UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON EDM ELECTRODE WEAR

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

by

NORAZWANI ARSHAD

FACULTY OF MANUFACTURING ENGINEERING

April 2009

© Universiti Teknikal Malaysia Melaka

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PSM

TAJUK: **Study on EDM Electrode Wear**

SESI PENGAJIAN: 2008-2009 Semester 2

Saya **NORAZWANI ARSHAD**

mengaku membenarkan tesis (PSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. 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 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	

Disahkan oleh:

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat Tetap:
LOT 2816, Kampung Bukit Bertam,
34500 Batu Kurau,
Perak

Cop Rasmi:

ABD. HALIM HAKIM BIN ABD. AZIZ
Pensyarah
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka
Karung Berkunci 1200 Ayer Keroh
75450 Melaka

Tarikh: 19/5/2009

Tarikh: 19/5/2009

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

© Universiti Teknikal Malaysia Melaka

DECLARATION

I hereby, declared this thesis entitled "Study on EDM Electrode Wear" is the results of my own research except as cited in references.

Signature : .....

Author's Name : NORAZWANI ARSHAD

Date : 15th May 2009

© Universiti Teknikal Malaysia Melaka

APPROVAL

This PSM submitted to the senate of UTeM and has been as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design). The members of the supervisory committee are as follow:

.....

(Abdul Halim Hakim Abdul Aziz)

(Official Stamp & Date)

ABD. HALIM HAKIM BIN ABD. AZIZ
Pensyarah
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka
Kutang Berkunci 1200 Ayer Keroh
75450 Melaka

© Universiti Teknikal Malaysia Melaka

ABSTRACT

Electrical Discharge Machining (EDM) is non-traditional manufacturing process for shaping hard metals and forming deep and complex-shaped holes by arc erosion in all kinds of electro-conductive materials. Despite that, EDM also a process of utilizing the removal phenomenon of electrical discharge in dielectric, therefore the electrode plays an important role which affects the material removal rate and the tool wear rate. The mains problems in EDM is the high rate of tool wear. The objective of this project are to study the behavior of electrode wear, to analyze the effect of process parameter on electrode wears and propose an optimum machining condition of EDM. As a result, there are 9 experiments will be conducted with different peak current (IP) and gap size. And mathematical modeling which is Design of Experiment (DOE) program is used to analysis data for optimization result. The obtain result according to this study is the optimum machining conditions that can be implemented to reduce the rate of the tool wear and at the same time the machining productivity and process reliability are increased.

Keywords: EDM, Electrode, Electrode Wear, EDM Parameters.

© Universiti Teknikal Malaysia Melaka

ABSTRAK

Pemesinan Nyahcas Elektrik (EDM) adalah proses pembuatan moden berfungsi membentuk logam berbentuk keras, dalam dan lubang berbentuk kompleks melalui hakisan lengkungan dalam semua bentuk bahan pengalirqn elektro. Di samping itu, EDM juga adalah proses mempergunakan fenomena pembuangan nyahcas elektrik dalam janakuasa elektrik, walaubagaimanapun elektrod memainkn peranan penting yang mana memberi kesan kepada kadar pembuangan bahan dan kadar kehausan mata alat. Masalah utama dalam EDM adalah kadar kehausan mata alat yang tinggi. Tujuan projek ini dibuat adalah untuk mengkaji kelakuan kehausan elektrod, menganalisis kesan proses parameter terhadap kehausan elektrod dan juga mencadangkan keadaan pemesinan yang optimum. Kesannya, terdapat 9 eksperimen akan dijalankan dengan menggunakan arus puncak dan saiz celahan yang berbeza. Dan model matematik yang mana adalah rekabentuk eksperimen digunakan untuk menganalisis data dalam mendapatkan parameter yang optimum. Hasil yang diperolehi daripada kajian ini adalah keadaan pemesinan yang optimum di mana ianya boleh diaplikasikan untuk mengurangkan kadar kehausan mata alat dan pada masa yang sama proses produktiviti dapat ditingkatkan.

Kata Kunci: EDM, Elektrod, Kehausan Elektrod, EDM Parameter.

