UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Study the Effect of EDM (Die Sinking) Parameters on Surface Roughness for Machining Tool-Steel

Thesis submitted in accordance with the requirements of the Universiti Teknikal Malaysia Melaka for the Bachelor Degree of Manufacturing Engineering in Manufacturing Process

By

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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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DECLARATION

I hereby, declare this thesis entitled **"Study the Effect Of EDM (Die-Sinking) Parameters on Surface Roughness for Machining Tool-Steel"** is the result of my own research except as cited in the references.

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ABSTRACT

The Electrical Discharge Machining (EDM) removes workpiece by an electrical spark erosion process. The variations in the machining parameters, such as polarity, pulse-on time, open discharge voltage, discharge current and dielectric fluid greatly affect the measures of the machining performance, for example surface roughness, electrode wear ratio and material removal rate. Therefore, proper selection of the machining parameters can result in better machining performance. This study is devoted to a study of the influences of EDM parameters on surface roughness for machining tool steel (AISI D2 Cold-work) which is widely used for various dies and cutters for its high strength and wear resistance due to formation of chrome carbide in heat treatment. The selected EDM parameters were Current (16-64A), Voltage (90-200 V) and Pulse OFF Time (5-10 μs). From the experimental, evaluation and analyzing result obtained, the higher discharge energy apparently producing the worst surface texture and fastest machining time. In the other hand, when applying lower discharge energy, machining time will be much longer but the surface texture will be better.

ABSTRAK

Permesinan Nyahcas Elektrik (EDM) membuang benda kerja melalui proses hakisan percikkan bunga api. Variasi parameter dalam permesinan adalah, kekutuban laksana, nadi masa, voltan pemberhentian terbuka, arus elektrik dan dielektrik bendalir dimana menjejaskan prestasi permesinan, seperti kekasaran permukaan untuk nisbah kehausan elektrod dan kadar buangan material. Oleh itu, pemilihan parameter yang sesuai dapat menghasilkan prestasi permesinan yang baik. Laporan tertumpu pada kajian tentang parameter- parameter EDM terhadap kekasaran permukaan untuk pemesinan bahan kerja “tool steel” unsur gred AISI D2 kerja-sejuk yang mana biasa digunakan untuk acuan dan mata alat pemotong disebabkan tinggi tahap kekerasan dan tahan terhadap kehausan yang mana akibat dari pembentukan krom karbida dalam proses pemanasan. Parameter EDM yang dipilih adalah arus elektrik (16-64A), voltan (90-200 V) dan nadi mase berhenti (5-10 μs). Hasil percubaan,penilaian dan penganalisaan, didapati lebih tinggi tenaga luahan dibekalkan lebih teruk bentuk permukaan yang terhasil dan kerja pemesinan menjadi semakin cepat. Berbeza apabila tenaga luahan dibekal adalah rendah, bentuk permukaan akan menjadi lebih baik namun masa pemesinan akan bertambah lama.

DEDICATION

For my beloved mother, father and Wan Aida

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

%	-	percent
°C	-	Celsius
µ	-	micro
µm	-	micro meter
µs		micro second
A	-	Ampere
cm	-	centimeter
CNC	-	computer numerical control
DC	-	direct current
DOE	-	design of experiment
EDM	-	electrical discharge machine
EWR	-	electrode wear rate
in	-	inch
kHz	-	kilohertz
kPa	-	kilopascal
m	-	meter
mm	-	millimeter
MPa	-	mega Pascal
MRR	-	material removal rate
OA	-	orthogonal Array
R_a	-	arithmetic mean value
R_q	-	root mean square average
V	-	Volt

CHAPTER 1
INTRODUCTION

1.0 Background

Nowadays the important use of Electro Discharge Machine (EDM) has been known worldwide. EDM has rapidly placed alongside the milling and the grinding equipments. The most common use EDM is machining dies, tools and molds made from hardened steel, high-speed steel, tungsten carbide and other work piece materials. Beside of that, EDM also has replaced many of the traditional machining process in some applications. EDM has many advantages. The most important thing is no force or no contact involve in the machining process. Therefore no tool or work piece force involve in the machining process like milling and grinding process in traditional machining.

It as well suited for making complex or fragile parts that cannot be done by the traditional machining process. Instead of that EDM process also can be used for high ratio deep cavity machining for making deep holes or slots with only using long electrodes. This process will keep the precision of making deep cavity machining compared with the traditional machining. Since the EDM process do not involve with forces, though material like titanium and nitralloy can be process easily. This make the EDM process is very important in producing part using though material like in the aerospace industries, military and car racing technologies.

