MODELING PULSE POWER GENERATOR OF ELECTRICAL DISCHARGE MACHINING

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Dedicated to my beloved mum

Zainab binti Abdullah

Beloved siblings

Azraimee bin Ahmad

Azren bin Ahmad

Azlinda binti Ahmed

Mohd Farid bin Ahmad

Azura binti Ahmad@Ahmed

Azimah binti Ahmed

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and

All my friends in MKEL programme

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ABSTRACT

Electrical Discharge Machining (EDM) is non-conventional manufacturing process that uses electrical energy to shape the material, high voltage as the source for removal, electrons as the medium to transfer the energy and spark erosion as the mechanism that involves in the manufacturing process. A series of stochastic sparks are produced when the gap between electrode and workpiece is very narrow just about 10 to 50 microns. EDM has been introduced to this project due to the capability covering a various type of conducting material such as steel, titanium, super alloys, refractories and aluminum. The selection of EDM pulse power generator is one of the most critical aspects to take into consideration in the manufacturing process. This project focused on the modeling and analysis of pulse power generator of EDM. A model of pulse power generator has been developed by using model-based design tools MATLAB/Simulink. Pulse power generator consists of power supply unit and pulse generator unit. The first section of pulse power generator which is linear power supply has been modeled accordingly. Similarly, the second section of pulse power generator which is the pulse generator, the system has been modeled in order to analyse the pulse profile of EDM. The characteristic of the pulse profile are an open circuit, normal discharge, arc and short circuit condition during the machining process. A model of pulse power generator has been presented and implemented successfully. The phases of the pulses have been discussed thoroughly which are initial phase, ignition phase, discharge phase and ejection phase. The pulse power generator model has been simulated and validated by the experimental results of previous research.

ABSTRAK

Electrical Discharge Machining (EDM) adalah proses pembuatan bukan konvensional yang menggunakan tenaga elektrik untuk membentuk bahan, menggunakan voltan tinggi sebagai sumber untuk penyingkiran, elektron sebagai medium untuk memindahkan tenaga dan percikan hakisan sebagai kaedah dalam proses pembuatan. Serangkaian bunga api stokastik dihasilkan apabila jurang antara elektrod dan sekeping kerja sangat sempit hanya kira-kira 10 hingga 50 mikron. EDM telah diperkenalkan dalam projek ini kerana keupayaan meliputi pelbagai jenis bahan yang dijalankan seperti keluli, titanium, aloi super, refraktori dan aluminium. Pemilihan penjana kuasa nadi EDM adalah salah satu aspek yang paling kritikal untuk diambil kira dalam proses pembuatan. Projek ini memberi tumpuan kepada pemodelan dan analisis penjana kuasa nadi EDM. Model penjana kuasa nadi telah dibangunkan dengan menggunakan alat reka bentuk berasaskan model MATLAB / Simulink. Penjana kuasa nadi terdiri daripada unit bekalan kuasa dan unit penjana nadi. Bahagian pertama penjana kuasa nadi yang merupakan bekalan kuasa linear telah dimodelkan dengan sewajarnya. Bahagian kedua penjana kuasa nadi yang merupakan penjana denyut telah dimodelkan untuk menganalisis profil nadi EDM. Ciri profil nadi adalah litar terbuka, pelepasan normal, arka dan keadaan litar pintas semasa proses pemesinan. Model penjana kuasa nadi telah dibentangkan dan dilaksanakan dengan baik. Fasa-denyut nadi telah dibincangkan yang terdiri daripada fasa awal, fasa pencucuhan, fasa pembuangan dan fasa ejeksi. Model penjana kuasa denyut telah disimulasikan dan disahkan oleh hasil kajian sebelum ini.

