UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EDM Performances of Copper Electrode on Different Materials

Thesis submitted in accordance with the partial requirements of the Universiti Teknikal Malaysia Melaka for the Bachelor of Manufacturing Engineering (Manufacturing Process) with honours.

By

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March 2008

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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SESI PENGAJIAN: 2007/2008

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APPROVAL

This thesis submitted to the senate of UTeM and has been accepted as partial fulfilment of the requirements for the degree of Bachelor of Manufacturing (Manufacturing Process).

The members of the supervisory committee are as follow:

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ABSTRACT

In recent years, remarkable developments have been made in die-sinking EDM, with its application broadening into new fields. It is necessary to considered surface finish and dimensional accuracy to accomplished high precision machining.

The main objective of this project is to find the effect of surface roughness and dimensional accuracy on three different materials which are tool steel (AISI D2), aluminum alloy 6063 and carbon steel (AISI 1045). The variable parameter used is pulse on-time (5µs, 10µs, 15µs, 20µs, 25µs, 30µs, 35µs and 40µs). These three materials will be machined by using 4 pieces of copper electrode.

As the result, surface roughness showed a proportion result against increasing pulse on-time. Dimensional accuracy showed inverse result as the pulse on-time increase. There are not much different found in the result. This might be the combination of pulse on-time used are too low to see the differentiation between the three parameters.

ABSTRAK

Dalam beberapa tahun kini, perkembangan yang luar biasa telah berlaku pada aplikasi penggunaan mesin nyahcas electrik yang membawa pengembangan dalam bidang baru. Adalah perlu untuk mengambil kira factor kekasaran permukaan dan ketepatan dimenesi ukuran untuk menyempurnakan permesinan berkepersisan tinggi.

Objektif utama untuk projek tahun akhir ini adalah untuk mencari kesan tahap kekasaran permukaan dan ketepatan dimensi ukuran pada tiga material besi yang berbeza seperti besi alatan bergred AISI D2, besi campuran aluminum 6063 dan besi carbon bergred AISI 1045. Parameter berbagai yang digunakan dalam eksperimen ini adalah “pulse on-time” (5µs, 10µs, 15µs, 20µs, 25µs, 30µs, 35µs and 40µs). Ketiga-tiga material akan di mesin dengan menggunakan 4 batang elektrod kuprum.

Sebagai keputusan, kekasaran permukaan adalah berkadar langsung dengan peningkatan parameter “pulse on-time”. Manakala ketepatan dimensi ukuran adalah berkadar songsang dengan parameter “pulse on-time”. Jelasnya, tidak bayak perbezaan yang dapat dirungkai dari keputusan eksperimen ini. Ini mungkin disebabkan oleh nilai gabungan parameter “pulse on-time” yang digunakan terlalu rendah untuk menunjukkan perbezaan yang ketara.

DEDICATION

For my beloved father and mother

ACKNOWLEDGEMENT

Alhamdullilah, Praise to Allah the Most Gracious, the Most Merciful, who's blessing and guidance have helped me through my final year project successfully.

First of all, I would like to express my sincere gratitude to my supervisor Mr. Abdul Halim Hakim B. Abdul Aziz, who has conducting and giving an opportunity to complete my final year project. A thousand of thanks I would like to convey especially to Mr. Jaafar who been supervised and helped me during my project session and all others laboratory stuffs.

Last but not least, my deepest gratitude to the most important person in my life, my lovely parents, Hj. Abd. Kadir Basiran and Hjh. Robiah Ahmad for giving me an inspiration and always been there when I needed them. Thank you.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE.

EDM	-	Electrical Discharge Machine
AISI	-	American Iron & Steel Institution
DOE	-	Design of Experiment
A	-	Ampere / Amperage
SEM	-	Scanning Electron Microscopy
DC	-	Direct Current
R-C	-	Resistor Condenser
µΩ	-	Micro OHM
˚C	-	Degree of Celsius
µin	-	Micro inch
C	-	Carbon
Mn	-	Manganese
Si	-	Silicon
Cr	-	Chromium
Ni	-	Nickel
Cu	-	Copper
Al	-	Aluminum
Mo	-	Molybdenum
W	-	Tungsten
Mg	-	Magnesium
Max	-	Maximum
Ra	-	Arithmetic mean value
Rq	-	Root mean square
RMS	-	Root mean square
µm	-	Micrometer
mm	-	Millimeter
µs	-	Microsecond
M	-	Minute
S	-	Second

