



PERFORMANCE OF COPPER TUNGSTEN ELECTRODE ON ALUMINIUM ALLOYS LM6 IN DIE SINKING USING FULL FACTORIAL METHOD

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

by

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APPROVAL

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

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(ASSOCIATE PROFESSOR IR. DR. MOHD AMRAN BIN MOHD ALI)

ABSTRAK

Pemesinan pelepasan elektrik (EDM) mati tenggelam adalah salah satu proses penting dalam industri perkilangan untuk memotong bahan keras yang tinggi oleh hakisan arka dalam semua jenis bahan konduktor elektron. Parameter pemesinan adalah peranan penting untuk menentukan kualiti yang baik untuk integriti permukaan produk. Tujuan projek ini adalah untuk mengkaji kesan parameter tenggelam EDM yang berkaitan dengan ciri-ciri pemesinan untuk aloi aluminium LM6 menggunakan kaedah faktorial penuh. Menilai parameter input adalah denyut nadi pada masa, pulse off time dan current. Sementara itu, projek ini membentangkan kajian fundamental mengenai ciri pemesinan iaitu kadar penyingkiran bahan (MRR), kadar pakai elektrod (EWR), kekasaran permukaan (Ra) dan pemerhatian keretakan kawah. Reka bentuk percubaan (DOE) menggunakan kaedah faktorial penuh telah digunakan untuk merangka urutan matriks yang dijalankan oleh 2 peringkat dengan 3 faktor. Hasil daripada projek ini menunjukkan bahawa faktor semasa adalah parameter yang paling penting diikuti oleh denyut nadi pada masa dan masa pulse off. Sementara itu, pengoptimuman tunggal untuk memaksimumkan nilai MRR adalah 0.3375, untuk meminimumkan nilai EWR ialah -0.0003 dan juga meminimumkan nilai Ra ialah 0.6386. Selanjutnya, pelbagai pengoptimuman ditetapkan untuk meminimumkan nilai Ra dan EWR dengan memaksimumkan nilai MRR. Ia didapati bahawa. Nilai pengoptimuman pelbagai yang diperolehi ialah 25.14A untuk saat ini, 400 μ s untuk masa pulsa, 1 μ s untuk masa pulse off, mempunyai output 0.269724g / min untuk MRR, 0.00416228g / min untuk EWR dan 2.18403 μ m untuk Ra dengan keinginan adalah 0.576 . Oleh itu, semasa adalah faktor yang paling penting. Ia adalah kerana nilai semasa yang tinggi meningkatkan kadar kerja lebur.

ABSTRACT

Electrical discharge machining (EDM) die sinking is the one of the important process in manufacturing industry for cutting high hardened material by an arc erosion in all kind of electron conductive materials. The machining parameter is an important role in order to determine the good quality for the surface integrity of the product. The purpose of this project is to study the effect of EDM die sinking parameters related to the machining characteristics for aluminium alloys LM6 using full factorial method. The input parameter assess are pulse on time, pulse off time and current. Meanwhile, this project presents fundamental study of the machining characteristics that are material removal rate (MRR), electrode wear rate (EWR), surface roughness (Ra) and observation the cracking of crater. The design of experiment (DOE) using full factorial method was applied to design the run matrix order by 2 levels with 3 factors. The result of this project shows that the current factor is the most significant parameters followed by pulse on time and pulse off time. Meanwhile the single optimization for maximize the value of MRR is 0.3375, for minimize the value of EWR is -0.0003 and also minimize the value of Ra is 0.6386. Further, multi optimization is set to minimize the value of Ra and EWR with maximize the value of MRR. It is found that. The multi optimization value that been obtained are 25.14A for current, 400 μ s for pulse on time, 1 μ s for pulse off time, having output 0.269724g/min for MRR, 0.00416228g/min for EWR and 2.18403 μ m for Ra with the desirability is 0.576. Therefore, the current is the most significant factor. It is because the high value of current increases the rate of melting work piece.

DEDICATION

Special dedicated to my beloved mother, my beloved father and my supportive siblings their endless support in term of motivation, support and caring as well throughout the whole project. Thanks to my supervisor because he willing to teach and help me whenever I had a problem. Not forgetting thanks to all my friends that always gives a supports, courage and prayers whenever I feel like I am in pressure during accomplish my project.

