ELECTRICAL DISCHARGE MACHINING OF HYBRID MATERIAL USING COPPER ELECTRODE

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Bismillahirahmanirahim

I strongly dedicated this project to my beloved father (Mohammad Yazid Bin Harun), mother (Faridah Bte Abdul Ghani) and my siblings (Helmi Husaini, Raimi Ruhaizat, Azrin Amirudin, Muhammad Hafeezudin and Leeqa Nurjannah), with their sincere prayers and endless support afforded me to successfully accomplish this thesis.

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ABSTRACT

In recent years, there has been a great of interest in copper alloy (FeCuSn) hybrid metal material due to several industrial applications. Extreme hardness and high brittleness properties of FeCuSn makes the machining of such material very difficult and time consuming, especially using traditional machining methods such as grinding and lapping techniques. Due to this, the cost of machining FeCuSn is very high. Despite high demand in electrical discharge machining (EDM) process by modern manufacturing industries, the mechanism of the process is quite complex. It is difficult to generate a model that can accurately correlate the input parameters with the responses. Optimum parameters play a significant role in increasing production rate and reducing the machining time. In this work, study on parametric optimization of surface roughness (Ra) , material removal rate (MRR) and tool wear ratio (TWR) on die-sinking EDM of copper alloy (FeCuSn) was carried out. This study also establishes the models that relate the responses and the most significant design parameters like pulse-on time (Ton), discharge current (Ip) and servo voltage (SV) will be achieved . Full factorial design was applied to select the most influential design parameters. The experimental data was analyzed using the analysis of variance (ANOVA). The ANOVA results revealed that Ton, Ip and SV were the most influential parameters which affect the Ra, MRR and TWR. The optimum responses (Ra, MRR and TWR) were achieved through the optimum parameters setting predicted by the design expert software. The developed models were validated through confirmation runs, and the error between the experimental and predicted values of the responses lies within the acceptable limit.

ABSTRAK

Aloi kuprum (FeCuSn) merupakan bahan besi hibrid yang semakin mendapat perhatian disebabkan kepelbagaian aplikasinya dalam industri. FeCuSn mempunyai sifat kekerasan dan kerapuhan yang amat tinggi menjadikan ia sukar untuk dimesin serta memerlukan masa yang lama, terutama apabila menggunakan kaedah pemesinan tradisional seperti teknik pengisaran dan pencanaian. Meskipun permintaannya dan kos yang tinggi dalam industri pembuatan termaju khasnya dalam proses electrical discharge machining (EDM) mekanisme untuk proses ini adalah kompleks. Ini disebakan kesukaran untuk menghasilkan model yang tepat dalam menghubungkaitkan kemasukan input dan respon dan ini memainkan peranan yang penting dalam peningkatan kadar pengeluaran dan pengurangan masa pemesinan. Kajian untuk mengoptimumkan parameter dari segi kekasaran permukaan (Ra), kadar pemotongan bahan (MRR) dan nisbah kehausan mata alat (TWR) untuk die-sinking EDM bagi FeCuSn telah dijalankan dengan menghasilkan model yang berkaitan antara respon dan rekabentuk parameter utama seperti tempoh masa denyutan (Ton), arus puncak (Ip) dan voltan puncak (SV) akan diperolehi. Rekabentuk faktorial penuh adalah untuk menentukan rekabentuk parameter yang paling dominan. Permukaan tengah sentral bagi rekebentuk komposit telah digunakan untuk menentukan koefisien model bagi parameter terpilih dan akan dianalisiskan melalui analisis varians (ANOVA). Didapati bahawa Ton, Ip dan SV merupakan parameter yang paling ketara yang mempengaruhi Ra, MRR dan TWR. Manakala itu, respon optimum (Ra, MRR dan TWR) telah dicapai dengan menetapkan ramalan optimum parameter menggunakan perisian Design Expert. Model yang terhasil telah disahkan melalui ujian pengesahan sementara ralat antara eksperimen dan nilai ramalan bagi respon terletak dalam had boleh terima.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

ANOVA	- Analysis of Variance
DOE	- Design of Experiment
EDM	- Electrical Discharge Machining
Ip	- Peak Current
MRR	- Material Removal Rate
Ra	- Arithmetical Mean Roughness
SR	- Surface Roughness
SV	- Servo Voltage
Ton	- Pulse-on Time
TWR	- Tool Wear Ratio

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Project Background

The electrical discharge machining (EDM) is one of the major manufacturing processes widely applied in die and mold making industry to generate deep and three-dimensional complex cavities in many different classes of materials under roughing and finishing operations.

