electrical discharges between tool, called the electrode, and the part being machined in the presence of a dielectric fluid. (Luis *et al.* 2005)

At present, EDM is a widespread technique used in industry for high-precision machining of all types of conductive material such as metals, metallic alloy, graphite, or even some ceramic material, of any hardness. The melting point, hardness, toughness, or brittleness of the material imposes no limitation. It thus provides a relatively simple method for making holes of any desired cross section in material that are too hard or brittle to be machined by most other method (DeGarmo *et al.* 1997)

They are virtually zero forces between the tool and the workpiece, so that very delicate work can be done. The process leaves no burrs on the edges. Its use has expanded very rapidly and now it is widely used to produce large body-forming dies in the automotive industry. (DeGarmo *et al.* 1997)

The process doesn't involve mechanical energy, the hardness; strength and toughness of the workpiece material do not necessarily influences the removal rate. The frequency of discharge or the energy per discharge is usually varied to control the removal rate, as are the voltage and current. The removal rate and surface roughness increase with increasing current density and decreasing frequency of spark.

The most important machining performance of EDM are the removal rate, the electrode wear, accuracy and surface texture. In this paper the effect of cutting parameters on workpiece surface layers in the die sinking electrical discharge machine is discussed.

1.1 Statement of the Problem

Modern EDM machinery is capable of machining geometrically complex or hard material component, that are precise and difficult to machine such as heat treated tool steels, composites, super alloy, ceramic, etc. Surface finish produce on machined surface plays an important role in production. It becomes more desirable so as to produce a better surface when hardened materials are machined, requiring no subsequent polishing.

Successive electrical discharges occur at high frequencies, and each discharge result in a tiny crater both on the tool and the workpiece surface. Surface textures created by the sparks have matte appearance covered by shallow craters, debris particle that resolidified after the discharged, and the pockmarks formed by entrapped gasses escaping from the resolidifying material. (A.Kadir *et al.* 2002)

1.2 Objectives

The purposes of this project are:

i. To evaluate the quality of the surface layer produce by different EDM parameters.

ii. To find the significant machining parameter that influences the surface roughness using orthogonal array approach.

iii. To characterize the morphology of EDMed surface of different machining parameters

1.3 Scope

According to the objective, the selected scopes for this project are:

i. To understand the EDM die sinking machining process.

ii. To obtain the surface finish by EDM die sinking with copper electrode.

iii. Study the effects of surface layer on the workpiece by using Scanning Electron Microscope (SEM)

iv. Apply the design of experiment (DOE) and ANOVA approach to analyze the most significant factor that influences the machining performance.

CHAPTER 2

LITERATURE REVIEW

2.1 Electrical Discharge Machine (EDM)

Electrical discharge machining (EDM) is one of the most extensively used non conventional material removal processes. Its unique feature of using thermal energy to machine electrically conductive parts regardless of hardness has been its distinctive advantage in the manufacture of mould, die, automotive, aerospace and surgical components.

EDM does not make direct contact between the electrode and the workpiece eliminating mechanical stresses, chatter and vibration problems during machining. The basis of EDM can be traced as far back as 1770, when English chemist Joseph Priestly discovered the erosive effect of electrical discharges or sparks. (Newman *et al.* 2003)

However, it was only in 1943 at the Moscow University where Lazarenko exploited the destructive properties of electrical discharges for constructive use. They developed a controlled process of machining difficult-to-machine metals by vapourising material from the surface of metal. The Lazarenko EDM system used resistance–capacitance type of power supply, which was widely used at the EDM machine in the 1950s and later served as the model for successive development in EDM. (Newman *et al.* 2003)

The basic EDM system consists of a shaped tool (electrode) and the workpiece, connected to a dc power supply and placed in a dielectric (electrically nonconducting) fluid **(Figure 2.1)** .When the potential difference between the tool and the workpiece is sufficiently high, a transient spark discharge thorough the fluid, removing a very small amount of metal from the workpiece surface **(Figure 2.2)**. The capacitor discharge is repeated at rates of between 50kHz and 500 kHz, with voltages usually ranging between 50V and 380V and current from 0.1 A to 500 A (Serope *et al.* 2001).