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LIST OF ABBREVIATIONS

Adj. MS	-	Adjusted mean squares
Adj. SS	-	Adjusted sums of squares
Al	-	Aluminium
Al-Sil2	-	Aluminium Alloy LM6
ANOVA	-	Analysis of variance
Co	-	Copper
DC	-	Direct current
DF	-	Degree of freedom
DOE	-	Design of experiment
EDM	-	Electrical discharge machining
EWa	-	The electrode weight after machining
EWb	-	The electrode weight before machining
EWR	-	Electrode wear rate
Ip	-	Peak current
L	-	Low
M	-	Medium
Mg	-	Magnesium
MRR	-	Material removal rate
n	-	number of reading
P	-	Percentage contribution
P-value	-	Probability value
Ra	-	Surface roughness

RC	-	Resistor capacitor
Rq	-	Root-mean square average
Seq. SS	-	Sequential sums of squares
ti	-	Pulse duration
tm	-	The machining of time
toff	-	Pulse off time
ton	-	Pulse on time
Wa	-	The weight of the material work piece before machining
Wb	-	The weight of the material work piece after machining

LIST OF SYMBOLS

%	-	Percent
+ve	-	Positive
°C	-	Degree Celsius
μm	-	micrometer
μs	-	microsecond
μΩ.cm	-	Electrical resistivity
A	-	Ampere
g/cm ³	-	Gram per centimetre cube
g/min	-	Grams per minute
K	-	Kelvin
kg.cm ³	-	Kilogram centimetre cube
MPa	-	Mega Pascal
nm	-	Nanometre
V	-	Voltage
-ve	-	Negative
W/mK	-	Watt per metre per Kelvin

CHAPTER 1

INTRODUCTION

This chapter explains about the background of this study, the problems, the aims and objectives of this project. There is also an explanation about the purpose of doing this project and is it important and relevant to the engineering.

1.1 Research Background

The purpose of this project is to study the performance of copper tungsten electrode on aluminium alloys LM6 in die-sinking using factorial method. The electric discharge machining (EDM) is the manufacturing process for cutting the shape of hard metal and forming deep area by wire erosion in all kind of electrical conductive material discharge. This machining also has capability to machine on hard materials where intricate complex shape is needed by Attar et al. (2017).

In this application of sinker EDM, the copper tungsten electrode is machined into the desired shape. This process is most widely used of making prototype and production parts. The advantage of the EDM machining is the process does not affected by the hardness of the material. This is because the hardened material can be machined avoiding possible distortion. Any complex shape required in the dies and mould can be easily produced to the required degree of accuracy and finish.

The input parameters evaluated are current, pulse on time and pulse off time. While, the output responses study of EDM die sinking are material removal rate (MRR), electrode wear rate (EWR), surface roughness (Ra) and surface appearance.

Design of experiment (DOE) using full factorial design method was applied to design the run matrix order. It is able to identify and analyse the performance and interaction factors without any confounding for EDM process. The analysis was done using Minitab software. The full factorial method used was 2 levels with 3 factors. The analysis of variance (ANOVA) was done in order to get the significant parameters and optimize combination of the parameters.

The expected result of this experiment that the current and pulse on time. While, for the surface roughness the most significant interaction factor is between current and pulse off time. The energy current like a thunder shoot on the work piece surface of aluminium LM6 when the current and rate of melting work piece is higher occurred at crater. Thus, the actual surface produced consists of small craters which useful in the retention of lubricants.

1.2 Problem Statement

The selection of the suitable material of the electrode is important caused it will effect of the test machining parameters such as pulse on time, pulse off time and peak current. The result performance will be poor in EDM die sinking if the material of the electrode is not suitable. The EDM die sinking also influences the surfaces integrity such as electrode wear rate (EWR), material removal rate (MRR), surface roughness (Ra), texture and cracking of craters. The aluminium alloy LM6 containing 12% silicon with well resistance to corrosion by Ali et al. (2014).

Therefore, in order to obtain the optimum parameters, the design of experiment (DOE) will be performed using full factorial method. Meanwhile, the electrode must be minimized

and the erosion of the work piece must be maximized in order to increase the machining efficiency. The important factor when use the electrode wear should be effective to enhance the machining productivity and process reliability.

1.3 Objectives

The main objective of this project is to investigate the effect of die sinking parameters on material removal, electrode wear rate and surface roughness for Aluminium Alloys LM6 using design of experiment through full factorial method.

- a) To find the most significant effect of machining parameters such as pulse on time, pulse off time and current for copper tungsten electrode on the EDM die-sinking characteristic.
- b) To investigate the interaction of machining parameters on the machining characteristics of Aluminium Alloy LM6 in surface roughness (Ra), material removal rate (MRR), electrode wear rate (EWR) and to evaluate the surface appearance of workpiece.
- c) To analyse the percentage of contribution using analysis of variance (ANOVA) and to optimize the machining characteristics using full factorial method using single and multi-response by setting maximum of MRR, minimum of Ra and minimum of EWR.

1.4 Scopes of the Research

The knowledge of the electrical discharge machine is very important for industry. Hopefully, this project get more experience to handle the EDM die-sinking caused it broad industrial applications. More, it can gain a lot of understanding of EDM die-sinking.