UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Study the Effect of Wire-EDM Parameters on Surface Roughness for Machining Die-Steel

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

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

Dr. Mohd Rizal Bin Salleh

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ABSTRACT

This study investigated the effects of machining parameters on surface roughness of wire EDMed D2 die steel. Die steel is the alloy composite steel with high hardness typically used in die maker. The machine involved in this study is Mitsubishi wire EDM R90 series in the University Technical Malaysia Melaka CNC center lab. The investigated machining parameters were Voltage Open, pulse-off time and pulse-peak current. Two level factorial design techniques were used to design the experiment and find out the parameters affecting the surface roughness. Results from the analysis show that pulse-peak current is significant variables to the surface roughness of wire-EDMed die steel. The surface roughness of the test specimen increases when pulse-peak current increase.

ABSTRAK

Kajian ini bertujuan untuk mengkaji kesan pembolehubah pemesinan terhadap kekasaran permukaan oleh mesin wayar nyahcas electrik ini. Besi acuan adalah besi aloi komposit yang mempunyai kekerasan yang tinggi yang banyak digunakan dalam industri membuat acuan. Mesin yang terlibat adalah Mitsubishi mesin wayar nyahcas elektrik siri R90 yang terdapat di Makmal CNC Universiti Teknikal Malaysia Melaka Pembolehubah mesin yang digunakan adalah arus elektik, voltan dibuka dan nadi masa tertutup. Teknik dua tahap faktorial digunakan untuk menjalan eksperimen ini dan mengetahui kaitan pembolehubah ini terhadap kekasarn permukaan. Keputusan dari analisis menunjukkan bahawa arus elektrik adalah pembolehubah yang paling penting untuk kekasaran permukaan pada bahan ‘die steel’ menggunakan mesin wayar nyahcas elektrik. Kekasaran permukaan pada contoh spesimen meningkat apabila arus elektrik yang dikenakan meningkat.

DEDICATION

For my beloved mother and father.

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TABLE OF CONTENTS

Abstact i

Abstrak ii

Dedication iii

Acknowledgements iv

Table of Contents v

List of Figure viii

List of Table x

List of Abbreviation, Symbols, Specialized Nomenclature xi

1. **INTRODUCTION** 1

1.1 Background 1

1.2 Problem Statements 2

1.3 Objectives 3

1.4 Scopes of the Project 3

2. **LITERATURE REVIEW** 4

2.1 Electric Discharge Machine (EDM) 4

2.1.1 Spark generator 6

2.1.2 Servo System 7

2.1.3 Dielectric system 7

2.1.4 Mechanical Structure 8

2.2 Material Removal Mechanism 8

2.2.1 Breakdown (Ignition) Phase 9

2.2.2 Discharge Phase 10

2.2.3 Erosion (Crater Formation) Phase 10

2.3 Basic principle of Electrical Discharge Machining (EDM) 11

2.4 Wire Electrical Discharge Machine (Wire EDM) 13

2.4.1 Introduction 13

2.4.2 Description of wire-EDM machine 14

2.4.3 The Principle of Wire Electrical Discharge Machine (Wire EDM) 16
2.4.4 Parameters.. 18
2.4.5 Dielectric fluid. 19
2.4.5.1Deionized water. 19
2.4.5 Wire elctrode.. 20
2.4.6 Flushing. 21
2.5 Material of Worpiece. 22
2.5.1 Cold Work Steel... 23
2.5.2 AISI D2 23
2.5.4 EDM.. 24
2.6 Surface Metrology. 24
2.6.1 Surface evaluation.. 25
2.6.2 Surface texture 25
2.6.3 Surface roughness 26
2.6.4 Surface roughness factor on Wire EDM 29
2.6.5 Characteristic of EDM surfaces 30
2.7 Design of Experiment (DOE). 32
2.7.1 DOE overview 32
2.7.2 Two Level Factorial Design 32