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LIST OF ABBREVIATIONS

EDM	-	Electrical Discharge Machining
AC	-	Alternating Current
DC	-	Direct Current
LPS	-	Linear Power Supply
SMPS	-	Switching Mode Power Supply
RC	-	Resistance Capacitance
MOSFET	-	Metal Oxide Semiconductor Field Effect Transistor
I	-	Current
V	-	Voltage
P	-	Power

LIST OF SYMBOLS

R	-	Resistance
L	-	Inductance
C	-	Capacitance
π	-	Pi (3.141593)
f	-	Frequency
Ω	-	Ohm
F	-	Farad
Hz	-	Hertz

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CHAPTER 1

INTRODUCTION

1.1 Background

With the advancement of technology in the field of space research, missile and nuclear industry, there is an increased demand for very complicated and precise component[1]. The need for micro-features, components, and products is rapidly increasing in diverse industries such as electronics, medical and aviation. Product miniaturization demands innovative manufacturing methods[2]. This challenge has been accepted and many new materials and non-conventional methods of machining have been developed to suit the requirement of the industry[1]. The weaknesses of traditional or conventional manufacturing method used today have been limited in their efficiency and ability for these new materials. Therefore, the new approach of contro system has been invented to deal with this new material that called non-conventional manufacturing method.

Non-conventional methods of machining having several specific advantages and promise a revolution in the field of technology. These methods capable to produce any intricate shape and are not affected by the hardness, brittleness, strength and toughness of a material. This method required an appropriate control parameter, depending upon the process used for machining. Non-conventional methods of machining are generally classified into some group as shown in Table 1.1.

Table 1.1: Classification of non-conventional methods of machining

Classification	Type
Energy to shape material	Electrical, Chemical, Mechanical
Source of energy for removal	Hydrostatic Pressure, High Voltage, High Current Density
Medium transfer the energy	High-velocity particles, Electrolyte, Electrons, Hot Gases
Mechanism involved in the processes	Ionic dissolution, spark erosion, chemical erosion, vaporization

There a few methods have been used for non-conventional machining processes such as Electrical Discharge Machining (EDM), Electrochemical Machining (ECM), Plasma Arc Machining (PAM), Ultrasonic Machining (USM) and Electron Beam Machining (EBM). Table 1.2 shows the application of non-conventional methods of machining with various work material include aluminum, steel, titanium, super alloys, refractories, ceramics, glass and plastic. This new invention makes the efficiency and capability of manufactures are greatly improved.

Table 1.2: Application of non-conventional method of machining with various work materials [1]

MATERIAL	EDM	ECM	PAM	USM	EBM
Aluminum	Fair	Fair	Good	Poor	Fair
Steel	Good	Good	Fair	Fair	Fair
Titanium	Good	Fair	Fair	Fair	Fair
Super alloys	Good	Good	Good	Poor	Fair
Refractories	Good	Fair	Poor	Good	Good
Ceramics	NA	NA	Good	Good	Good
Glass	NA	NA	Fair	Fair	Fair
Plastic	NA	NA	Fair	Good	Fair

Electrical Discharge Machining (EDM) is one of the most accurate non-conventional manufacturing processes used for cutting or creating intricate shapes in very hard or difficult-to-cut, electrically conducting materials[3]. EDM has been introduced on this project due to the capability of this non-conventional method covering a various type of conducting material. EDM is the non-conventional method that uses electrical energy to shape the material, a high voltage as the source for removal, electrons as the medium to transfer the energy and spark erosion is the mechanism involves in the manufacturing process. Various types of products, such as dies and molds, can be produced by EDM[4]. EDM is one of the most significant manufacturing processes widely used in the die and mold making industry to generate an intricate shape, mold cavity, complex shapes[5].

A variability of research work has been carried out on different aspects of EDM such as tool material-workpiece combination, type of dielectric, pulse train, flushing techniques and hybridization of EDM with other non-conventional techniques such as ultrasonic machining, electrochemical machining and abrasive machining. In EDM process, pulse power generator is required to obtain the discharge spark. The efficiency of production is depending on the performance of the pulse power generator[6]. Therefore, the selection of pulse power generator is one of the most critical aspects to take into consideration in EDM manufacturing process. The project has been conducted to model the pulse power generator that capable to supply a maximum voltage with the variable current that can be verified by the development of the system. In this project, the pulse power generator model that consists of the linear power supply model and a pulse generator model can represent 4 types of pulse profile which are an open circuit, normal discharge, arc and short circuit during the machining process.

