UNIVERSITI TEKNIKAL MALAYSIA MELAKA

SURFACE INTEGRITY STUDY IN EDM DIE SINKING PROCESS

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

by

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APPROVAL

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

……

Supervisor

ABSTRAK

Projek ini membincangkan empat parameter yang boleh mempengaruhi prestasi EDM Die Sinking ketika membuat pemesinan kepada keluli dengan menggunakan elektrod tembaga berdimensi 10 mm × 10 mm. Tujuan utama kajian ini ialah untuk menyiasat kesan pada ciri-ciri pemesinan kekasaran permukaan, rekahan permukaan dan ketebalan permukaan putih yang mana dipengaruhi oleh parameter mesin. Reka bentuk eksperimen (DOE) telah digunakan untuk eksperimen ini. Kaedah Taguchi telah memilih untuk membentuk bentangan percubaan dan analisis kesan setiap parameter kepada ciri-ciri pemesinan dan meramalkan persekitaran optimum untuk parameter seperti arus kemuncak (IP), tempoh denyutan ON (ON), tempoh denyutan OFF (OFF), dan Voltan (V). Kaedah Taguchi menggunakan tiga peringkat dan 4 parameter. Semua keputusan telah buat pengesahan dengan menggunakan perisian ANOVA. Dalam siasatan ini, *Die Sinking EDM AQ35L* digunakan untuk kajian pemesinan. Bagaimanapun , *Mitutoyo Surface Roughness Tester, SJ.301* digunakan untuk menguji kekasaran permukaan manakala *Scanning Electron Microscopy, EVO 50* untuk mengukur ketebalan lapisan putih dan rekahan permukaan. Selain daripada itu, ujian pengesahan dilakukan untuk membuat perbandingan dengan meramalkan hasil. Hasil keputusan, arus kemuncak dan voltan merupakan faktor utama dalam siasatan ini terutamanya kekasaran permukaan.

ABSTRACT

This project was discussed about 4 parameters that can be effect the performance of EDM Die Sinking while machining mild steel by using copper electrode with dimension of 10 mm × 10 mm. The main purpose of this study is to investigate the effect on machining characteristics of Surface Roughness, Crack Density and White Layer Thickness which influenced by the machining parameters set up. Design of Experiment (DOE) had applied for this experiment. Taguchi method had chosen to formulate the experimental layout and analyze the effect of each parameters on machining charcteristics and predict optimal setting for parameters like Peak Current (IP), Pulse ON Time (ON), Pulse OFF Time (OFF), and Voltage (V). Taguchi method was approach by three levels and 4 parameters. All the results had do confirmation by using Analysis of Variance (ANOVA). In this investigation, Die Sinking EDM AQ35L was used to do machining. However, Mitutoyo Surface Roughness Tester, SJ.301 was used for measuring the surface roughness while Scanning Electron Microscopy, EVO 50 was used to measure white layer thickness and crack density. Besides than that, confirmation tests were done to do comparison with the predicted result. For the result, peak current and voltage is the primary significant effect to the machining chracteristics investigated especially the surface roughness.

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LIST ABBREVIATIONS

A	-	Ampere
AC	-	Alternating Current
AISI	-	American Iron and Steel Institute
ANOVA	-	Analysis of Variance
CNT	-	Carbon Nano Tube
DC	-	Direct Current
DOE	-	Design of Experiment
EDM	-	Electrical Discharge Machining
EDX	-	Energy disperse X-ray
EW	-	Electrode Wear
FYP	-	Final Year Project
HAZ	-	Heat Affected Zone
IP	-	Peak Current
MM	-	Milimimeter
MRR	-	Material Removal Rate
PCS	-	Process Conditions Scheme
RA	-	Surface Roughness
RL	-	Recast Layer
SEM	-	Scanning Electron Microscope
SRT	-	Surface Roughness Tester
UBC	-	Ultrasonic Bath Cleaner
V	-	Voltage
WLT	-	White Layer Thickness

CHAPTER 1
INTRODUCTION

1.1 Background

Electrical Discharge Machining (EDM) technique is widely used for machining hardened steel. EDM is sometimes called with name; spark erosion machining. The most frequently used application is die-sinking EDM for mold steel fabrication and also wire cut EDM. In EDM process, chemical action is abandoned and metal is removed by the intense heat of electric sparks. EDM is uses electrical discharges or sparks to erode the work piece of material. No physical cutting force involved between electrode and work piece while do machining. The benefit of using this machine is it can be used to produce complex shape that cannot be produce by other machining.

