UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Study of Sharp Edge Cutting In Wire EDM

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTEM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Design) with Honours

by

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DECLARATION

I hereby, declared this thesis entitled “Study of Sharp Edge Cutting in Wire EDM” is the result of my own research except as cited in references.

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ABSTRACT

Wire electrical discharge machining (WEDM) is a thermal machining process by the usage of an electrode to begin the sparking process. During the WEDM process, the material is eroded ahead of the wire and there is no direct contact between the workpiece and the wire which could eliminate the mechanical stresses during machining. The utilizing of continuous traveling wire electrode enables this machine to machining parts with varying hardness or complex shapes accurately. However, due to varying factors like wire tension, wire speed, angle of cut, open-circuit voltage, current, dielectric flow and so on, WEDM could not achieve the accurate dimension during machining especially when cutting the sharp edge at a particular angle. Thus, this study is conducted to finds out the best optimum conditions using WEDM machine (Mitsubishi RA90) in Universiti Teknikal Malaysia Melaka (UTeM) to fabricate high quality products in terms of surface roughness, sharp edge angle and dimensional accuracy. A triangle shape that contains 30^{o} and 120^{o} angle is cut on a mild steel plate to analyze the performance parameters characteristics under different machining conditions or design parameters that have been selected. All the performance parameters are tested using suitable measurement equipment. The surface roughness tester is equipment used to measure the texture of the sample surface. The dimensional accuracy will be measured using optical comparator and meanwhile the accuracy of sharp edge error is analyzed using digital imaging and measurement system. Then, all the data are collected in tables and graphs form to ease the process of data interpretation.

ABSTRAK

WEDM atau Mesin Dicas Elektrik Wayar ialah suatu proses pemesinan termal dengan penggunaan elektrod bagi mencetuskan proses percikan. Semasa proses WEDM, bahan kerja dihakis ke hadapan oleh wayar dan tanpa sebarang hubungan terus secara langsung antara bahan kerja dengan wayar yang mana dapat menghapuskan tekanan mekanikal semasa proses pemesinan. Penggunaan wayar elektrod yang sentiasa bergerak secara berterusan membolehkan mesin ini untuk memesin komponen yang mempunyai pelbagai jenis kekerasan atau bentuk kompleks dengan tepat. Walau bagaimanapun, disebabkan pelbagai faktor seperti ketegangan wayar, kelajuan wayar, sudut pemotongan, voltage litar terbuka, arus elektrik, arus dielektrik dan lain-lain lagi, menyebabkan WEDM tidak dapat menghasilkan dimensi yang tepat semasa proses pemesenan terutama skali ketika memotong sisi tajam pada suatu sudut. Oleh itu, kajian ini dijalankan untuk mengenalpasti keadaan optimum yang paling baik menggunakan mesin WEDM (Mitsubishi RA90) yang disediakan di makmal FKP, UTeM untuk menghasilkan produk yang berkualiti tinggi dari segi kelicinan permukaan, sisi suatu sudut tajam dan ketepatan dimensi. Satu bentuk segitiga yang mempunyai sudut 30^o dan 120^o dipotong pada satu kepingan milsteel untuk menganalisa ciri-ciri parameter yang terhasil dalam pelbagai keadaan pemesenan atau parameter rekaan yang telah dipilih. Penguji kekasaran permukaan adalah alat yang digunakan untuk mengukur tekstur permukaan sampel. Ketepatan dimensi akan diukur menggunakan pembanding optik manakala ketepatan sudut sisi tajam dianalisa menggunakan mikroskop alat. Kemudian, semua data dikumpulkan dalam bentuk jadual dan graf untuk memudahkan proses tafsiran data dibuat.

DEDICATION

For my beloved father, Zakaria bin Idrus and my mother, Halimah binti Sulaiman, sis and bro thank you for your encouragement and understanding during completing this project.

Also dedicated to all my friends who always support and giving hands to help me without hoping any rewards. Your effort in helping me cannot be repaid with any valuable things.

Not forgetting my supervisors, En. Abd. Halim Hakim b. Abd. Aziz. Without his commitment, guide and advice it is impossible for me to complete this project.

