EFFECT OF EDM DIE-SINKING PARAMETERS ON THE MATERIAL CHARACTERISTICS OF ALUMINIUM ALLOY LM6 USING COOPER TUNGSTEN

NOR HALIDA ILYANI BINTI KAMARUDIN

B050910307

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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

by

NOR HALIDA ILYANI BINTI KAMARUDIN
B 050910307
860605115258

FACULTY OF MANUFACTURING ENGINEERING
2013

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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ABSTRAK

Electric discharge machine (EDM) adalah proses untuk memotong logam keras dan membentuk secara mendalam dengan cara hakisan arka dalam semua jenis bahan konduktif. Ia adalah salah satu daripada proses pemesinan bukan tradisional yang melibatkan pelepasan percikan fana melalui bendalir disebabkan oleh perbezaan potensi antara elektrod dan bahan kerja. EDM banyak digunakan di mana bentuk yang kompleks rumit perlu dimesin dalam bahan-bahan yang sangat keras seperti keluli alat keras. Projek ini mengkaji ciri-ciri EDM hasil dari *electrode wear rate* (EWR), *material removal rate* (MRR), *surface roughness* (Ra), dan pemerhatian kawah pada permukaan bahan kerja. Eksperimen telah dilakukan menggunakan mesin EDM SODICK AQ35L. *Design of experiment*(DOE) dengan menggunakan *taguchi method* telah digunakan untuk mereka bentuk jadual eksperimen ujian, dan menganalisis faktor penting yang mempengaruhi ciri-ciri pemesinan untuk proses EDM. Sebanyak sembilan ujikaji telah dijalankan dengan setiap satu diulang sebanyak tiga kali. Keputusan yang diperolehi daripada kajian ini menunjukkan bahawa *current*, *pulse on time* dan *pulse off time* adalah faktor yang paling penting yang melaksanakan ciri-ciri pemesinan EDM. Parameter optimum bagi eksperimen ini ialah *current* dengan tahap 1 diikuti oleh *pulse on time* tahap 2 dan tahap 3 *pulse off time*. Ia akan menyokong dengan peratusan sumbangan menggunakan *analisis of varians* (ANOVA) bagi MRR, *current* 62.57%, *pulse on time* 36.10% dengan 23.41% *pulse off time*. Kemudian, untuk EWR, *current* 57.35% dengan 25.31% daripada *pulse on time* dan *pulse off time* 14.11%. Akhir sekali, bagi Ra peratusan untuk *current* adalah 99.85%, *pulse on time* 17.13% dengan 0.10% *pulse off time*. Oleh itu, *current* adalah faktor penting semasa bahan kerja melebur.

ABSTRACT

Electric discharge machining (EDM) is the process for cutting hard metal and forming deep area by arc erosion in all kind of electro conductive material. It is one of the non-traditional machining processes that involved a transient spark discharges through the fluid due to the potential difference between the electrode and the work piece. EDM is most used where intricate complex shapes need to be machined in very hard materials such as hardened tool steel. This paper presents a fundamental study of characteristics of electrode discharge machine (EDM) that are electrode wear ratio (EWR), material removal rate (MRR), surface roughness (Ra), and appearance observation. The experiment was done using SODICK AQ35L EDM machine. Design of experiment (DOE) using taguchi method was applied to design the experimental number of trials, and analyze the significant factors that affecting the machining characteristics for EDM process. Total of nine experiments were conducted with each repeated three times. The results obtained from this research shows that current, pulse on time and pulse off time were the most significant factor effecting the EDM machining characteristics. The optimum parameters for this experiment which are current with level 1 followed by pulse on time of level 2 and level 3 pulse off time. It will support with the percentage of contribution using analysis of variance (ANOVA) of MRR, current 62.57%, pulse on time 36.10% with 23.41% pulse off time. Then, for EWR, current 57.35% with 25.31% of pulse on time and pulse off time 14.11%. Lastly, for Ra the percentage for current is 99.85%, pulse on time 17.13% with 0.10% pulse off time. Thus, the flow of current melting the workpiece that’s why the current was the significant factor.

DEDICATION

Special dedicated to my mother

Shamsiah Binti Yusuf

My beloved father

Kamarudin Bin Mat Saman

My supportive siblings

Mohammad Amirul Asyraf Bin Kamarudin

Nur Alifah Ilyana Binti Kamarudin

Muhamad Aliff Haiqal Bin Kamarudin

For my adored friends

Suraya Laily

(Master's Student)

And to all my relatives and friends for their supports, courage and prayers.
May Allah bless all of you

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A	-	Ampere
ANOVA	-	Analysis Of Variance
CNC	-	Computer Numerical Control
DC	-	Direct Current
DOE	-	Design of Experiment
Ea	-	Electrode Weight after machining
Eb	-	Electrode Weight before machining
EDE	-	Electro-Discharge Erosion
EDM	-	Electrical Discharge Machine
EDG	-	Electric Discharge Grinding
EWR	-	Electrode Wear Rate
HAZ	-	Heat Affected Zone
HB	-	Higher is better
Ip	-	Peak Current
LB	-	Lower is better
MRR	-	Material Removal Rate
NB	-	Nominal is best
OA	-	Orthogonal Array
Ra	-	Surface Roughness
Rq	-	Root- Mean Squire Average

Sil_2	-	Silicate
S/N	-	Signal to Noise
TiC	-	Titanium Carbide
TWR	-	Tool Wear Rate
V	-	Voltage
Wa	-	Material Weight after machining
Wb	-	Material Weight before machining
îe	-	Peak Current
n	-	Number of Reading
td	-	Time Delay
te	-	Period of Time
tm	-	Machining time
to	-	Interval of Time
t_{off}	-	Pulse Off Time
t_{on}	-	Pulse On Time
ue	-	Low Discharge Voltage
ûi	-	Open Circuit Voltage
µm	-	Micrometer
µs	-	Microsecond

CHAPTER 1
INTRODUCTION

This section explains the background of the area of the study, the aims and objectives of this study, and why this study interesting and relevant to the engineering field.