In this study, EDM Die Sinking is selected as a machine to machining mild steel which as a work piece. Mild steel is using widely in industry or any applications because low cost, easy to form and ductility properties. It is a famously known as a standard of materials. Automotive industry and building structures is the examples of industry which using it. Besides than that, mild steel have a low carbon which makes it is more malleability. This is easy to make form into bar while also can be bent without break due of it ductility.

Although many previous researchers do researching on surface integrity, it is still lacking on information. So, this study will be investigate of the effect on parameters set up which peak current, pulse ON time, pulse OFF time, and open voltage to machining of mild steel by using EDM Die Sinking. The response factors that want to observe is

more to surface integrity include surface roughness, crack density and white layer thickness. All of the parameters are set up at the machine. These parameters are supposed that have potential influence to the surface of work piece after do machining. Others of the parameters like polarity, servo speed, servo voltage and others will be set up as a constant in this study.

For support this study, copper is selected as an electrode for do machining. It is used in this study because it is suitable do machining for small to medium area. The copper characteristic is malleable, ductile and also good conductor. However, it has low chemical reactivity. Copper mostly used in electrical equipment and constructions. This is a good properties to make is as an electrode in this experiment because it have high electrical conductivity to do machining to mild steel work piece. However, the obvious properties are the wear is possible in machining and impossible if no mirror finish of machining. So this properties need to care properly while machining of mild steel. The size is selected is 10 mm × 10 mm which the shape of electrode is square.

The machining of work piece is using EDM Die Sinking AQ35L. However, there are two types of machine that are used to study the surface integrity. There are Surface Roughness Tester (SRT) and Scanning Electron Microscope (SEM). The SRT is used is a portable types. SRT is normally common tool is used to study the surface roughness on the work piece before do analysis. It will show the results by graph on the printed paper and results display n the digital screen. SEM is another common tool to examine EDM surfaces. In this study, SEM is use to study the cracks density that occurred on the work piece and also white layer thickness. Design of Experiment had been using to investigate this study which Taguchi method is selected. Three levels, four factors and four responses need to investigate during the study. Although this is only research by machining mild steel with copper electrode by using EDM Die Sinking, hope the information can be applied in the future especially in industrial of machining.

1.2 Problem Statement

The surface integrity describes the mechanical, metallurgical, topological, and chemical conditions of the surface region (Jun, 2002). Surface roughness, crack density and white layer thickness are main goal that need to be archive in order to get better surface integrity in EDM Die Sinking process. These responses are need to measure under the surface integrity. However, practical is not perfect as a theory while do machining processes. This is happen due to free variables and related nature of process. Nowadays, overall EDM more advance which have process control and servo control that can maintain the spark gaps and optimum condition. Beside than that, overall process control is now frequently performed by Computer Numerical Control (CNC) but to maintain the variables for determine the best surface integrity at the product still an extremely difficult job.

The better of surface integrity is affected by number of factors. It become rougher when high current densities applied which give higher discharge energies, more viscous dielectric and lower frequency. In order to get better surface integrity, the optimum parameter of peak current, pulse ON time, pulse OFF time, and open voltage have to be determined. The larger inertia and higher viscosity of the liquid dielectric indicate a faster Material Removal Rate but a rougher surface finish. Pulse OFF time does not influence on surface wear but it will make machine unstable if pulse OFF time is higher. If this happen, more sparks will occurred and this will bring out more cracks on the work piece.

This research is more focus onto investigate the influence of various combination of machining parameters in EDM Die Sinking, in an attempt to optimize the material better surface integrity when using such approach and machining mild steel by using copper electrode. This research can be as a reference to others researcher in the future to do another research and do improvement for any lacking of information. Others than that, it can be as a reference and give more information to industry for doing improvement while operating EDM Die Sinking for their productions.

1.3 Objective of Study

The objectives of this study are as follows:

a. To study the surface integrity of mild steel material
b. To identify the suitable peak current in order to reduce surface crack density.
c. To evaluate the performance of EDM Die Sinking on mild steel with focus on surface roughness, crack density, and white layer thickness.