1.2 Problem Statements

The efficiency and performance of the EDM process which are the material removal rate (MRR), surface finish, wear on workpiece and electrode is mainly determined by the kind of power generator used for EDM machining. The gap discharge status has a great effect on the machining performance together with the machining efficiency, material removal rate, surface roughness and tool wear rate in EDM processes. The final surface finish quality of the workpiece is resolute by the energy per spark that is applied to the gap. In the EDM process, the rectangular pulses sensed between the electrodes can be classified into four classes, namely open circuit, normal discharge, arc and short circuit, correspondingly. An ignition delay has been used as parameter for gap control in EDM processes. The effectiveness of the EDM can be controlled by this parameter.

An arc and short circuit condition are an abnormal condition produced by imperfect flushing of debris and outcome in the incidence of continues sparking on the same position which could create a large and rough greater size and knowingly affect the surface quality. An extremely short ignition delay, as an arcing pulse has, usually portends the weakening of the gap status and instability of an EDM process. An arc pulses can be attributed to the local overheating in the gap, which makes the dielectric fluid easier to break down. Usually, arc pulses prime to an ineffective EDM process and will harm the surface quality in finish machining. In this project, the model of pulse power generator has been proposed to analyse the pulse profile of EDM during machining process expecially during an abnormal condition . The model has been validated with the sample of experiment data.

1.3 Objectives of Project

The objectives of this project are as follows

1) To model pulse power generator using MATLAB/SIMULINK.
2) To simulate EDM pulse profile during machining.
3) To analyze pulse profile such as open circuit, normal discharge, arching and short circuit.

1.4 Scope of Project

To achieve the objective of this project, there are some procedures need to be designated in this project. The theory involved in designing the device is investigated before constructing the device. First, the priciple of EDM power generator has been studying. Power Generator for EDM consists of power supply unit and pulse generator unit. The model of the linear power supply and pulse generator was modelled and simulated by using MATLAB/Simulink. The linear power supply was chosen due to the simplicity, reliability, noise free and cost effectiveness of this power supply. There are a few types of the pulse generator for EDM system such as RC generator, Rotary Impulse Generator (RIGS), Controlled Pulse Circuit (CPC) and transistor pulse generator. Transistor pulse generator was selected because having the facility to provide higher metal removal rate (MRR) due to its high discharge energy. Beside that pulse duration and discharge current can be arbitrarily changed depending on machining characteristic.

The electrical model has been modelled for 4 types of pulse profile which are an open circuit, normal discharge, arc and short circuit characteristic by using MATLAB/SIMULINK. Then, the simulation of pulse profile performance during all the condition carried out is analysed and compared with the sample of experiment data from the laboratory. The limitation of this project is the simulation does not consider the stochastic nature of EDM process.

1.5 Report Outlines

The thesis consists of five chapters. In the first chapter, it discusses the project background, problem statement, objectives, scope and report outline.

Chapter 2 presents the background, type of EDM, related work and an overview of the pulse power generator of EDM. The principle of EDM system and a previous study on EDM pulse power generator are explained in detail in this chapter.

In chapter 3, the focus is a detailed description of the model of the linear power supply and pulse power generator. It is clear and concise of work performed. This chapter describes the sample of experiment data to the model pulse power generator.

In chapter 4, the model of linear power supply, a model of pulse power generator and a sample of experiment data is attached. This chapter presented simulation result of pulse power generator model. The analysis and comparison between simulation and sample of experiment data are obtained to achieve the objectives of the project.

Lastly, the conclusion of the project is written in the fifth chapter. It also provides suggestions and recommendations for future wor

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