The EDM process also not involve with the rotation of the tool. Therefore no problem will occur when machining sharp internal corners, the dimension maintain at high accuracy of precision. Compared with the traditional machining, problem will

occur for machining internal corner where it all depends to the radius of rotating tool. EDM also has low cost for tooling. No die set needed to do EDM machining process. Therefore complex parts and prototypes can be made easily.

At last, EDM is a system that can produce high quality and high precision products in a very efficient way to meet the requirement and demand for precision machine tools. The study of EDM process will make the evolution of the EDM grow and the knowledge will play important role in the manufacturing process industry.

The typical parameter used in EDM such Electrode material, Electrode polarity (+/-), pulse current Ip (A), pulse duration time (micro s), pulse off time to (micro s), average voltage U (V), working current density Id (A/cm2), Average current I (A), open gap voltage Vo (V), Dielectric and flushing mode.

The most important machining performance of EDM is the removal rate, the electrode wear, accuracy and surface texture. In this paperwork “The effect of EDM die sinking parameters on surface roughness for machining tool steel material” is discussed. There are many parameters in EDM die sinking that can be considered. Three level process parameter such as voltage (V), pulse OFF time (μs) and peak current (A) with two level of factor (High) and (Low) considered for this study. By controlling the chosen processes parameters the required surface roughness will be derive and the final result will be evaluate in order to get the most significant machining parameter that influences fine surfaces roughness.

1.1 Problem Statement

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 were 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 .The present study examines the effects of pulsed current, pulse time and pulse pause time on surface roughness in the 40CrMnNiMo864 composite (AISI P20) tool steel. Therefore the effect of EDM parameter for parameters voltage (V), pulse OFF time (µs) and peak current (A) for machining tool steel with grade AISI D2 still being studied to get the significant parameter and optimum value for machining performance of tool steel material alloy steel (AISI D2 cold-work).

1.2 Objectives

The purposes of this project are:

i. To study the effect of EDM die sinking for three chosen parameters voltage (V), pulse OFF time(µs) and peak current (A) on surfaces roughness for machining tool steel.
ii. To evaluate the quality of the surface roughness that produced from the EDM machining of tool steel.
iii. To find significant parameter and optimum value of surfaces roughness from the surfaces quality evaluation.

1.3 Scope and limitation

Scope of study including:

Run a machining process using EDM die sinking advanced machine type Sodick LN2/LQ Series to examine methodically and in detail the machining performance (surfaces roughness) in CNC laboratory Fasa B, UTeM. This project focuses on study the effect of working surface and the parameter factor chosen was the Voltage (V), Pulse OFF (µs) and Peak Current (A). Design of Experiment (DOE) will be

implementing to know how many times machining process should be run. Where the chosen parameter was set in proportion with the DOE and the other parameters remain constant. The material to be tested is tool steel D2-AISI Cold-Work and the electrode were copper electrode. At the end of machining process, surface roughness (R_a) value of the working surfaces will be evaluating using Portable Surface Roughness Tester (SJ 301). Finally, DOE approach was apply to analyze the most significant factor that influences the optimum value of the machining performance using MINITAB software. Then from the result obtained, the comparison of the surface roughness between the set of experiment using different level of parameter setting will be discussed.

CHAPTER 2
LITERATURE REVIEW

2.1 Electrical Discharge Machining (EDM)

Electric discharge machining (EDM) is one of the most popular non-traditional material removal processes and has became a basic machining method for the manufacturing industries of aerospace, automotive, nuclear, medical and die-mold production. The theory of the process was established by two Soviet scientists B.R. and N.I. Lazarenko in the middle of 1940s. They invented the relaxation circuit and a simple servo controller tool that helped to maintain the gap width between the tool and the workpiece. This reduced arcing and made EDM machining more profitable and produced first EDM machine in 1950s. Major development of EDM was observed when computer numerical control systems were applied for the machine tool industry. Thus, the EDM process became automatic and unattended machining method (Kiyak and Cakir, 2007).

From the machining technique point of view, electro discharge machining (EDM) is classified as a non-traditional machining technique. This technique has been widely used in modern metal-working industry and its versatility and ability to cut fully hardened steels has enabled it to be widely accepted, especially in the die making industry in addition to high speed machining applications (Haron *et al* 2001).