1.4 Scope of Study

In order to get the best result, this research must be scoped narrower where it consists of:

a. Parameters to be studied include peak current, pulse on time (ON), pulse off time (OFF), and open voltage.
b. Machining mild steel material with using copper electrode
c. Surface integrity need to be investigated includes surface roughness, crack density, and white layer thickness.
d. As the analysis to the surface integrity, Surface Roughness Tester and SEM test will be conducted to the specimen.

1.5 Report outline

This report represents five chapters. The following outline below is content of this project:

1.5.1 Chapter 1

The first chapter of this thesis describes about background study, project objective, scope of project and problem statement.

1.5.2 Chapter 2

This chapter describe about literature review which is focus on the research and information about the project. Every fact and information which is found through journal or other references will be compared and the better methods have been chosen in this project.

1.5.3 Chapter 3

This chapter explains about the project methodology approach taken and a closer look on how the project implemented. Each achievement and selection taken when the project is implemented will be explained in detail for each stage until the project is success. This chapter also briefly describe about the step of the project, the method of analysis that used in this project, how to operate it and followed by interpretation of data.

1.5.4 Chapter 4

This chapter will be describing about the finding of project such as result and the analysis conducted of EDM Die Sinking machine and reconstruct. These methods are performed on ease. Analysis results are obtained in SEM test and Surface Roughness Tester.

1.5.5 Chapter 5

Discussion and conclusion achieved in this project and also future suggestion in order to improve this project.

1.6 Gantt Chart

Table 1.1: Gantt chart of project

No.	Year	2010																						2011																			
	Month	July			August				September				October				November				December				January				February				March				April				May			
		1	2	3	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	Confirmation title																																										
2	Problem idenfication																																										
3	Objective & scope identification																																										
4	Project briefing																																										
5	Searching information																																										
6	Execute on information																																										
7	Chapter 1:Introduction																																										
8	Chapter 2: Literature review																																										
9	Chapter 3: Methodology																																										
10	Sample preparation																																										
11	Process preparation																																										
12	Collecting data & running progress																																										
13	Result analysis & data																																										
14	Chapter 4: Result & discussion																																										
15	Chapter 5: Conclusion																																										
16	Logbook fulfill																																										
17	Report review																																										
18	Report completion																																										
19	PSM 1 submission																																										
20	Presentation																																										
21	PSM 2 submission																																										
22	Presentation																																										

Information:

= Planning Work

= Holiday

CHAPTER 2
LITERATURE REVIEW

EDM is a non-conventional machining process that very interesting to do a research due to the specifications and it performance. It has so many advantages to the user which especially when do machining to Mild Steel as for an example. In this chapter, deeply explanation and review from previous researcher will be included. This review can be as a guide for the experiment later.

2.1 Electric Discharge Machining

Previous researcher until today, do research about EDM in two kinds of research. One is called the modeling technique and the other is called the novel technique (Sreebalaji, 2010). The modeling technique is:

a. Mathematical modeling
b. Artificial intelligence
c. Optimization techniques such as regression analysis, artificial neural network, genetic algorithm, etc.

The modeling technique is used to authorize the efforts of input parameters on output parameters. This is happened because EDM is a complex process machining which have many input parameters such as:

a. Machining depth
b. Tool radius
c. Pulse on time
d. Pulse off time
e. Discharge current
f. Orbital radius
g. Radial step
h. Offset depth
i. Output parameters like material removal rate and surface quality

For the novel techniques, it is more focus on how conventional or unconventional machining principles can be integrated to EDM. This integration will be improving the efficiency of machining processes to get better Material Removal Rate (MRR) and surface quality. The previous researchers have been research about the novel techniques in EDM from 1996.

EDM is a non-conventional machining process. EDM is one of the most commonly used non-conventional machining methods and has unique characteristics in that it is basically a non-contact type thermal machining process and can be equally effective, irrespective of the hardness of the work material (Singamneni, 2010). EDM is widely used of technique in the industry for high precision machining by using all the conductive materials likes graphite, metals, metallic alloys and other ceramic materials which not care about hardness. It had been used with widely at manufacturing industrial. A machining process and, more broadly, any manufacturing process, can be represented by the Process Conditions Scheme (PCS), which is the diagram used to analyse the condition features of machining and conjugate (Yao, 2005). According to Yao studied that using the process conditions scheme, the correlations and possible integrations between different processes are more intuitive than directly examining the details of individual processes. At the base, can see it represents interactions such as thermal and mechanical: