EFFECT OF WIRE EDM PROCESS PARAMETERS ON MACHINING CHARACTERISTICS OF ALUMINIUM ALLOY 6061 USING TAGUCHI METHOD

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

by

SITI ZAHARAH BINTI MOHD

B051410052

930727-11-5046

FACULTY OF MANUFACTURING ENGINEERING

2017

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **EFFECT OF WIRE EDM PROCESS PARAMETERS ON MACHINING CHARACTERISTICS OF ALUMINIIUM ALLOY6061 USING TAGUCHI METHOD**

SESI PENGAJIAN: 2016/17 Semester 2

Saya **SITI ZAHARAH BINTI MOHD (930727-11-5046)**

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:
NO. 226, KAMPUNG BARU,
FELDA NERAM SATU,
KEMAMAN, TERENGGANU.

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 Wire EDM Process Parameters on Machining Characteristics of Aluminium Alloy 6061 using Taguchi Method" is the result of my own research except as cited in references.

Signature : ……

Author's Name : SITI ZAHARAH BINTI MOHD

Date :

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Manufacturing Process) (Hons).

…….....

(Dr. Mohd Amran bin Md Ali)

ABSTRAK

Electric Discharge Machining (EDM) adalah salah satu proses bukan traditional *(NTP)* yang boleh digunakan ketika memesin reka bentuk geometri yang kompleks. *Wire EDM (WEDM)* merupakan satu dari pada jenis *EDM* yang boleh digunakan untuk memotong dan memesin bahan yang sangat keras, nipis dan juga menghasilkan lubang yang bersaiz mikro. Objektif utama projek ini adalah untuk mengkaji kesan proses parameter dari *WEDM* seperti *pulse on time, pulse off time, voltage*, dan *peak current* terhadap kesan pemesinan seperti *material removal rate (MRR), kerf width (KW)* dan *surface roughness* (R_a) daripada bahan *AA6061* dengan menggunakan Taguchi method sebagai reka bentuk eksperimen untuk mengetahui parameter optimum. *ANOVA* digunakan dalam mencari parameter yang paling penting. Mesin yang digunakan dalam projek ini adalah *SODICK VZ300L* bersama bersama wayar tembaga berdiameter 0.2 mm sebagai elektrod. *MRR* dikira berdasarkan berat sebelum dan selepas yang dibahagikan dengan masa permesinan manakala *KW* diukur menggunakan *Vertical Optical Comparator*. R_a pula diukur menggunakan Portable Surface Roughness. AA6061 dipilih sebagai bahan ujikaji kerana susah dipotong menggunakan cara konvensional. Bahan ini digunakan secara meluas dalam automotif, pembinaan dan aeroangkasa pada masa kini. Empat factor dengan tiga nilai berbeza iaitu nilai rendah, sederhana tinggi dan tinggi diaplikasikan menggunakan *Taguchi Method* dalam usaha mencari parameter penting yang mempengaruhi kesan proses terhadap *AA6061*. Menggunakan *Taguchi Method*, hanya sembilan parameter yang akan dijalan kan dan diulang 3 kali bagi setiap parameter itu. Berdasarkan keputusan dan perbincangan ujikaji, pulse on time merupakan parameter penting dengan peratusan tertinggi bagi setiap kesan proses sama ada menggunakan *single objective* mahupun *multi objective.*