CHAPTER 1

INTRODUCTION

1.1 Background

The Electrical discharge machining (EDM) is a non-traditional concept of machining which has been widely used to produce dies and molds. It is also used for finishing parts for aerospace and automotive industry and surgical components. Electrical discharge machining (EDM) is a well-established machining option for manufacturing geometrically complex or hard material parts that are extremely difficult-to-machine by conventional machining processes.

The recent developments in the field of EDM have progressed due to the growing application of EDM process and the challenges being faced by the modern manufacturing industries, from the development of new materials that are hard and difficult-to-machine such as tool steels, composites, ceramics, super alloys, hastalloy, nitralloy, waspalloy, nemonics, carbides, stainless steels, heat resistant steel and etc. being widely used in die and mould making industries requiring high precision, complex shapes and high surface finish (Shankar *et al.* 2003). In order to find advance materials such as super alloy, ceramic and metal matrix composite, the cost expenditure for these materials is too high. As a result, there are three materials were concerned for this research. The materials are tool steel (AISI D2), aluminum alloy 6063 and carbon steel (AISI 1045).

There have been many published studies considering surface finish of machined materials by EDM. It was noticed that various machining parameters influenced surface roughness and setting possible combination of these parameters was difficult to produce optimum surface quality. It was noticed that various machining parameters influenced surface roughness and setting possible combination of these parameters was difficult to produce optimum surface quality. The influences of some machining parameters such as pulsed current, pulse time, pulse pause time, voltage, dielectric liquid pressure and electrode material have been examined. One study examined P20 tool steel and provided useful information the effects of some machining parameters on surface roughness, but the selected of pulsed current values was very low 1–8A. (Kiyak & Cakir, 2007). Hence, this research will concerned the same parameter used instead of higher pulse current values.

1.1 Problem Statement

Most of the previous research about EDM die-sinker is emphasizing on the variety of EDM parameter to optimize the parameter value in order to determine the machining performances. With awareness of producing high quality product, this project is focusing on the effect of different material machined on surface roughness and dimensional accuracy. In order to find advance materials such as super alloy, ceramic and metal matrix composite, the cost expenditure for these materials is too high. As a result, there are three materials were concerned for this research on the machining performances. The materials are tool steel (AISI D2), aluminum alloy 6063 and carbon steel (AISI 1045).

On the other hand, parameter value determination also consisted in this project difficulty. The parameters concerned for this project is pulse duration time. According to previous EDM thesis or journal, this parameters value determined are used not the same type of machine as available indeed. Hence, the optimum machining parameters should be estimated in order to determine the best machining performances such as surface roughness and dimensional accuracy. Besides, this project is a study of machining performances on different materials.

1.2 Objectives

Those objectives evaluated are to assist and complete this project:

i. To determine surface roughness by using surface roughness tester for each materials.

ii. To determine dimensional accuracy by using toolmaker's microscope for each materials.

iii. To analyze the surface roughness and dimensional accuracy on three different materials.

1.3 Scope

This project has a limitation and scope of research. The project is emphasizing on the machining quality such as surface roughness and dimensional accuracy. The surface roughness will be examined using surface roughness tester and the dimensional accuracy will be analyzed using Toolmaker's Microscope. The parameter variables concerned for the machining process is pulse duration time (5µs, 10µs, 15µs, 20µs, 25µs, 30µs, 35µs and 40µs). According to M. Kiyak and O. Cakir (2007), it was observed that surface roughness of workpiece and electrode were influenced by pulsed current and pulse time, higher values of these parameters increased surface roughness. Lower current, lower pulse time and relatively higher pulse pause time produced a better surface finish. Hence, the pulse duration time (5µs, 10µs, 15µs, 20µs, 25µs, 30µs, 35µs and 40µs) is examined on tool steel (AISI D2), aluminum alloy 6063 and carbon steel (AISI 1045) to determine surface roughness and dimensional accuracy.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter will briefly introduce the literature research of this project. It is consisted of the EDM machine, process parameter, material selection and EDM performance measurement.