The best supported theory to the explanation of electrical discharge machining process is the thermoelectric phenomenon and according to Van Dijck et al. (1974) and other researchers such as Zolotych (1955), Crookall and Khor (1974), Dibitonto et al. (1989) and König and Klocke (1997) the material removal in electrical discharge machining is associated with the erosive effect produced when spatially and discrete discharges occur between two electrical conductive materials. Sparks of short duration are generated in a liquid dielectric gap separating tool and workpiece electrodes. The electrical energy released by the generator is responsible to melt a small quantity of material of both electrodes by conduction heat transfer. Subsequently, at the end of the pulse duration a pause time begins and forces that can be of electric, hydrodynamic and thermodynamic nature remove the melted pools.

In this study, EDM machining parameter is highlighted on the effect on the surface of work material of Iron-Copper-Tin (FeCuSn) hybrid metal material. Hybrid materials have been a great interest of researchers and manufacturing industries

nowadays because of its strengthening affect. Many of the researchers have developed much kind of material composition in order to fit its application in various field as stated earlier. Therefore it is crucial to provide optimum parameter setting for hybrid material specifically in EDM to machine such material closed to near net shape whilst maintaining its hardness.

It is important to get near net shape component because it is relatively reduce cost, time, energy and may increase the production. In this case, only several parameters will be analysed and evaluated with design of experiment (DOE) method to optimize important parameters in this study in order to achieve the optimum quality surface of FeCuSn by EDM machining.

1.2 Problem Statement

The electrical discharge machining (EDM) is the most famous manufacturing process due to its accuracy cutting, especially for intricate shapes and design, regardless of the material hardness being employed. A few problems are been highlighted, as the selection of machining parameters such as pulse-on time, pulse-off time, peak current and voltage in obtaining good cutting performance is still constricted against the cutting of materials.

A part from that, there is no specific machining parameters for hybrid metal materials that can machine material close to near net shape specifically by EDM. Furthermore, the machining parameters are depending on the operator experiences. There are still needs to study, if the machining parameters have relationship with the surface quality or rates of material removal. In this study, various aspect of surface quality such as, surface roughness, surface finish and surface morphology are considered as a response variables for this study to evaluate the EDM parameters process during experimental work.

The aim of this project is to study the effect of machining parameter in EDM to determine optimum input parameters in obtaining a good surface quality, surface finish and surface morphology especially for FeCuSn hybrid metal material.

1.3 Objective of The Research

The objective is crucial in providing a clear purpose and as a guide to the assessment strategies to achieve the goal of studies. There are two main objectives for this study, which are:

(i) To analyse and evaluate of EDM cutting for FeCuSn hybrid metal material for precision cutting process in term of surface roughness, material removal rate and tool wear ratio

(ii) To evaluate the input parameters of cutting process for FeCuSn hybrid metal material by EDM process.

1.4 Project Scope

The scope of this experimental study is conducting a machining process by utilizing electrical discharge machining (EDM) which to analyze their cutting performance. The study will be focused upon the effect of the working surface and the surface morphology of work materials. The appropriate machining parameters such as pulse on time, pulse off time and peak current will be reset according to the Design of Experiment (DOE) while the other parameters remain constant. DOE analysis can help to optimize the machining processes by analyzing and evaluating the cutting performance. The material tested is FeCuSn hybrid metal material and utilizing the copper tungsten electrode as the electrode with the diameter of 10 mm.

After machining, the material will be evaluated using Surface Texture Machine, Research Microscope and Scanning Electron Microscope (SEM). Thus, from the obtaining results, the comparison will be made based on the surface morphology evaluation such as porosity, cracks formation and recast layer of FeCuSn. The results are then be analyze through Analysis of Variance (ANOVA) to determine the significant effect for every responses involved, in order to obtain high surface quality (SQ) and surface finish for FeCuSn. As a conclusion of this experiment, the guideline of FeCuSn hybrid metal material of EDM can be established.

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