1.1 Background of the Project

Electrical discharge machine (EDM) die-sinking is an important non-traditional manufacturing method which it known as EDM die-sinking is a process of machining electrically conductive materials by using controlled sparks that happen between an electrode and a work piece in the existence of a dielectric fluid. These materials would have been difficult to machine by conventional methods, but EDM die-sinking has made it relatively simple to machine intricate shapes that would be impossible to produce with conventional cutting tools. In EDM die-sinking process, the shapes of mold cavities are directly copied from that of tool electrodes, so time consuming preparation work must be done on the fabrication of the corresponding tool electrodes (Iqbal A. and Khan A. A.,2010).

The uses of EDM die-sinking in the production of forming tools are to produce plastics moldings, die castings, forging dies etc., has been firmly established in recent years. This machining process is continually finding further applications in the metal machining industry. Although, the application of EDM die-sinking is limited to the machining of electrically conductive work piece materials, the process has the capability of cutting these materials regardless of their hardness and toughness (Lee and Li, 2001).

The case study of this project are to determine the best material removal rate (MRR), electrode wear rate (EWR), surface roughness (Ra), and texture & cracking of craters. Using this testing, the best performance of the of machining for EDM die-sinking can be archived when the the best combination of parameters should be studied to produce an optimum result.

In this project, the effect of EDM die-sinking parameters such as pulse on time, pulse off time and current on the surface integrity. The condition by using EWR, MRR, Ra, and texture & cracking of craters will be evaluated with copper beryllium using electrolytic copper show that usefulness of EDM die-sinking process.

The advantages of the EDM die-sinking machines are it can use to cut of any material that is electrically conductive, burr is free when using the EDM die-sinking process, and complex dies will can be produce by EDM die-sinking machine with accurately, low costs and faster. It also needed the hardened tool material must be harder than workpiece material to get the good effect and the very important is very fine holes can be easily drilled.

1.2 Problem Statement

In using electrical discharge machine (EDM) die-sinking can be caused poor performance if not choose the suitable material of the electrode and it will effected of the test parameters such as pulse on time (t_{on}), pulse off time (t_{off}), voltage (V) and peak current (Ip). Meanwhile, it also influences the surface integrity when using EDM like electrode wear rate (EWR), material removal rate (MRR), surface roughness (Ra), and texture & cracking of craters when it is apply on the aluminum alloy LM6 containing silicate and titanium carbide. So that, design of experiment (DOE) will be performed in order to obtain the optimum parameters. Besides that, erosion of the workpiece must be maximized and the electrode must be minimized in order to increase the machining efficiency. Therefore, studying the electrode wear and related significant factors would be effective to enhance the machining productivity and process reliability.

1.3 Objectives

The objectives of this project are:

a) To study the effect of machining EDM die-sinking 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 machining characteristics of aluminum alloy LM6 in surface roughness (Ra), material removal rate (MRR), electrode wear rate (EWR) and appearance observation.

c) To optimize the machining characteristics using taguchi method and to analyze the percentage of contribution using analysis of varice (ANOVA)

1.4 Scope of the Project

These projects will analysis about the various type of machining parameter relate to the machining characteristics while EDM die-sinking process. In this process, the material that use is silicate and titanium carbide and the electrode is copper. The scope should be low cost and short time use to finishing the process. To analyze the result and the data collections, the calculations is very important to calculate the machining characteristics which are electrode wear rate (EWR) and material removal rate (MRR). The higher friction coefficients are needed when to get surface roughness and the presence of crater is observed under digital image microscope.

Nowadays, more knowledge about electrical discharge machine is very important. So that, hopefully with this project can gain a lot of understanding of EDM die-sinking and get more experience to handle and use it because EDM die-sinking broad industrial applications. .

1.5 Outline of the report

This report is divided in five chapters as follows:

a) Chapter 1 – background of the project, problem statements, objectives of the project and the scopes of the project.
b) Chapter 2 – literature review of EDM, machining parameters and characteristics
c) Chapter 3 – gives information on electrode and material, testing procedure that involve in the experiment.
d) Chapter 4 – result and analysis of the experiments.
e) Chapter 5 – summarize the results and discussion as well as conclusion of the case study.

CHAPTER 2
LITERATURE REVIEW

This section basically analysis of patent, journal paper, article and conference paper to the research purpose. The similarities and differences between what other people investigated had been taken out as well as the machine design. In order to establish a new machining method for EDM, the research question and purpose of each review have been evaluated.

2.1 EDM Machining Operation

Electrical Discharge Machining (EDM) is most widely and successfully applied process in machining of hard metals or those that would be very difficult to machine with traditional techniques. The material is removed from the work piece by the thermal erosion process which is by a series of recurring electrical discharges between a cutting tool acting as an electrode and a conductive work piece in the presence of a dielectric fluid. This discharge occurs in a voltage gap between the electrode and work heat from the discharge vaporizes minute particles of work piece material, which are then washed from the gap by the continuously flushing dielectric fluid (Reddy *et. al*. 2010) as shown in Figure 2.1.