© Universiti Teknikal Malaysia Melaka

DEDICATION

For my dearest mom and dad.

© Universiti Teknikal Malaysia Melaka

ACKNOWLEDGEMENT

This project was performed under the supervision of Mr. Abdul Halim Hakim Abdul Aziz , whom I would like to thank for the freedom granted in carrying out this research. I also would like to express my deep appreciation for Mr. Abdul Halim Hakim understanding regarding the difficulties I had during the project. I would like to gratefully acknowledge Mr. Taufik for his help on the DOE software and for being my panels to evaluate my report.

I would like to thank technicians that gave instruction and knowledge about EDM generally. And to all my friend who we have worked together for our projects, I could not achieve it without their support and encouragement.

A special thank to my parents for their patience and support, I really appreciate the sacrifies they have made for me.

© Universiti Teknikal Malaysia Melaka

TABLE OF CONTENT

Abstract i

Abstrak ii

Acknowledgement iii

Table of Content iv

List of Tables x

List of Figures xii

List Abbreviations xv

CHAPTER 1: INTRODUCTION ……...…..1

1.1 Project Background ……..…….....1

1.2 Problem Statement …….....2

1.3 Objective ……..……...…...3

1.4 Scope …….…….....3

1.5 Schematic of Project ……...……...….…..3

1.6 Gantt Chart …….……...……...4

CHAPTER 2: LITERATURE REVIEW ……7

2.1 Introduction ….....7

2.2 Electrical Discharge Machining (EDM) …….....……7

2.2.1 Principles of EDM ……...9

© Universiti Teknikal Malaysia Melaka

2.2.2 EDM Operation …….....11

2.2.3 Type of EDM …….....12

2.2.3.1 EDM Die Sinking ……..……..…..12

2.2.3.2 EDM Wire Cut ……..…….....13

2.2.4 Process Capability …….....16

2.2.5 Advantage ……...…...17

2.2.6 Disadvantage ……...……..18

2.2.7 Limitations ……..……...…18

2.3 EDM Die Sinking ……...…19

2.3.1 Introduction …….……...……..….19

2.3.2 Process of EDM Die Sinking ……..…..20

2.3.2.1 Servo Mechanism ……..…….....20

2.3.2.2 The Discharge Process …….……..21

2.3.2.3 Metal Removal Rates …….……..…...22

2.3.3 Process Parameter ……..23

2.3.3.1 Gap Size ……...……..23

2.3.3.2 Current ……...……23

2.3.3.3 Voltage ……...…...24

2.3.3.4 Pulse Duration (On-Time) ……...……...…..25

2.3.3.5 Pulse Interval (Off-Time) ……...……...26

2.3.4 Electrode ……...26

2.3.4.1 Copper Electrode ……...……27

2.3.4.2 Graphite Electrode ……...…..28

© Universiti Teknikal Malaysia Melaka

2.3.4.3 Brass Electrode ……..…...….28

2.3.4.4 Aluminum Electrode ……...….…….28

2.3.4.5 Mild Steel Electrode ……....…..29

2.3.5 Dielectric Fluid …….….29

2.3.5.1 Types of Dielectric ……..…….30

2.3.5.2 Methods of Circulating Dielectrics …….....30

2.4 Electrode Wear ……..….34

2.4.1 Types of Electrode Wear …….....35

2.4.2 Correlation between Electrode Wear Ratio and Machining Parameter ….....36

2.4.3 Volumetric Wear ……...37

2.4.4 Design of Experiment……39

CHAPTER 3: METHODOLOGY …….……40

3.1 Introduction 40

3.2 Methodology 40

3.2.1 Phase I: Conceptual And Planning 42

3.2.2 Phase II: Experiment And Analysis 42

3.2.2.1 Experiment.....42

3.2.2.2 Material Preparation.....44

3.2.2.3 Equipment.....46

3.2.2.4 Eexperiment Procedure.....53

3.2.3 Phase III: Discussion And Conclusion 55

© Universiti Teknikal Malaysia Melaka

CHAPTER 4: RESULT.....56

4.1 Introduction.....56

4.2 Manual Experiment.....56

4.2.1 Result for Constant IpP=2.0a with Different Gap Size.....57