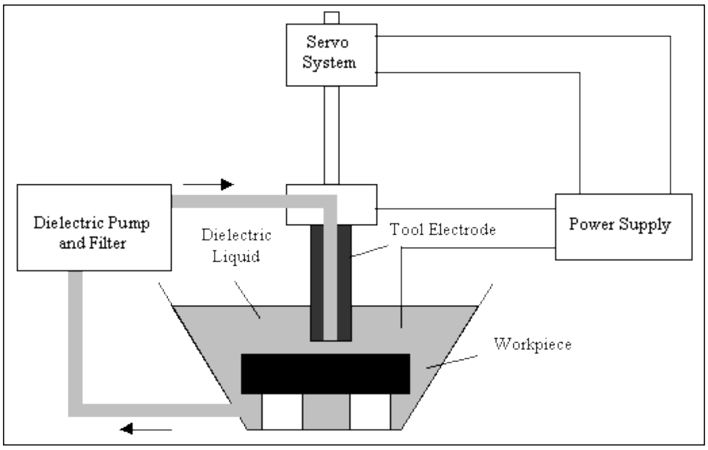


Figure 2.1: Schematic illustration of the electrical-discharge machining Process. (Serope *et al.* 2001)

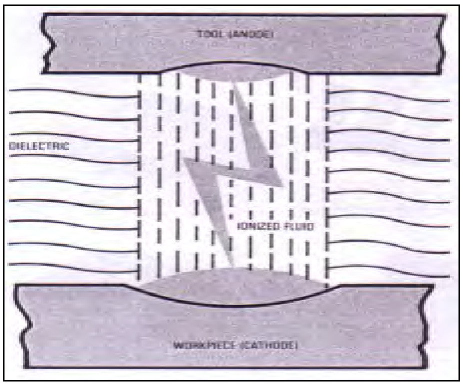


Figure 2.2: A controlled spark discharge removes a very small particle of metal during each electrical discharge (Serope *et al.* 2001).

2.2 Die-Sinking EDM

Die sinker or sinker EDM a common name for vertical EDM. Taken from the antiquated cavity- making process called hobbing. Hobbing is the process of forcing a pre hardened tool steel shape or hob into the workpiece material under great pressure, effectively cold-forming a cavity for a die or mold. This process was called sinking, a die or die sinking, so the term "sinker" for EDM evolved naturally because an electrode was sunk into the workpiece instead of a hardened hob (Bud *et al*. 1997).

RAM EDMing machines are also referred to as die sinkers or vertical EDMs and range in sizes and automation from manual operating table top systems to large CNC ones. A ram EDM a number of main subsystems:

i. Power supply
ii. Dielectric fluid
iii. Electrode
iv. Servo system

The power supply provides series of DC current Electric discharges between the electrode and the work piece. It also controls:

i. Pulse voltage
ii. Current
iii. Pulse frequency
iv. Electrode polarity

The die sinking EDM, **Figure 2.3** has a cutting tool (electrode) shaped to the form of the cavity, mounted in the ram of machines. The electrically conductive workpiece is fastened to the machine table below the electrode. The DC power supply produces a series of short, high-frequency electrical arc discharge between the electrode and the workpiece. This action removes (erodes) tiny particle of metal from the workpiece and as the process continues, the electrode reproduces its form in the workpiece. (Krar *et al*. 1998)