ABSTRACT

Electrical Discharge Machining (EDM) is one of non-traditional process (NTP) that can apply on machining complex geometrical design. Wire EDM (WEDM) is one of the types of EDM that used for machining high toughness material, thin material and also can cut micro hole. The main objective of this project is to study the effect of wire EDM process parameter such as pulse ON time, pulse OFF time, peak current, and voltage on machining characteristics such as material removal rate (MRR), kerf width (KW) and surface roughness (R_a) of Aluminum Alloy 6061 (AA6061) using Taguchi method as the design of experiment (DoE) to optimize the machining characteristics. In finding the most significant parameters, analysis of variance (ANOVA) is applied. Type of machine used is WEDM model VZ300L and this project used brass material of wire electrode with diameter of 0.2mm. The MRR is calculated based on weight before machining minus with weight after machining and divided with time machining, and measuring KW by using vertical optical comparator. Then the surface roughness is measured by portable surface roughness. In this project, AA6061 is employed as the specimen in this project because of its difficulties to cut by conventional machine. This material widely used in automotive, construction and aerospace nowadays. Four factors (control parameters) with three levels (low, medium and high) were applied in the Taguchi method to optimize the machining characteristics on WEDM of AA6061. By using Taguchi, there are 9 runs of experiment in this project. The result shows that pulse on time is the most significant factors with highest percentage contribution for each respond either using single or multi objective.

DEDICATION

To my beloved parents,
Mohd bin Sulaiman and Zaleha binti Mohamad

ACKNOWLEDGEMENT

First and foremost, all praise to The Almighty, who made this accomplishment possible. I seek his mercy, favor and forgiveness.

Thousands of thanks to my great supervisor, Dr. Mohd Amaran bin Md Ali for the help, encouragement and guidance from the beginning until end of this writing project.

For my parents, Mohd bin Sulaiman and Zaleha binti Mohamad and my family who are always provides me with love and support all the time in order for me to complete this work. Their enthusiastic caring is valuable for me.

My thanks and appreciations also go to my colleagues in developing the project and people who gave willingly helped me out with their abilities.

Thank you.

TABLE OF CONTENT

E Response table of Signal to noise ratio (MRR)

F Response table of Signal to noise ratio (KW)

G Response table of Signal to noise ratio (R_a)

H ANOVA for MRR

I ANOVA for KW

J ANOVA for R_a

K Predicted value for MRR

L Predicted value for KW

M Predicted value for R_a

N Surface Appearance for each Specimen

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AA6061	-	Aluminium Alloy 6061
ANOVA	-	Analysis of Variance
Avg	-	Average
CNC	-	Computer Numerical Control
D	-	Depth
DoE	-	Design of Experiment
EDM	-	Electric Discharge Machining
GRA	-	Grey Relational Analysis
GRC	-	Grey Relational Coefficient
GRG	-	Grey Relational Grade
GRN	-	Grey Relational Normalization
H	-	Height
I_p	-	Peak current
KW	-	Kerf Width
MRR	-	Material Removal Rate
NTP	-	Non-traditional process
R_a	-	Surface roughness
S/N ratio	-	Signal to noise ratio

SOP	-	Standard Operating Procedure
T_m	-	Time machining
T_{off}	-	Pulse off time
T_{on}	-	Pulse on time
V	-	Voltage
W_a	-	Weight after
W_b	-	Weight before
WEDM	-	Wire Electric Discharge Machining
α	-	Alpha – value of significant level

CHAPTER 1
INTRODUCTION

This chapter discusses about the background, problem statement, objectives and scope of this project. Background explains about electrical discharge machining for wirecut machine. Then, the problem statement and the objectives of this project are described clearly. Besides that, the scope of this project which mentions about the machine used, type of raw materials, electrode, parameters and design of experimental.

1.1 Background of The Project

Todays, Non-Traditional Process (NTP) is being known and famous as a new technology in manufacturing engineering industry. NTP is a group of machining or process that produces high quality of product with precision, accuracy and productivity using high technology process which is applied non-contact between workpieces and cutting tools. Electrical Discharge Machining (EDM) is one of the important processes in NTP group.

In year 1970, EDM was being developed commercially after a scientist from Russia completely utilized the advantage of EDM in year 1943 (Kuriachen *et al.* 2012). However, EDM was being discovered for the first time in long time ago in the year 1770 by Joseph Priestly who is English scientist. There are two types of EDM that are use today with different control parameters but in same respond parameters; wire EDM and EDM Die Sinking.

Days by days, wire EDM have a place and being used in manufacturing industry in various application such as aerospace, nuclear, medical and automotive industry (Guitrau *et al.* 1997). In addition, wire EDM become famous because it can be used in cutting and

producing complex and smallest part for various type of material; ceramic, silicon, metal, cemented carbides, alloy and also sintered materials (Sivarao, 2015).

In wire EDM, there are various types of electrode to be used in order to machine and cut a workpieces or in order to complete a cutting process. Different type of workpiece materials can be used with different type of electrode materials. Normally for workpieces of aluminium material, electrode with copper type of material is suitable. There are also specific diameters of electrode that need to be known before start a machining process. The diameter of electrode also affected the quality and surface roughness of a part. The range of electrode is between 0.05 mm to 0.3 mm for copper, brass or tungsten material (Brajesh e*t al.* 2014).

In this project, the effect of WEDM parameters such as pulse on time, pulse off time, voltage and peak current are investigated on the material characteristics such as material removal rate, kerf width and surface roughness of aluminium alloy 6061. After go through the machining process, the data measurement obtained are analysed using of Taguchi method. Then analyse of variance (ANOVA) to be applied in order to finish this investigation. Single and multi-objectives by Taguchi methods are implemented to find optimize result.

1.2 Problem Statement

Wire-EDM is one of the famous non-traditional processes with high accuracy, efficiency and quality. In order to achieve the accuracy and its efficiency, there are few important parameters that need to be studied such as pulse on time, pulse off time, peak current and voltage. Moreover, lately aluminium alloy 6061 is a material that widely used today because of its good impact properties. This material also has lack of investigation of performance material characteristics towards wire EDM machining process. Therefore, by analyse the effect of wire EDM parameters on machining characteristics such as material removal rate (MRR), surface roughness (R_a) and kerf width (KW) of aluminium alloy 6061 using the best DOE should be the best way to handle and counter this issue.

1.3 Objective of The Project

The main objective of this project is to study the effect of wire-EDM process parameters on machining characteristics of material of aluminium alloy 6061. In order to achieve the main objective, three sub-objectives to be focus as below:

i. To study the wire-EDM process parameters such as pulse on time, pulse off time, peak current and voltage.
ii. To evaluate the effect of wire-EDM parameters on surface roughness (R_a), material removal rate (MRR) and kerf width (KW) of Aluminium Alloy 6061.
iii. To optimize using single and multi-objective of wire-EDM parameters on machining characteristics using Taguchi Method and ANOVA analysis.

1.4 Scope of The Project

Sodick Electrical Discharge Machine (EDM) wire-cut with model VZ300L is the type of the machine used in this project. This machine used electrode wire with size 0.20 mm as its diameter with deionized water. The type of material of this electrode wire is brass. While the workpiece used to investigate the parameter using wire EDM is Aluminium Alloy 6061. This project implemented L9 (9 runs) and repeated in three times for every test. The entire test is analysed based on three responses variable which are surface roughness (Ra), material removal rate (MRR), and kerf width (KW). After all the investigations were done for all control and response parameters, the data and result are recorded. Then analysing of matrix of machining characteristics is done using DoE. The type of DoE that used is Taguchi method with single and multi-objective optimization. Lastly, ANOVA is conducted on significant of parameter's contribution to machining performance for further analysis.

1.5 Organization of This Report

This report consist of five chapters excluded references and appendices. The five chapters included are chapter 1; introduction, chapter 2; literature review, chapter 3; methodology, chapter 4; results and discussion and chapter 5; conclusion and recommendation. In chapter 1, all the important information regarding to this project is explained in detail in every sub-topic such as background, objectives, problem statement and scope of this project. The control and respond parameters also state in this chapter. Second chapter is about literature review. The previous study that related to this project is mention in this chapter. Besides that, comparison between this project and previous study is also discussed in this chapter. Methodology, which consists of step along operation of this project will stated in chapter 3. The Gantt chart and flow chart are also attached. In other words, this chapter are discussing about the flow of this project. In chapter 4, all the data and result are discussed. The discussion is based on the data after run the project using wire-EDM. The result that has been optimizing using Taguchi Method and ANOVA also discuss in this chapter. All the result and conclusion from the previous chapter will be concluded in chapter 5. Along completed this project, there are few thing that need to improved. So, all the recommendation also described in chapter 5. Last but not least, the evaluated machining parameter such as Material Removal Rate, Surface Roughness and Kerf Width are being attached in appendices and the sources of references will state in references chapter.

