TECHNICAL UNIVERSITY MALAYSIA MALACCA

Analysis Of The Influence Of Electrical Discharge Machine Die Sinking Parameters On Material Removal Rate Of Mild Steel

Thesis submitted in accordance with the requirements of the Technical University Malaysia Malacca for the Degree of Bachelor of Engineering (Honors) Manufacturing (Process)

By

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ABSTRACT

This thesis discusses about the analysis of electrical discharge machine (EDM) die sinking parameters on the material removal rates (MRR) of mild steel. Initially, five important factors are identified as a factor influencing and affecting MRR. The factors are electrical discharge peak current (IP), servo voltage (SV), main supply voltage (V), servo speed (S) and jump speed (JS). Even though five parameters are considered affecting MRR, it is significant to find which are affecting most. So, design of experiment (DOE) method is used to predict the most affecting parameters. After DOE analysis, it is found that only three major parameters plays a vital role in the material removal rate. They are IP, SV and V respectively significant. Based on the significant parameter, a mathematical model is constructed and developed. This design mathematical model is used in the conducted experiment and hence applied to determine the MRR of mild steel.

DEDICATION

Specially dedicated to my beloved family.

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LIST OF ABBREVIATION

ANOVA	-	Analysis of Variance
CNC	-	Computer Numerical Control
DOE	-	Design of Experiment
EDM	-	Electrical Discharge Machine
IP	-	Electric Discharge Peak Current
JS	-	Jump Speed
MRR	-	Material Removal Rate
S	-	Servo Speed
SV	-	Servo Voltage
V	-	Main Supply Voltage

CHAPTER 1
INTRODUCTION

1.1 Background

Electrical discharge machining is a new technology adopted in advanced machining process to remove the material part using electrode as cutting tool. The tool materials that are commonly used are copper and graphite due to its wear resistance. There are also other type of materials that can be used but not widely such as copper tungsten, aluminum, tellurium copper, brass and tungsten carbide. The main factor for choosing the electrode depends on good electrical conductivities. The choice of electrode will firstly base on how easy the electrode can be machined to get the desired shape. Second the electrode is chosen on it based own mechanical properties that can long lasting of it wear mechanical properties. It means that the electrode having lower melting point the tool wear rate will increase.

The working principle of EDM is to produce and generating spark and hence to remove the material. The simplest way to understand the spark generating is the same like the car lead acid batteries. It has a cathode and an anode. Connect one end of the anode with a wire and the cathode end is free. By using wire that connected at anode touch it to the cathode the spark will produce. After the spark has been produce by the car lead acid there will be some amount of the end is been removed. Where the anode is representing the electrode and the cathode is represent for the work material. That is the basic EDM principle working. EDM does not need any mechanical force to remove the material but it needs only the impulse of voltage and ampere to remove the part material.

1.2 Problem Statement

Electrical discharge machining (EDM) has been used effectively in the machining of hard, high strength and temperature resistant materials. Material is removed by means of rapid and repetitive spark discharges across the gap between the cutting tool and the work piece. In EDM, it is most important to select machining parameter for achieving optimal machining. Usually, the desired machining parameters are determined based on experience or handbook values. However this dose not ensures that the selected machining parameter result in optimal or near optimal machining performance for that particular electrical discharge machining and environment. To solve this task in the present study, the Design of Experiment (DOE) method is used as an efficient approach to determine the optimal machining parameters in the electrical discharge machining process.

The electrical discharge machining removes work piece by an electrical erosion process. The variations in the machining parameters such as the polarity, servo speed, voltage, jump speed, peak current and servo voltage are greatly affect the machining performance.

Through determining the effect of voltage and current the material removal rate (MRR) will be change directly because it is simultaneously connected. By going trough the analysis of the MRR it can decrease the cycle time and also can find the cost estimation of the product. Effect of the using high rate MRR and low rate MRR have to be determine either it will effect to the work material. The determination of MRR is best for industry that used it for making mold and to remove the hard conductivity material.

1.3 Objective

The objectives of this project are:

I. To determine the material removal rate (MRR) of mild steel using graphite.

II. To find the most significant electrical discharge machining parameter that influences the MRR.

1.4 Scope of Project

1. Understand the EDM Die Sinking process.
2. Machining implementation of mild steel with graphite electrode.
3. Determine MRR with different machining parameter.
4. Analyze the result with Design of Experiment (DOE).

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Machine has a broad term to describe; machine is always describing as equipment that helping man to done operation. Another term of describing machine is a device that transmits energy to perform some task. Machine can also be described as a man slave. Why it is call as a man slave? It is because the machine is operating by mans instruction to complete the men task.

Machine has three basic categories. First categories machine is computer numerical control (CNC) type machine. The second category is manual type machine and a third category is semi automatic machine.

In manufacturing, machine is like a brother to the engineers and technician. Machine is helping people to give high production. Machine that is popular among the engineers is the machine that based on removal rates. This is because in producing part it always comes from raw material then it comes a product. Some kind of machine that based on removal rates is electro discharged machine (EDM), turning machine and lathe machine. These are common machine in production.