The basic process in EDM is carried out by producing controlled electric sparks between a tool (electrode) and the workpiece, both of which are immersed in a dielectric fluid. The electric spark raises the surface temperature of both the electrode and workpiece to a point where the surface temperatures are in excess of the melting

or even boiling points of the substances. Metal is thus primarily removed in the liquid and vapour phases. By controlling the electrical parameters, removal of material may be confined to some extent to the workpiece (Haron *et al* 2001).

Wear of the tool (electrode), however, cannot be ignored because when this occurs the geometrical characteristics of the electrode will not be reproduced on the workpiece. The surface generated by EDM consists of debris, which has been melted or vapourised during machining, lying on or incorporated into the cratered spark-eroded surface. This resulting product of the erosion process, commonly known as debris, has an important relation to the various aspects of EDM. Debris formation is analog to chip formation in traditional machining, and normally debris has a spherical shape with slight ellipticity. Usually, the size as well as the formation of debris depends on the current supplied during machining (Haron *et al* 2001).

Electrical discharge machining EDM, or spark machining, as it also called, removes material with repetitive spark discharges from a pulsating DC power supply, with a dielectric flowing between the workpiece and tool (Boothroyd and Knight, 2006).

The process uses thermal energy to generate heat that melts and vaporizes the workpiece by ionization within the dielectric medium. The electrical discharges generate impulsive pressure by dielectric explosion to remove the melted material. Thus, the amount of removed material can be effectively controlled to produce complex and precise machine components. However, the melted material is flushed away incompletely and the remaining material resolidifies to form discharge craters. As a result, machined surface has microcracks and pores caused by high temperature gradient which reduces surface finish quality (Kiyak and Cakir, 2007).

2.1.1 Typical (EDM) machine

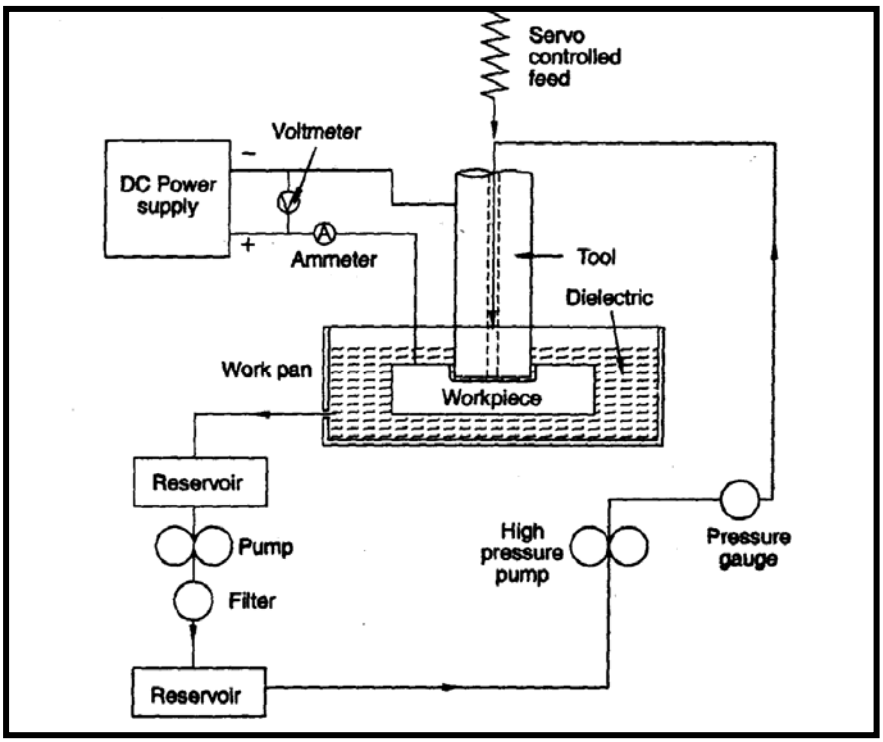

Figure 2.1: A diagram of the components that form a typical EDM machine. (Rao, 2000)

The basic EDM part component is spark servo system, generator, mechanical structure and dielectric liquid (Figure 2.1).

a) Controlled Feed Servo System

A servo system can maintains a movement of the electrode towards the workpiece at such a speed that the working gap, and hence, the sparking voltage remains unaltered.This occurs when both electrode and workpiece are eroded during the process, after a certain time dimensions of the electrodes will be changed considerably. The result is increase in interelectrode gap. This will increase the voltage required for sparking. This problem can be