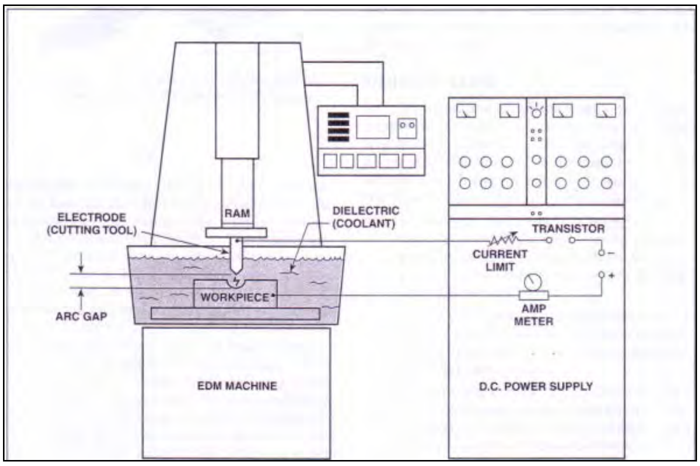


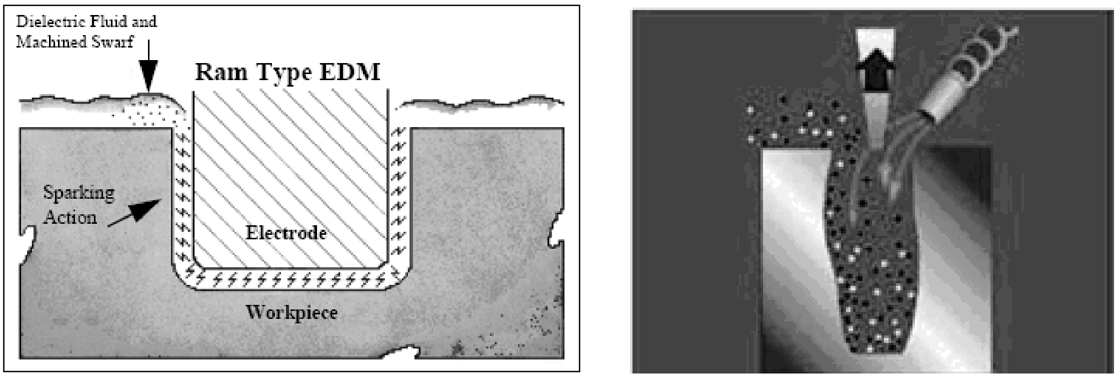
Figure 2.3: Ram-type EDMs plunge a tool, shaped to the form of the cavity required, into a workpiece (Courtesy of Kelmar Associates).

2.3 Principle of Die sinking EDM

According to Krar, the principle of spark erosion was just followed. The workpiece and the tool (electrode) are placed in a working position in such a way that they do not touch each other. The cutting process takes place in a tank where the tool and work are separated by gap that is filled with an insulating fluid.

The workpiece and the tool are both connected to a DC power supply with a cable. When the switch on one cable lead is closed, an electrical potential is applied between the tool and work. Initially, no current flow because the dielectric fluid between the tool and work is an insulator.

As soon as the gap between them is reduced, a spark jumps across the gap and highly heats a very small area of the work material. The current is then automatically shut off and the discharge channel collapses very quickly. The molten metal on the surface of the material evaporates explosively, forming a small crater (Krar *et al*. 1998). **Figure 2.4(a)** shows the control spark removes metal during electrical discharge machine of RAM or Die sinking EDM.



(a) (b)

Figure 2.4: (a) Control spark removes metal during electrical discharge machine (by Technical Service Department-Brush Wellman Inc.); (b) Erosion process: ball-screw die-sinker (Zhao *et al.* 2003)

The metal particles are washed away by the dielectric fluid and the process is repeated many times per second. As one discharge follows another, the crater continues to get bigger, taking the shape of the electrode.

Figure 2.4 (b) shows the die-sinking process of the conventional ball-screw driven EDM, in which the electrode moves up and down slowly along with auxiliary flushing required for removal of debris. When machining very deep and narrow features such as a hole, the slow movement of the electrode does not efficiently expel the eroded debris from the electrode/workpiece interface. (Zhao *et al.* 2003)

2.4 Die Electric Fluid

Oils have been used as dielectric fluid as long as the process has existed, but only in the past decade have any appreciable researches or scientific approaches been made as to their composition and compatibility with people and the environment. There are many different types of fluid available. Typically, fluids with parrafinic, napthenic and aromatic bases are used (Bud *et al.* 1997).