4.2.2 Result for Constant IP =3.0a with Different Gap Size.....61

4.2.3 Result for Constant IP=4.0a with Different Gap Size.....64

4.2.4 Result for Gap Size =0.1mm with Different IP.....67

4.2.5 Result for Gap Size =0.3mm with Different IP.....67

4.2.6 Result for Gap Size =0.5mm with Different IP.....67

4.3 Results from Doe Analysis.....68

4.4 Image of Electrode After Machining.....71

4.5 Corner Radius of Electrode After Machining.....75

Chapter 5:Discussion.....79

5.1 Introduction.....79

5.2 The Effect Of Process Parameter On Electrode Wear.....80

5.2.1 Effect of Peak Current.....80

5.2.1.1 Graphs for Constant IP=2.0a with Different Gap Size.....80

5.2.1.2 Graphs for Constant IP=3.0a with Different Gap Size.....82

5.2.1.3 Graphs for Constant IP=4.0a with Different Gap Size.....84

5.2.2 Effect of Gap Size.....86

5.2.2.1 Graph for Constant Gap Size=0.1mm with Different IP.....86

5.2.2.2 Graph for Constant Gap Size=0.3mm with Different IP.....88

© Universiti Teknikal Malaysia Melaka

5.2.2.3 Graph for Constant Gap Size=0.5mm with Different IP.....90

5.2.3 Summary.....91

5.2.3.1 Summary of Effect of Peak Current on Electrode Wear.....91

5.2.3.2 Summary of Effect of Gap Size on Electrode Wear.....92

5.3 An Optimum Machining Condition of Edm.....93

5.4 The Tool Performance And Quality of Product.....94

CHAPTER 6:CONCLUSION.....97

REFERENCES 98

© Universiti Teknikal Malaysia Melaka

LIST OF TABLES

3.1 Experiment Planning……43

3.2 EDM Die Sinking Specification……48

3.3 EDM Die Sinking Parameter……49

4.1 Data of Different Types of Wear at Constant IP = 2.0a……...57

4.2 Measurement Before and After Machining for Tool 1……58

4.3 Measurement Before and After Machining for Tool 2……59

4.4 Measurement Before and After Machining for Tool 3……60

4.5 Data of Different Types of Wear at Constant IP = 3.0a……61

4.6 Measurement Before and After Machining for Tool 4……61

4.7 Measurement Before and After Machining for Tool 5……62

4.8 Measurement Before and After Machining for Tool 6……63

4.9 Data of Different Types of Wear at Constant IP = 4.0A……...64

4.10 Measurement Before and After Machining for Tool 7……64

4.11 Measurement Before and After Machining for Tool 8……65

4.12 Measurement Before and After Machining for Tool 9……...66

4.13 Data of Different Types of Wear at Constant Gap Size = 0.1mm……67

4.14 Data of Different Types of Wear at Constant Gap Size = 0.3mm……67

4.15 Data of Different Types of Wear at Constant Gap Size = 0.5mm……67

4.16 Worksheet for Doe Result……68

4.17 Image of Wear at Constant IP = 2.0A……...71

© Universiti Teknikal Malaysia Melaka

4.18 Image of Wear at Constant IP = 3.0A……...72

4.19 Image of Wear at Constant IP = 4.0A……73

4.20 Corner Radius at Constant IP =2.0A……..75

4.21 Corner Radius at Constant IP =3.0A……..76

4.22 Corner Radius at Constant IP =4.0A……..77

5.1 Comparison between Manual Experiment and Mathematical Result……..94

5.2 Surface Roughness for Workpiece…….94

© Universiti Teknikal Malaysia Melaka

LIST OF FIGURES

1.1 Gantt Chart Of PSM 1……...5

1.2 Gantt Chart Of PSM 2……...6

2.1 A Controlled Sparks Removes Metal during Electrical Discharge System….8

2.2 Basic Elements of an EDM…….10

2.3 Stages of Single Spark……11

2.4 Tool Movement Required To Produce Cavities of Various Shape……....18

2.5 Construction of EDM Machine……...20

2.6 Effect of Pulse Duration on Relative Wear Ratio……...25

2.7 Circulating Dielectric Fluid Down Through the Electrode…….31

2.8 Circulating Dielectric Fluids Up Through the Workpiece……..32

2.9 Circulating Dielectric Fluid Down Through the Workpiece by Vacuum…...33

2.10 Circulating Dielectric Fluid by Vibration……...33

2.11 Electrode Wear……35

2.12 Illustration of the Erosion Process……..37

3.1 Flow Chart of the Project……...41

3.2 Dimension of Electrode……..44

3.3 Shape of Electrode……..…44

3.4 Dimension of Workpiece……....45

3.5 Shape of Workpiece after Milling……..45

3.6 EDM Die Sinking Machine……47

© Universiti Teknikal Malaysia Melaka

3.7 Vertical Optical Comparator……..50

3.8 Digital Microscope……51

3.9 Surface Roughness Tester…….....52

3.10 Weighing Scale……..53

4.1 Schematic of Electrode Wear……...57

4.2 Pareto Chart of the Standardized Effect……...69

4.3 Normal Probability Plot of the Standardized Effect……69

4.4 Response Optimization……..70

5.1 Graph of Gap Size Vs End Wear at Constant IP =2.0A……...80

5.2 Graph of Gap Size Vs Corner Wear at Constant IP =2.0A……..80

5.3 Graph of Gap Size Vs Volumetric Wear at Constant IP =2.0A……...81

5.4 Graph of Gap Size Vs End Wear at Constant IP =3.0A……...82

5.5 Graph of Gap Size Vs Corner Wear at Constant IP =3.0A……..82

5.6 Graph of Gap Size Vs Volumetric Wear at Constant IP =3.0A……...83

5.7 Graph of Gap Size Vs End Wear at Constant IP = 4.0A……..84

5.8 Graph of Gap Size Vs Corner Wear at Constant IP = 4.0A…….84

5.9 Graph of Gap Size Vs Volumetric Wear at Constant IP = 4.0A……..85

5.10 Graph of Peak Current Vs End Wear at Constant Gap Size = 0.1mm…….86

5.11 Graph of Peak Current Vs Corner Wear at Constant Gap Size = 0.1mm....86

5.12 Graph of Peak Current Vs Volumetric Wear at Constant Gap Size Of 0.1mm……....86

5.13 Graph of Peak Current Vs End Wear at Constant Gap Size = 0.3mm…….88

5.14 Graph of Peak Current Vs Corner Wear at Constant Gap Size = 0.3mm….88

© Universiti Teknikal Malaysia Melaka

5.15 Graph of Peak Current Vs Volumetric Wear at Constant Gap Size = 0.3mm……...89

5.16 Graph of Peak Current Vs End Wear at Constant Gap Size = 0.5mm……...90

5.17 Graph of Peak Current Vs Corner Wear at Constant Gap Size = 0.5mm…...90

5.18 Graph of Peak Current Vs Volumetric Wear at Constant Gap Size = 0.5mm……...91

5.19 Surface of Workpiece at IP of 2.0 with Gap Size 0.1mm……...95

5.20 Surface of Workpiece at IP of 3.0a with Gap Size O.1mm……95

5.21 Surface of Workpiece at IP of 4.0a with Gap Size 0.1mm……96

© Universiti Teknikal Malaysia Melaka

LIST OF ABBREVIATIONS

EDM	-	Electrical Discharge Machining
DC	-	Discharge Current
CNC	-	Computer Numerical Control
MRR	-	Material Removal Rate
SAE	-	Society of Automotive Engineers
IP	-	Peak Current
DOE	-	Design of Experiment

© Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

1.1 Project Background

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 discharge between tool called the electrode an the part being machined in the presence of a electric fluid. At present, EDM is widespread technique used in industry for high precision machining of all types of conductive materials such as metals, metallic alloys, graphite, or even some ceramics material of any hardness (C.J. Luis *et al.*2005). In tool die and mould making industries, EDM is commonly used for machining heat treated tool steels materials.

EDM also manufacturing process based the erosion of metals sparks discharges. Shaped tool or known as electrode and the workpiece are the basics EDM system which connected to a DC power supply and place in a die electric. The sparks in this process erode away the electrode, thus changing its geometry and adversely affecting the shape produced and its dimensional accuracy. Tool (electrode) wear is thus an

© Universiti Teknikal Malaysia Melaka

important factor which is related to the melting point of the electrode of the materials involved.

EDM has a high capability of machining the accurate cavities of dies and moulds. Nevertheless, electrode wear occurs during EDM process leading to a lack of machining accuracy in the geometry of workpiece. Furthermore, electrode wear imposes high costs on manufacturers to substitute the eroded complicated electrodes by new ones for die making. In order to increase the machining efficiency, erosion of the workpiece must be maximized an that of the electrode minimized in EDM process (H. Zarepour *et al.* 2007).

This study will investigate an optimum machining condition and electrode wear of EDM. This investigation will be done through a several experiments between electrode and workpiece to identify an effect of process parameter on electrode wear. Furthermore, the behavior of electrode wear of EDM die sinking process will be studied to define an optimum machining condition for reducing an electrode wear.

1.2 Problem Statement

The electrode plays an important role which affects the material removal rate and tool wear rate. The main problem in EDM is the high rate of tool wear. Electrode wear occurs during the EDM operation when the electrode gets eroded due to the sparking action. Machining parameter is the major factors that contribute an electrode wear.

© Universiti Teknikal Malaysia Melaka

1.3 Objective

i. To study the behavior of electrode wear.

ii. To analyze the effect of process parameter on electrode wear.

iii. To propose an optimum machining condition of EDM.

1.4 Scope

This project is focuses on the electrode wear and identifies an optimum machining condition of EDM. Therefore, the behavior of electrode wear will be studied and investigated. The main focus is on electrode wear of EDM. In addition, this project aims to finding the effect of process parameters on electrode wear of electrical discharge machining die sinking through the several experiment. The process parameter in this project is focused on peak current and gap size.

1.5 Schematic of Project

Chapter 1 describes about the background of the study, objective, scope of project and problem statement.

© Universiti Teknikal Malaysia Melaka

Chapter 2 instead some literature reviews related to the study which includes reviews on EDM machine, its principles and its application, overview of EDM die-sinking and it's significant and description of electrode wear.

Chapter 3 explains the methodology and the flow of this project in detail from the beginning.

Chapter 4 shows the description of experiment, the result of the analysis and the presentation of data.

Chapter 5 includes a discussion from the experiment that had been done, the results of the study and implication of the findings of the study.

Chapter 6 presents a conclusion on the study and suggestion or recommendation for the future.

1.6 Gantt Chart

Gantt chart has been generated to present the sequence of project activities. It also gives a visual presentation of the schedule of the project flow. Despite that, Gantt chart is very useful tool to monitoring the project progress. Figure 1.1 and Figure 1.2 below are the Gantt chart for PSM 1 and PSM 2. Figure 1.1 show a planning for PSM 1 which is contains an introduction, literature review and methodology while Figure 1.2 present a flow for PSM 2 that includes a result, discussion and conclusion.

© Universiti Teknikal Malaysia Melaka

Gantt Chart of PSM 1

No	Activity	Duration	Start	Finish	JULY				AUGUST				SEPTEMBER				OCTOBER				
					W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17
1	Selecting title for PSM.	1 wk	7-Jul	14-Jul																	
2	Discuss the objectives, scope and problem statement with supervisor.	1 wk	16-Jul	23-Jul																	
3	Research and literature review.	9 wks	16-Jul	17-Sep																	
4	Writing up chapter 1- Introduction.	2 wks	14-Aug	23-Aug																	
5	Developing methodology.	2 wks	23-Aug	6-Sep																	
6	Send draft to supervisor.	1 wk	6-Sep	13-Sep																	
7	Refinement.	3wks	13-Sep	4-Oct																	
8	Report submission.	1 day	8-Oct																		
9	Presentation preparation.	3 wks	8-Oct	22-Oct																	
10	PSM presentation.	2 day	30-Oct	31-Oct																	

Figure 1.1: Gantt Chart of PSM I

© Universiti Teknikal Malaysia Melaka