EFFECT OF EDM DIE SINKING PARAMETERS ON THE MATERIAL CHARACTERISTICS OF ALUMINIUM ALLOY LM6 USING GRAPHITE ELECTRODE

NOR ATIQAH BINTI JAAFAR SIDEK
B050910068

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
2013

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF EDM DIE SINKING PARAMETERS ON THE MATERIAL CHARACTERISTICS OF ALUMINIUM ALLOY LM6 USING GRAPHITE ELECTRODE

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

by

NOR ATIQAH BINTI JAAFAR SIDEK
B050910068
890815-05-5406

FACULTY OF MANUFACTURING ENGINEERING
2013

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Effect of EDM Die Sinking Parameters on the Material Characteristics of Aluminium Alloy Lm6 Using Graphite Electrode**

SESI PENGAJIAN: 2012/ 2013 Sem 2

Saya **NOR ATIQAH BINTI JAAFAR SIDEK**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM 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 ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

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

Disahkan oleh:

_____ _____

Alamat Tetap:

Lot 172, Kg. Bagan Pinang,

71000 Port Dickson,

Negeri Sembilan.

Cop Rasmi:

Tarikh: _____ Tarikh: _____

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

DECLARATION

I hereby, declared this report entitled “Effect of EDM Die Sinking Parameters on the Material Characteristics of Aluminium Alloy LM6 Using Graphite Electrode” is the result of my own research except as cited in the references.

Signature : .....

Author’s name : NOR ATIQAH BINTI JAAFAR SIDEK

Date :

APPROVAL

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

.....

ABSTRAK

EDM die sinking ialah proses yang digunakan untuk menjalankan pemotongan lubang yang bersaiz mikro dan dalam, serta bahan yang keras dengan ukuran yang mempunyai kejituan yang tinggi. Dalam kajian ini, objektif utama adalah untuk mendapatkan parameter yang optimum bagi proses *EDM die sinking* iaitu merangkumi, *peak current* (I_p), *machining voltage* (V), *pulse on-time* (T_{On}) dan juga *pulse off-time* (T_{Off}) yang bertujuan untuk meningkatkan *material removal rate* (MRR), mengurangkan *electrode wear rate* (EWR) dan *surface roughness* (Ra). Selain daripada itu, tujuan kajian ini juga untuk mengkaji pembentukkan kawah pada permukaan bahan kerja. Mesin EDM dengan model SODICK (AQ35L) digunakan dalam kajian ini, manakala *analytical balance* (METTLER TOLEDO) digunakan untuk menimbang bahan kerja dan juga elektrod. Nilai MRR dan EWR dikira selepas menjalankan ujikaji. Bahan grafit digunakan sebagai elektrod yang berfungsi untuk memesin *Aluminium Alloy LM6*, yang merupakan komposit bagi *aluminium silicon alloy*. Dalam *design of experiment* (DOE), kaedah *Taguchi* telah di aplikasikan dengan menggunakan ketiga-tiga tahap iaitu tahap tertinggi; +1, sederhana; 0 dan terendah; -1. Tambahan pula, terdapat 9 ujikaji yang dijalankan dengan mengulanginya sebanyak tiga kali. Daripada, keputusan yang diperolehi daripada S/N ratio, nilai MRR yang maksima adalah 0.694841g/s. Nilai EWR dan Ra yang diperolehi adalah 0.000065g/s dan 2.52μm. Manakala, hasil dapatan yang diperolehi daripada *Analysis of variance* (ANOVA) ialah I_p adalah parameter yang paling mempengaruhi dalam ujikaji ini; MRR (58.57%), EWR (55.57%) dan Ra (97.56%). Oleh itu, nilai *peak current* yang tinggi akan menghasilkan nilai MRR yang tinggi dan *surface roughness* yang rendah akan terhasil jika nilai peak current juga rendah. Apabila menggunakan grafit sebagai *electtrode* ia menyebabkan nilai EWR meningkat.

ABSTRACT

EDM die sinking is a widespread process which works very effectively in the machining of micro holes, deep holes and harder material with high dimension accuracy. In this study, the objective is to optimize the machining parameters of the EDM process including peak current (I_p), machining voltage (V), pulse on-time (T_{On}) and pulse off-time (T_{Off}) for increasing the material removal rate (MRR), reducing the electrode wear rate (EWR) and surface roughness (Ra) and finally investigating the craters of the workpiece. EDM machine model SODICK (AQ35L) was used in this project and the weight of the workpiece and electrode was measured using the analytical balance (METTLER TOLEDO). The MRR and EWR were calculated after experimental work. Graphite was used as an electrode to machine the Aluminium Alloy LM6, which is a composite of aluminium silicon alloy. Design of experiment (DOE), using Taguchi method has been applied in this project at three levels (high; +1, medium; 0 and low; -1) and there are 9 experiments were done with three repetitions. From the result of S/N ratio, the maximum MRR is 0.694841g/s. The lower EWR and Ra is 0.000065g/s and 2.52µm. Analysis of variance (ANOVA) results shows that I_p is the most significant parameter for this experiment. The results is MRR with 58.57% folowed by EWR with 55.57% and Ra with 97.56%. Thus, higher peak current produced higher MRR and surface roughness is low if the peak current also in low value. In terms of EWR in EDM, when using graphite as an electrode, it will increase the EWR.