2.2 Machine

Electro Discharge Machine is a process of machining that is using spark to remove the material as shown in figure2.1. Figure2.1 shows the tool is not contacting the workpiece to remove the material. The contact is happen between the dielectric to produced spark. The spark can be control by length of the gap. The spark also can be control with the current and the voltage of the EDM.

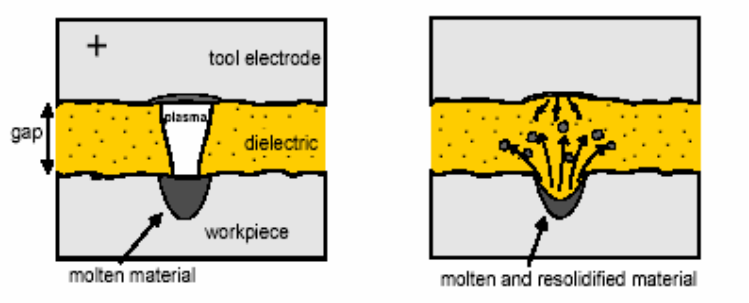

Figure2.1: Material removing by EDM

2.3 Electrode

Electrode is one of the important components in EDM die sinking. Electrode is work as cutting tool. In machining process the cutting tool is need to be selected to get the better result when machining. The electrode must have its own criteria to be use in EDM machining. Firstly the electrode must be good conductivity of electrical and heat. Next, the electrode must be easily machined to reduce the tooling cost. The electrode must be highly wear rates so that the electrode will be long life. Tool is also choose to there hardly decomposition too the other material. In early stage the electrode is choose based on try and error to choose the material type.

The common material of tool is graphite, copper and copper-tungsten. This material is choosing because the material is good conductivity of current then the material is not easily decomposition to the workpiece.

2.4 Tools and Its Properties

2.4.1 Graphite

Graphite is come from Greek word “graphein” it means to write. Graphite has low density (2.1 -2.3 g/cm^3) and it depend the graphite type. Graphite is optically opaque even in extremely thin sections. The material of graphite is unaffected by weather. Graphite has thermal and electrical conductivity and it has low coefficient of friction.

Property	Type		
	Flake	Crystalline	Amorphous
Composition Carbon, % Sulfur, %	 90 0.10	 96 0.70	 81 0.10
Density, g/cm^3	2.29	2.26	2.31
Resistivity, Ω cm	0.031	0.029	0.091
d-spacing (002),nm	0.3355	0.3354	0.3361
Degree of graphization, %	99.9	100	28
Morphology	Plate	Plate Needle	Granular

Table 2.1: Characteristic and Properties of Three Types of Natural Graphite. (Handbook of Carbon, Graphite, Diamond and Fullerenes, Hugh O. Pierson)

2.4.2 Copper

Copper is a chemical element. The symbol of copper is Cp. Copper appearances are metallic pinkish red. See figure 2.2 for more clearly view of copper. Its atomic number is 29. Another name for copper is cuprum. It is a ductile metal and excellent of electrical conductive. Copper has 63.546 g/mol atomic mass. Copper

melting point is 1084.62ºC. Copper are widely use in electrical industry. Copper are also used in the household product and also in structural engineering.

Figure 2.2: The appearance of cuprum/copper.

2.4.3 Copper Tungsten

Copper tungsten sintered materials are manufactured with different copper contents, from 20% up to 70%, depending on the use to which they are put. The method of manufacture depends on the percentage of tungsten present. Materials with large percentages of tungsten (around 80%) are generally made by the impregnation process, where it is advantageous to use a coarse grain tungsten powder to decrease arc erosion. For percentages of the order of 60%, liquid phase sintering is more appropriate, and for materials with less tungsten, powder mixtures without a liquid phase are sintered together.

Materials with a low copper content are used for high currents to improve contact life and breaking capacity. With a higher copper content, about 67%, the material erodes slightly less than pure copper, at low currents (around 20 amp), and the improvement in erosion resistance is enhanced at higher currents, but this is accompanied by considerable deformation of the contact surface. The contact resistance increases considerably on arcing, due to oxidation and depletion of copper in the interface.

For larger contact forces, the static welding limit of copper-tungsten (60/40) is very much higher than for any other material of this type, although at low contact forces the hardness of the material produces very small metallic contact areas, resulting in high contact resistance and low welding limit.

2.4.4 Aluminum

Aluminum is a group of chemical elements. The symbol for aluminum is Al. Aluminum has atomic number 13. It is ductile and poor metal group. Aluminum atomic mass is 26.9815386 g/mol. Aluminum melting point is 2519ºC. Aluminum appearance is in silvery color. See figure2.3 for looking the aluminum appearance.