2.2 Die-Sinker EDM

The earliest EDM equipment was design to make the cavities in dies by letting the electrode work its way straight down into the metal block until the desire depth was archive. These early machine were therefore called die-sinking or plunge EDM machines. Since the vertical position of the electrode was controlled by a hydraulic ram, there are also called ram EDM machine (Adnan, 2002).

Die sinker or sinker EDM is a common name for vertical EDM. This process was called sinking, a die or die sinking, so the term “sinker” for EDM evolved naturally because an electrode was sunk into the workpiece (Bud, 1997).

Die-Sinker EDM is one of the most extensively used non conventional material removal processes. This technique has been developed in the late 1940s where the process is based on removing material from a part by means of a series of repeated electrical discharges between tool called the electrode and the work piece in the presence of a dielectric fluid. The electrode is moved toward the work piece until the gap is small enough so that the impressed voltage is great enough to ionize the dielectric. Short duration discharges are generated in a liquid dielectric gap, which separates tool and work piece. The material is removed with the erosive effect of the electrical discharges from tool and work piece. EDM does not make direct contact between the electrode and the work piece where it can eliminate mechanical stresses chatter and vibration problems during machining. Materials of any hardness can be cut as long as the material can conduct electricity. EDM techniques have developed in many areas. Trends on activities carried out by researchers depend on the interest of the researchers and the availability of the technology (Abbas *et al*. 2005).

The die sinking EDM, Figure 2.1 has a cutting tool (electrode) shaped to the form of the cavity, mounted in the ram of machines. The electrically conductive workpiece is fastened to the machine table below the electrode. The DC power supply produces a series of short, high-frequency electrical arc discharge between the electrode and the workpiece. This action removes (erodes) tiny particle of metal from the workpiece and as the process continues, the electrode reproduces its form in the workpiece (Krar *et al*. 1998).

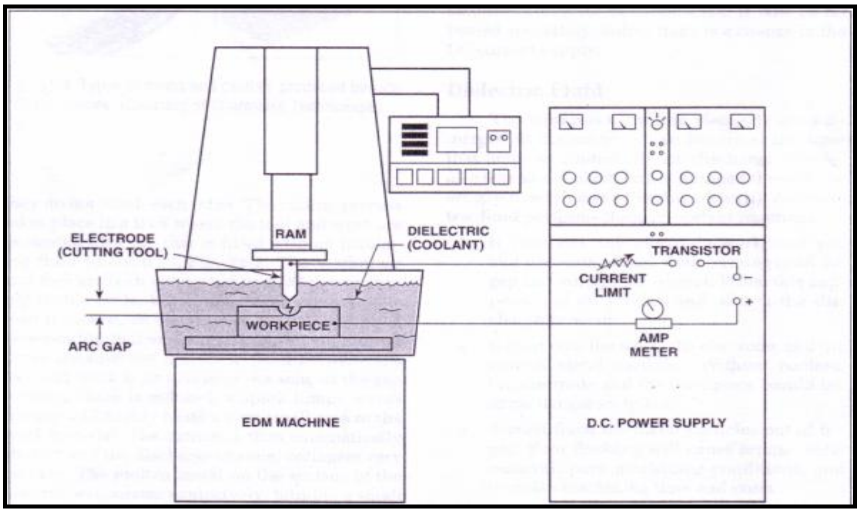


Figure 2.1: Ram-type EDMs plunge a tool, shaped to the form of the cavity required, into a workpiece (Bahari, 2007).

2.2.1 A Review of Current Research of EDM Die-Sinker

Electrical discharge machining (EDM) is a well-established machining option for manufacturing geometrically complex or hard material parts. There are various types of products which can be produced using EDM such as dies and moulds. Parts of aerospace, automotive industry and surgical components can be finished by EDM. According to Abbas et al. 2006, the current research trends are in EDM on ultrasonic vibration, dry EDM machining, EDM with powder additives, EDM in water and modeling technique in predicting EDM performances.

In recent years, EDM researchers have explored a number of ways to improve the sparking efficiency including some unique experimental concepts that depart from the EDM traditional sparking phenomenon. Despite a range of different approaches, this new research shares the same objectives of achieving more efficient metal removal coupled with a reduction in tool wear and improved surface quality (Ho & Newman, 2003).