3. METHODOLOGY 34
3.1 Introduction.. 34
3.2 Selection machines and material 35
3.2.1 Wire EDM.. 35
3.2.2 Portable Surface Roughness Tester 38
3.2.3 Material 39
3.2.4 Wire Electrode 39
3.3 Profile Design and Drawing 40
3.4 Identify the method of DOE 40
3.4.1 Two Level Factorial Design and Minitab software 40
3.5 Parameters.. 41
3.6 Conduct of experiment- machining using wire EDM...................................... 42
3.6.1 Procedure for measuring surface roughness 42

3.6.2 Metallurgy Microscope 43
3.7 Data collection and analysis 44

4. RESULTS 45
4.1 Surface Roughness Data 45
4.2 Factorial Design Analysis 49
4.3 Reduced Model 52
4.4 Surface Texture 53

5. DISCUSSION 55

6. CONCLUSSION AND RECOMENDATION 57
6.1 Conclussion 57
6.2 Recommendation 58

REFERENCES 59

APPENDICES

A. Gant chart for PSM1
A Gant chart for PSM2
B Profile drawing
C Surface roughness results

LIST OF FIGURES

2.1	Basic Elements of an EDM system.	6
2.2	Evolution of a single spark in the EDM process	12
2.3	wire EDM machine.	14
2.4	Schematic of wire-EDM system	16
2.5	Basic principle of wire	17
2.6	A schematic diagram of wire rotation in wire EDM operation	21
2.7	AISI D2 die steel compositions	23
2.8	Coefficient of Thermal Expansion (x10-6/C°)	23
2.9	Standard terminology and symbol to describe surface finish. The quantities are given in µin	25
2.10	The Arimethic mean value	27
2.11	Coordinate used for surface roughness measurement	28
2.12	ISO-Recommended Roughness Values and Grade Numbers for the specification of surface roughness	39
3.1	Flow chart for overall project	35
3.2	Mitsubishi wire EDM machine RA 90 series	36
3.3	Mitutoyo Portable surface roughness (SJ 301)	38
3.4	EDM brass cutting wire electrode.	39
3.5	Technical drawing for profile design.	40
3.6	Calibration process using Mitutoyo Portable Surface Roughness	43
3.7	Metallurgy Microscope	44
4.1	Surface Roughness (R_a) versus IP and Off Time (OFF)	47
4.2	Surface Roughness (R_a) versus Voltage Open (V_o)	47
4.3	Surface Roughness (R_a) versus Off Time (OFF)	48
4.4	Normal probability plot of the effects	49

4.5 Interaction Plot (data means) for Surface Roughness (Ra) 50
4.6 Main Effects Plot (data means) for Surface Roughness (R_a) 51
4.7 Pareto Chart of the Effects 52

LIST OF TABLES

2.1	Basic types of tool and die steel	22
3.1	Machine specification	36
3.2	Total of the experiment test	41
3.3	Values of each parameter	41
4.1	Surface roughness value for material die steel.	45
4.2	Surface texture results	53

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE.

%	-	percent
°C	-	Celsius
µ	-	micro
µin	-	micro inch
A	-	Ampere
AA	-	arithmetic average
ANOVA	-	analysis of variance
CNC	-	computer numerical control
DC	-	direct current
DOE	-	design of experiment
EDM	-	electrical discharge machine
in	-	inch
IP		Peak current
kHz	-	kilohertz
mm	-	millimeter
MRR	-	material removal rate
OFF		Off time
PSM	-	Projek Sarjana Muda
Ra	-	arithmetic mean value
Rq	-	root mean square average
SEM	-	scanning electron microscope
V	-	Volt
Vo		Voltage Open

CHAPTER 1

INTRODUCTION

1.1 Background

The development in manufacturing machining have create new era to the many industrial such as automotive, aerospace and other industrial that need precision in their products. The new machines have introduced to change the old conventional method in machining process. The ability of this machine also improves because of the requirement in many industries that need accuracy and reduce machine time.

Accompanying the development of mechanical industry, the demands for alloy materials having high hardness, toughness and impact resistance are increasing. One of those technological developments is novel materials for making various kinds of dies. New die steels have been continuously introduced to the die manufacturers, and affect their die-making processes or their die quality (Boonmung and Kanlayasari, 2007). Nevertheless, those materials are difficult to be machined by traditional machining methods. Hence, non-traditional machining methods including electrolytic grinding, supersonic machining and electrical discharging machining (EDM) are applied.

EDM is one of the unconventional machine develop from the previous conventional machine like milling. EDM is the precision manufacturing machining processes available for creating complex or simple shapes and geometries within parts and assemblies.

Wire-EDM uses electro-thermal mechanisms to cut electrically conductive material. The material is removed by a series of discrete discharges between the wire electrode and the workpiece in the presence of a dielectric fluid, which creates a path for each discharge as the fluid becomes ionized in the gap. The region in which discharge occurs is heated to extremely high temperatures, so that the work surface is melted and removed.

There are many parameter and variables that influence the EDM operation. The parameters that were used influenced the result of the surface roughness. The parameters which influence surface roughness are pulse-on time (ON), pulse-off time (OFF), pulse-peak current (*I*p), and wire tension (*W*T), cutting tool and material of workpiece

The research of this paperwork is to study the wire EDM machining process performance In this paperwork will be focuses on the effect of wire EDM parameters on the surface roughness for machining die steel. The several parameters stated will be study to analyzed machining performance in surface roughness. The evaluations are defined from the experiment outcomes.

1.2 Problem Statement

The wire EDM machining is the most accurate manufacturing process. But there are a few problems that need to be highlighted. The selection of cutting parameters for obtaining higher cutting efficiency or accuracy in wire-EDM is still not fully solved. This is because due to the complicated stochastic process mechanisms in wire-EDM. AISI D2 is new material use in wire EDM machining process in UTeM, so the suitable value parameter need to study to get high quality in surface finish.

1.3 Objectives:

1. To study the effect of wire-EDM parameters on surface roughness for machining die steel by conducting several machining process.

2. To evaluate the quality of the surface roughness produce by different EDM parameters using surface roughness tester.

3. To find the derivative parameters that affects the EDM surface roughness.

1.4 Scope of the Project

The scope of this project is conducting a machining operation using wire EDM to analyze the machining performance. The machining operation is using Mitsubishi RA 90 series wire EDM. This study will be focused on the effect of the working surface. The parameter such as voltage open, pulse off time and pulse peak current will be set according to the design of experiment (DOE) and the other parameters remain constant. The material tested is AISI D2 high carbon and the electrode is brass wire diameter 0.25mm will be use during the experiment. After the machining operation, the surface of cutting material will analyzed using surface roughness tester. The surface roughness tester using is Portable Surface Roughness Tester (SJ 301). Then from the result obtained, the comparison of the surface roughness between the set of experiment will be discussed.

CHAPTER 2

LITERATURE REVIEW

2.1 Electrical Discharge Machine (EDM).

The beginning of EDM came during the Second World War, when two Russian physicists B.R. and N.I. Lazarenko published their study on The Inversion of the Electric Discharge Wear Effect which related to the application to manufacturing technology of the capacity of electrical discharges, under controlled distribution, to remove metal.

EDM was being used at that time to remove broken taps and drills. The early "Tap-Busters" disintegrated taps with hand fed electrodes, burning a hole in the center of the tap or drill, leaving the remaining fragments that could be picked out. This saved workpieces and very expensive parts from being scrapped and re-made. This process opened the birth of Vertical EDM, also called: Sinker, Conventional, Ram, Plunge or Diesinker EDM, because the burned downward in the Z-axis. These machines were, and still are primarily used to make precision cavities in metal for the mold industry.(kalpakjian, S and Schmid, S.R, 2000)

The recent increase in the use of hard, high strength, and temperature resistant materials in engineering has made it necessary to develop many machining techniques. With the exception of grinding, conventional method of removing material from a workpiece are not readily applicable to most of these new materials. Most of the new machining processes have been developed specifically for materials that are difficult to machine, but some of them have found use in the production of complex shapes and cavities in softer, more readily machined material. The EDM is one of unconventional method that use in machining process as the development in manufacturing technology.

Basically Electric Discharge Machining (EDM) is a process for eroding and removing material by transient action of electric sparks on electrically conductive materials. This process is achieved by applying consecutive spark discharges between charged workpiece and electrode immersed in a dielectric liquid and separated by a small gap. Usually, localized breakdown of the dielectric liquid occurs where the local electrical field is highest. Each spark melts and even evaporates a small amount of material from both electrode and workpiece. Part of this material is removed by the dielectric fluid and the remaining part resolidifies rapidly on the surfaces of the electrodes. The net result is that each discharge leaves a small crater on both workpiece and electrode. Application of consecutive pulses with high frequencies together with the forward movement of the tool electrode towards the workpiece, results with a form of a complementary shape of the electrode on the workpiece.

The material removal rate, electrode wear, surface finish, dimensional accuracy, surface hardness and texture and cracking depend on the size and morphology of the craters formed. The applied current, voltage and pulse duration, thermal conductivity, electrical resistivity, specific heat, melting temperature of the electrode and workpiece, size and composition of the debris in dielectric liquid can be considered as the main physical parameters effecting to the process. Among them, applied current, voltage and pulse duration are the parameters which can be controlled easily.

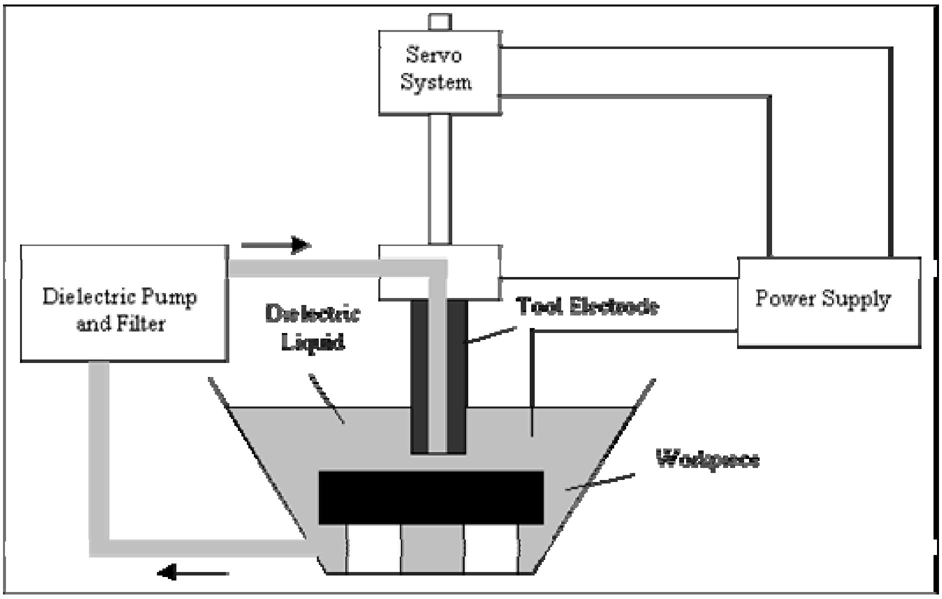

Figure 2.1. Basic elements of an EDM system. (Nedians., Fortunecity, 2007)

Every EDM machine has the following basic elements as shown in Figure 2.1.

1. Spark generator
2. Servo system
3. Dielectric liquid
4. Mechanical structure

2.1.1 Spark Generator .

The required energy is in the form of pulses usually in rectangular form. Recent studies have been shown that application of pulses in the form of trapezoids resulted with a marked improvement in cutting efficiency. The optimum pulse form is not exactly a trapezoid, but similar.