CHAPTER 2
LITERATURE REVIEW

This chapter describes about the previous research study that related to this project. The previous research study related are EDM, WEDM, control process parameters of WEDM, responses of WEDM, Aluminium Alloy 6061 material and DoE of Taguchi method and ANOVA analysis.

2.1 Electric Discharge Machining (EDM)

EDM is published for the first time during the Second World War. A study that relate to the manufacturing technology about the electrical discharge on the topic of 'The Inversion of The Electric Discharge Wear Effect' was published that time by Russians physicist. Their study also relate to the metal removal and distribution under control.

Nedians and Fortunecity (2007) stated that, there were four basic elements that must have in every EDM; spark generator, servo system, dielectric liquid and mechanical structure. In spark generator elements, the energy is required in the form of pulses. Usually it is in rectangular form. However, the generators can be distinguished based on the way in which the voltage is transformed and the pulse is controlled. Servo system is about corrosion of the electrode and workpieces during the process. The dimension of the electrode is changed in a time. The result is observed in interelectrode gap. When there is increase the interelectrode gap, the voltage required for sparking is increase too. Figure 2.1 shows principle of WEDM.

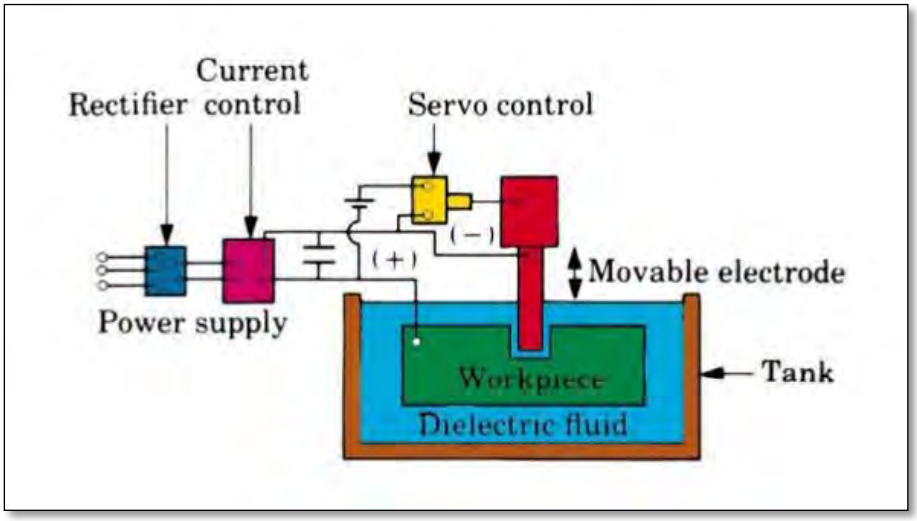

Figure 2.1: Basic principle of EDM (Kumar, R. 2014)

The advantages of using EDM are it can produce complex shape which is conventional machine cannot produce it. By using EDM, the machining process between workpieces and tools is not touch to each other or in other word, there is no direct contact. That is why it can machine even small workpieces or weak materials with exact dimension and highly precise and accuracy.

2.2 Wire Electric Discharge Machining (WEDM)

WEDM is the adaptation of basic EDM process that can machine complex design and part by using electrical conducting material either in two and three dimensional. (Anon and Fortunecity, 2007) Shan (2012) was stated in her study with title 'Working Principle and Performance of WEDM' that "WEDM is an advanced thermal machining process capable of accurately machining parts with complicated shapes, especially for the parts that are very difficult to be machined by traditional machining process". The researcher also mentions WEDM is applied non-contact process method to remove material based on conventional EDM. The best part of this study mentioned that WEDM can produce good surface finish quality with accurately.