DEDICATION

For my beloved mother, father and sisters, their endless support in term of motivation, support and caring as well throughout the whole project.

ACKNOWLEDGEMENT

Bismillahirrahmannirahim,

Alhamdulillah, a very grateful to ALLAH S.W.T in every way giving me the will and strength to complete this research. I would like to express my highest appreciation to my supportive supervisor , Dr. Mohd Amran bin Md Ali, whose help and give a good advice and suggestion.

I would like to thank to the all technical staffs of Faculty of Manufacturing Engineering at University Technical Malaysia Melaka for their cooperation and giving me some useful ideas.

Next, I would like to express my special thanks to my beloved family members and friends who continue giving me encouragement and patience.

Last but not least, thanks alot for those who have directly or indirectly contributed towards completing this research.

TABLE OF CONTENT

LIST OF TABLES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Al	-	Aluminium
Al-Sil2	-	Aluminium Alloy LM6
ANOVA	-	Analysis of Variance
CNC	-	Computer Numerical Coordinate
Cu	-	Cuprum
DC	-	Direct Current
DOE	-	Design of Experiment
EDM	-	Electrical Discharge Machining
EWR	-	Electrode Wear Rate
EWR_{AVG}	-	Average of Electrode Wear Rate
Fe	-	Ferum
Fi	-	Ratio of the mean square error to the residual error
$\hat{i}_e$	-	Discharge current
I_p	-	Peak current
L	-	Low
M	-	Medium
Mg	-	Magnesium
Mn	-	Manganese
MRR	-	Material Removal Rate
MRR_{AVG}	-	Average of Material Removal Rate
n	-	The number of experiments in orthogonal array
Ni	-	Nickel
OA	-	Orthogonal Array
P	-	Percentage contribution
Pb	-	Lead
R-Sq	-	R Square
R-Sq (adj)	-	R Square Adjusted
Ra	-	Surface Roughness
Ra_{AVG}	-	Average of Surface Roughness

RC	-	Remote Control
Si	-	Silicon
S/N	-	Signal-to-Noise
SNRA	-	Signal Noise Ratio Average
SS_d	-	Sum of the squared deviations
SS_T	-	Total sum of squared deviations
t	-	Machining time
td	-	Delay time
te	-	Period of time
ti	-	Pulse duration
Ti	-	Titanium
to	-	Interval time
t_{off}	-	Pulse off time
t_{on}	-	Pulse on time
tp	-	Pulse cycle time
ûi	-	Open circuit voltage
ue	-	Discharge voltage
V_i	-	Variance of i^{th} experiments
V_o	-	Open circuit voltage
V_w	-	Working voltage
Wta	-	Weight of the electrode after machining
Wtb	-	Weight of the electrode before machining.
Wja	-	Weight of workpiece after machining
Wjb	-	Weight of workpiece before machining
Zn	-	Zinc
τ	-	Duty factor
•C	-	Degree Celsius
ρ		Density of Aluminum Alloy 6 Series
µs	-	microsecond
-ve	-	Negative
%	-	Percentage
δ	-	Spark gap

CHAPTER 1
INTRODUCTION

This part of the report, present the background of the project. The introduction acts as a frame for the body, which the problem statement, objective and scope included here. Background of the study describe generally about EDM die sinking. Besides that, the outlines prepared to ensure the ordering of project development.

1.1 Background

EDM die sinking is an electro-thermal non-traditional machining process, where electrical energy is used to remove metal by means of electric spark erosion. In this process an electric spark is used as cutting tool to cut or erode the workpiece and produce the desired shape. EDM has been widely applied in modern industry for producing complex cavities in moulds and dies which are difficult to manufacture by conventional machining (Prabu *et al.*, 2009).

The types of material used in electrical discharge machining (EDM) are limited to the conductive materials such as: metal, metallic alloys, graphite, or even some ceramic materials (Khairul, 2008). Since the EDM die sinking process does not involve mechanical energy, the machining ability is not affected by hardness, strengths or toughness of the workpiece material. Therefore, a comprehensive study of the effect of EDM parameters such as peak current, machining voltage, pulse duration and interval time should be done.

On the machining characteristics such as an electrode wear rate (EWR), material removal rate (MRR) and surface roughness (Ra) is greatly significant and could be of necessity (Amri *et al.,* 2009). There are so many research conducted to study the effect of EDM parameter to the workpiece. The study conducted was to obtain the optimum parameter in the EDM process in order to produce parts with very minimal defects. This project will study and do analysis of surface roughness (Ra), material removing rate (MRR), electrode wear (EWR) and cracking of the crater via workpiece (Aluminum Alloy LM6) for the EDM die sinking machine.

The output variable depends on the accuracy of the electrode and if the correct current is used, very fine finish can be obtained. When high current applied, its produce large sparks and makes large work piece craters. If low current applied, a small sparks are produced which create small craters. The sparks in this process erode away the electrode, thus changing its parameters and adversely affecting the shape produced and its dimensional accuracy.