Electrical energy in the form of shot duration impulses with a desired shape should be supplied to the machining gap. For this purpose, spark generators are used as the source of electrical pulses in EDM. The generators can be distinguished according to the way in which the voltage is transformed and the pulse is controlled. The discharge may be produced in a controlled manner by natural ignition and relaxation, or by means of a controllable semiconductor switching elements. Nowadays, sophisticated computer aided spark generators are in use as a result of fast development in electronics industry. These types of generators give us a better manner in controlling physical parameters.

2.1.2 Servo System.

Both electrode and workpiece are eroded during the process, after a certain time dimensions of the electrodes will be changed considerably. The result is increase in interelectrode gap. This will increase the voltage required for sparking. This problem can be solved by increasing the pulse voltage or decreasing the gap distance. The former is not feasible since most of the electrical energy is used for overcoming breaking strength and producing plasma in dielectric liquid rather than machining, in addition to that, the required voltage can increase to the levels that spark generator can not supply, therefore; the interelectrode gap should be maintained constant during the process. This can be achieved by a servo system which maintains a movement of the electrode towards the workpiece at such a speed that the working gap, and hence, the sparking voltage remains unaltered.

2.1.3 Dielectric Circuit.

High cooling rates during resolidification process changes the chemical composition of the both electrodes and dielectric liquid machining particles called debris are formed. Formation of such particles effects on machining performance, therefore, dielectric liquid should be circulated to prevent contamination in working gap. This circulation is done by a dielectric circuit which is composed of a pump, filter, tank and gages.

2.1.4 Mechanical Structure.

EDM machines have similar construction with conventional drilling and milling machine frames with vertical tool feeding and horizontal worktable movements. Since there is not a real contact between electrodes, that's why, it is considered that, the frame elements not taking much force as in conventional machining so simpler design is possible. This consideration needs a little bit attention, because gas bubbles collapses at the end of discharge and cause high frontal shock waves, therefore; the frame should be strong enough to keep its dimensional stability. (Nedians., Fortunecity, 2007)

2.2 Material Removal Mechanism.

A perfect general theory for EDM can not constructed since each machining condition has its own particular aspects and involves numerous phenomena, i.e., heat conduction and radiation, phase changes, electrical forces, bubble formation and collapse, rapid solidification. In addition, theories of how sparks eroded the workpiece and electrode have never been completely supported by the experimental evidence since it's very difficult to observe the process scientifically. Thus, most of the published studies are mostly concerned with simplified models of different events of EDM. Development of high-speed computers and comprehensive numerical techniques enabled scientist to involve more parameters in their models than before, but still many aspects of the process can not be explained in detail.

Melting, vaporization and even ionization of the electrode materials occurs at the point where the discharge takes place. Flushing action of the dielectric liquid pulls away whole vaporized and some of melted material. The result is formation of a crater on both electrode surfaces. Theoretical models based on one spark can be extended to the machining with same side effects. Generally the physics of the sparks can be investigated in three phases.

(i) Breakdown (Ignition) phase

(ii) Discharge phase

(iii) Erosion(Crater Formation) phase

Breakdown phase takes a relatively small percent of the total spark time. It varies from few microseconds to several hundreds depending on discharge conditions. Erosion is only observed only in later stages of spark, partly after the discharge has eased.

2.2.1 Breakdown (Ignition) Phase.

Breakdown in liquids is the initial condition for plasma formation. There are several proposed theories which try to explain the breakdown phase, but consistent results with experiments can not be obtained. A simplified expression can be given as below.

The charge induced on the two electrodes by the power supply creates a strong electric field. This field is strongest where the electrodes are closest to each other. This is the point where discharge takes place. Molecules and ions of the dielectric fluid are polarized and oriented between these two peaks and forming a narrow, low-resistance channel. When the dielectric strength of the liquid in the gap exceeded due to the electric field, breakdown occurs. Electrons emitted from both electrodes and the stray electrons and ions in the dielectric liquid are accelerated. When accelerated electrons and ions reached to the electrons a current flow starts which is the beginning of the discharge phase.

2.2.2 Discharge Phase.

Discharge phase of the process is similar to many gas discharges in that a constant current is passed through the plasma. But, shorter pulse duration and use of dense