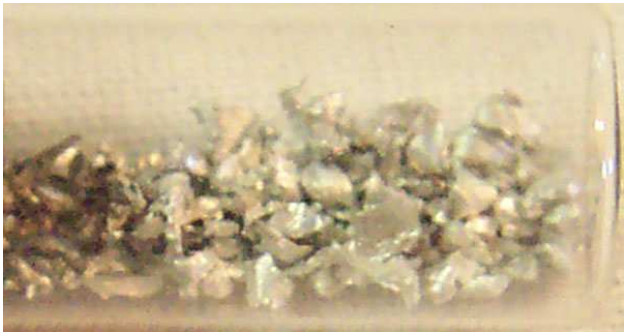

Figure 2.3: The aluminum metal appearance.

2.5 Dielectric Fluid

The dielectric fluid acts as an insulator between the electrode and the workpiece. There are many dielectrics to choose based on the insulation properties of the fluid. Air is not a very good insulator but it still can be used. Water is best. But water has a few drawbacks. First, it causes rust to the workpiece or the electrode itself. Second, the electrical discharge separates the water into pure hydrogen and pure oxygen this element very explosive pair. The water can be as dielectric but it is must-deionized water. A good compromise then is kerosene. No rust problem and no

dangerous gasses are produced with kerosene while the process is done between the electrode and workpiece.

Dielectric functionally works as insulator until the potential is sufficiently high. It also works as a flushing medium and carry away the debris in the gap and lastly it is a cooling medium. (Kalpakjian, 2000)

2.6 Material Removing Rate MRR

There are three ways of expressing the MRR by the equation and each equation is showing the different unit.

$$MRR = \frac{M}{t}$$ ----------equation 1

M= mass workpiece before machining – mass workpiece after machining
t = machining time

The second equation is:
Electrode area (in2) x Depth of cut (in) / Time of cut (min) ----------equation 2

The third equation is:
$MRR = F_{c.}\, I_e.\, U_e.\, t_s / (t_s + t_i)$----------equation 3
(Journal Of Material Processing Technology Y. Chen and S.M Mahadivan)

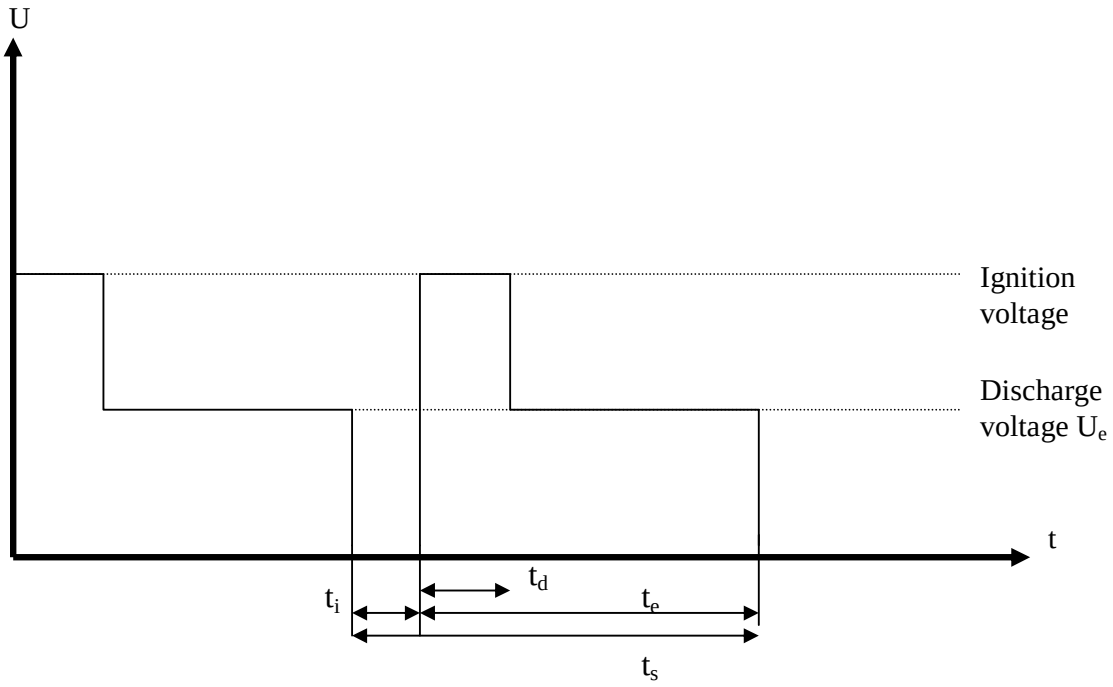

Figure2.4: Voltage – Time diagram

In figure 2.4 show that the symbol (ts) is known as the pulse duration whiles the time interval between is switching the generator on and off for the next pulse is the pulse interval (ti). Time delay, (td) are the periods of time during the voltage remain at the value of the ignition voltage while the current stays at zero.

There are three cases that will influence most in the MRR. First is in the workpiece. Second, is in the gap between electrode and workpiece and third is in the electrode.

In the workpiece MRR is influenced by the thermal conductivity of the workpiece. Copper for example has a low melting point but it also has a low MRR as it is a good conductor a heat. On the other hand steel has a high MP but a low Thermal conductivity hence has a higher MRR.

In the gap; Particles in the work gap will contribute significantly to slowing down the MRR.