Taguchi design using a design of experiment (DOE) was used. Using this approach, the significant factors of MRR, EWR, Ra and their associated levels on each response were determined by ANOVA analyses. Analysis of variance (ANOVA) and signal-to-noise (S/N) ratio were performed and calculated, respectively. The important control parameters were the following: peak current, voltage, pulse off-time, and pulse on-time. The experimental workpiece was composed of conductive material were used.

1.2 Problem Statement

EDM die sinking is a machining method primarily used for hard metals or those that would be very difficult to machine (small hole, sharp edge, deep slot, etc.) with traditional techniques. EDM die sinking typically works with materials that are electrically conductive. There is a need to understand the important parameters that greatly influence the surface integrity when using EDM die sinking. It was noticed that various machining parameters influenced material removal rate (MRR), electrode wear rate (EWR) and surface roughness (Ra) and setting possible combination of those parameters was difficult to produce optimum surface quality. Thus, the need the best setting of EDM dies sinking parameters in machining Aluminum Alloy LM6 using a graphite electrode is necessary to get the better EDM die sinking characteristics of MRR, EWR and Ra. Design of experiments (DOE) will be implemented in order to obtain the optimum parameters.

1.3 Objectives

The objectives of this study are:

a) To study the effect of machining parameters such as pulse on-time, pulse-off time, voltage and current on the EDM die sinking characteristics of Aluminium Alloy LM6.
b) To evaluate the machining characteristics of Aluminium Alloy LM6 on the material removing rate (MRR), electrode wear rate (EWR), surface roughness (Ra) and appearance observation.
c) To optimize the machining characteristics using Taguchi methods and analysis of percentage contribution using Analysis of Variance (ANOVA).

1.4 Scopes

The experiment is conducted by using the EDM die sinking. The type of raw material used is Aluminum Alloy LM6, 10 mm in thickness. There are some parameters that selected which are really affecting the surface texture of Aluminum Alloy LM6 after the machining done. They are pulsed on time (T_{On}), pulsed off time (T_{Off}), peak current (I_p) and machining voltage (V).

In this project, various EDM machining characterization techniques will be conducted to understand the effect of machine parameters on the material properties. Design of experiment (DOE) is implemented as it is one of the experimental methods. Once the machining process on EDM die sinking is finished, amount of electrode material removal rate (EWR), surface roughness (Ra) and amount of workpiece material removal rate (MRR) are evaluated.

1.5 Outlines

This report is divided into six chapters. Chapter one consists of the background of the project, problem statements, objectives of the project and the scopes of the project. In this chapter, it is expressed about the background of EDM die sinking application till the problems occur in it and the research conducted in obtaining the optimum parameter in EDM die sinking. Section number two is chapter two.

Chapter two consists of a literature review of the project. The literature review is an evaluation, integrating the previous research together, and explaining on how it integrates into the proposed research program. In the literature review, the main points that have been stated are four major points.

The third chapter is methodology. There are four steps expressed in methodology. The first step is to determine the number of specimens or experiments should be conducted by applying the Taguchi method. The second step is to prepare the

specimens into a certain dimension using lathe machine and EDM wire cut. Fourth step is the experimental procedure in EDM die sinking cutting process which is stated all the parameters in EDM process and the last step is to observe the machined specimens, collect the related data and do the result analysis.

Next, chapter four consists of results, analysis of experiments and discussion. Results of material removal rate (MRR), electrode wear rate (EWR) and surface roughness (Ra) are analyzed by Minitab Software Version 16 using Taguchi method. The analysis of percentage contribution for each output factor are analyzed using analysis of variance (ANOVA).

Lastly, chapter five consists of conclusion and recommendation suggested. The findings in effect of machining parameters, machining characteristics on the output parameters and optimizing the machining characteristics are concluded. Some recommendations are proposed for further investigation in effect of EDM die sinking parameters on the material characteristics of Aluminium Alloy LM6 using graphite electrode.

CHAPTER 2
LITERATURE REVIEW

Literature review is one of the scope studies. It will give part in order to get the information about EDM die sinking. Research journals, books, printed or online conference article were the main source in the project guides. This part includes the machining operation, parameters, characteristics measuring equipments and others. Literature review section work as references, to give the information and guidance.

2.1 EDM Machining Operations

EDM is the thermal erosion process in which metal is removed by a series of recurring electrical discharges between a cutting tool acting as an electrode and a conductive workpiece, in the presence of a dielectric fluid. EDM are different from most chip-making machining operation which the electrode does not make physical contact with the workpiece for material removal. Figure 2.1 illustrates the basic components of the EDM process.

Since, the electrode does not make any contact with the workpiece, EDM has no tool force. The electrode must always be spaced away from the workpiece by the distance required for sparking, known as the sparking gap (Jameson, 2001). This discharge occurs in a sparking gap between the electrode and workpiece. Heat from the discharge vaporizes minute particles of the workpiece material, which are then washed from the gap by the continuously flushing dielectric fluid.