In EDM, commonly copper and graphite tools are used as electrodes. But high tool wear is the major drawback of these electrodes for prolonged machining. According to Khanra et al. (2006) state that research is going on to develop a tool material for EDM, which has a high electrical and thermal resistance, high wear resistance and easy fabricability and availability. Many researchers are trying to develop composites material as an EDM tool material by powder metallurgy route.

2.2.2 Basic Principles of EDM Die-Sinking

The basic principle of EDM die sinking is where the work piece and tool are place in a way where it does not touch each other. The tool used for EDM Die Sinking called electrode. The machining process takes place in a container filled with dielectric fluid. The fluids are used to cool the electrode where the discharging process took placed and flush away the debris and unwanted products. DC power supply is used to connect the workpiece and electrode. Initially, no current flow because the dielectric fluid between the tool and work is an insulator. When the power is on, the potential different is applied to the workpiece and tool electrode. Then, the gap between the tool and workpiece become closer. Sparks contributing jump across the gap from electrode to the workpiece. The molten metal on the surface of the material evaporates explosively, forming a small crater (Krar *et al*. 1998). The material is removed with the erosive effect of the electrical discharges from tool and work piece. (Abbas *et al*. 2005). Figure 2.2 shows the debris particles are washing away by dielectric fluid. The process keeps repeating many times per second. Another important aspect for the basic operation fro EDM are dielectric fluid and the flushing technique.

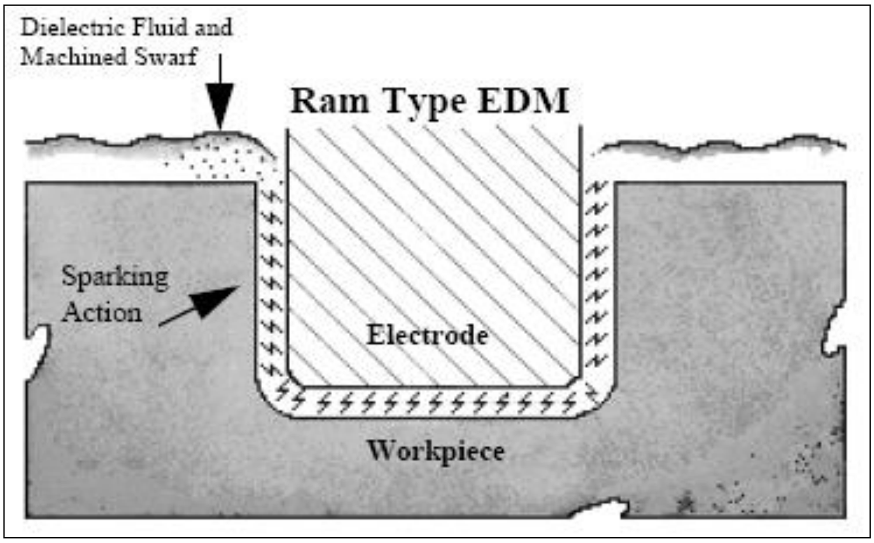


Figure 2.2: Control spark removes metal during electrical discharge machine (Bahari, 2007)

2.2.2.1 Die Electric Fluid

Oils have been used as dielectric fluid as long as the process has existed, but only in the past decade have any appreciable researches or scientific approaches been made as to their composition and compatibility with people and the environment. There are many different types of fluid available. Typically, fluids with parrafinic, napthenic and aromatic bases are used (Bud G.E, 1997).

According to Krar, *et al*. (1998), the workpiece and the electrode are submerged in the electric oil, an electrical insulator that helps to control the arc discharge. The oil also acts as a coolant, and is pumped through the arc gap to wash away the chips (swarf). A die electric fluid performs three important functions:

i. It insulated the electrode /workpiece gap and prevents a spark from forming until the gap and voltage are correct. When this happens, the oil ionizes and allows the discharge to occur.
ii. It must cool the work, the electrode, and the molten metal particles. Without coolant, the electrode and the workpiece would become dangerously hot.
iii. It must flush the metal particles out of the gap. Poor flushing will cause erratic metal removal, poor machining conditions, and increase machining time and cost.

For most EDM operation, kerosene is the common dielectric used with certain addictives that prevent gas bubble and deodorant. Silicon fluids and mixture of these fluids with petroleum oils have excellent results. Other dielectric fluids such as aqueous solution of ethylene glycol, water in emulsion and distilled water.

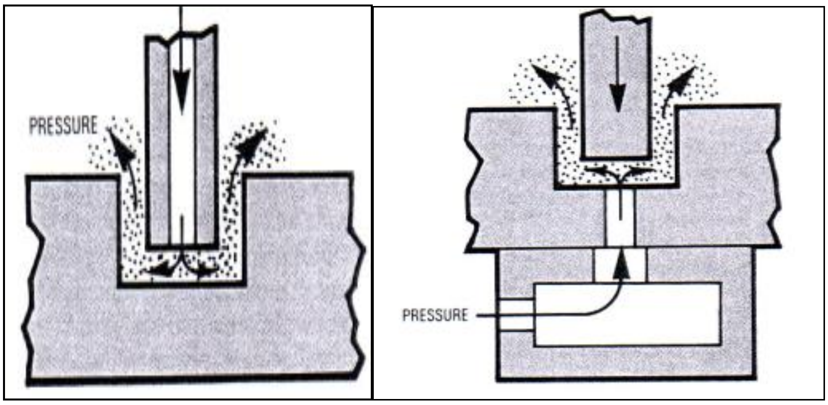
All dielectric oil will change in darken colour after use, but it seem only logical to start with liquid that is as clear a possible to allow viewing of the submerged part. Clear or "white –white" should be the choice, because any fluid that is not clear when brand new certainly contains undesirable contaminants. (McGeough & Regius 1998)

2.2.2.2 Flushing

Flushing is the process of introducing clean dielectric fluid into and through the spark gap. This serve several purposes in introduce “fresh” dielectric to the cut, flushes away the “chips” and debris from the spark gap and cools the electrode and workpiece. According to Bud G.E, 1997, on EDM Handbook, there are three type of flushing. There are as follows.

a) Pressure

This is the most common type of flushing; it is also often referred to as injection flushing. The oil is forced through the spark gap, either through holes, Figure 2.5(a), in the electrode or from holes in the workpiece it self , Figure 2.5(b),

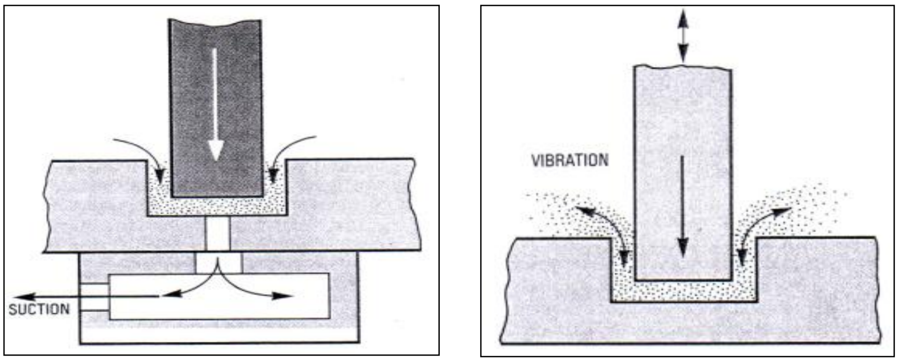


(a) (b)

Figure 2.3: (a) Down through the electrode (b) Up through the workpiece (Bud G.E, 1997).

b) Suction

Suction is opposite of pressure suction. The electrode and workpiece are prepared in the same manner as pressure flushing situations, but instead of the oil being “pushed” through the gap, it is “pulled” through vacuum, Figure 2.4 (a).



(a) (b)

Figure 2.4: (a) By vacuum flow. (b) By vibration. (Bud G.E, 1997)

c) Jet or side or vibration

The least efficient method, but far better than none at all, is jet flushing, or side wash. This is the strategic placement of hoses or flushing “wands” to direct the stream of oil to flush the gap during pulsed electrode movement. The vibration Figure 2.4 (b), method is especially valuable for small holes or blind cavities where it would be impractical to use other methods.