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LIST OF ABBREVIATIONS

B.C.	–	Before century
CNC	–	Computer Numerated Circuit
ECM	–	Electro Chemeical Machining
EG	–	Electro grinding
EDM	–	Electric Discharge Machine
PSM	–	Projek Sarjana Muda
USM	–	Ultrasonic machining
WEDM	–	Wire Electro Discharge Machine
HAZ	–	Heat Affected Zone
MRR	–	Material Removal Rate
CMM	–	Coordinate Measuring Machine

CHAPTER 1
INTRODUCTION

"The word *manufacturing* is derived from the Latin *manu factus*, meaning made by hand." The word manufacture first appeared in 1567, and the word "manufacturing" appeared in 1683. The word *product* means something that is produced, and the word "product" and *production* first appeared sometime during the 15th century. The word "manufacturing" and "production" often are used interchangeably. (Kalpakjian, S. and Schmid, S., 2006)

1.1 Background

Material and manufacturing process has been developed gradually over the centuries using new materials and complex operations. It started in 4000 B.C., using material existed during that period such as stone, flint, wood, bone, ivory, and composite tools. All these material are using the muscle power to be used. Then, basics equipments like hoe, hammer and axe are invented. These inventions still need the human energy to be generated. It also need to be improve since there are a lot of limitations especially when manufacturing the harden material.

More energy required to enables the product to be manufactured. Due to that reason, more complicated machines are created to replace human power and to make the manufacturing of the product easier. This kind of machine is known as conventional machines. This machine can be categorized as semi-auto machine because human energy still needed to handle the machine. The product quality of this machine is depends on the operator who is handling the machine. Problems still occurs when

using this machine. Since this machine also depending on human's ability, the quality of the product is not very satisfied. It is hard to achieve the accuracy required since all the setting is done manually. In addition, there are a lot of new harden material existed which cannot be machined by the conventional machine. Thus, it is the need to create a machine that integrates with the computer to make the machining operation more effective and efficient.

Utilization of computers in manufacturing applications has proved to be one of the most significant developments over the last couple of decades in helping to improve the productivity and efficiency of manufacturing systems. These advance methods, which in the past have been called nontraditional or unconventional machining began to be introduces in the 1940's **(**Kalpakjian, S. and Schmid, S., 2006). These requirements lead to the development of electrical-discharge machining, chemical, electrical, laser and high-energy beams as energy sources for removing material from metallic or non-metallic workpiece. Developments of nontraditional machining have given a lot of benefits to industry applications. It has been commonly used in automotive, aerospace, mould tool and die making industries.

Since this kind of machining approach has been using in a lot of critical sectors and industries, the qualities of every product that will be manufactured need to be precise and really high quality in meeting the demands. Due to this reason, one of non-conventional machining which is electrical-discharge machining (EDM) is taken to be studied in this research to perform a very good machining condition while manufacturing every component. The electrical-discharge machining (EDM) can be used for all electrically conducting materials regardless of its hardness. Geoffrey, B. and Winston A.K., 1989 stated that the two most common EDM machines are wire cut and the vertical ram type. This study wills only covers only on Wire EDM (WEDM) type. WEDM is an adaptation of the basic EDM process, which can be used for cutting complex 2-dimensional and 3-dimensional shapes through electrically conducting materials. The workpiece is moved under computer numerical control (CNC) relative to the wire and this enables complex shaped profiles to be cut through sheet and plate materials. However, it seems hard to get the accurateness of the manufacturing part since the accuracy of the parts machine is depending on the shape of the geometry being machined. The problem of inaccuracy is obviously

happen when sharp edge machining is executed. The edge or corner of the component that should be sharp at a particular angle desired, tend to form a radius shape. Thus, this study is conducted to find the best optimum condition in order to increase the accuracy of the product.

1.2 Problem statement

Electrical Discharge Machining (EDM) has become an economic, rapid and highly efficient process for machining all conductive materials. It is capable of machining various shapes of parts precisely. However, the problem comes when the sharp edge of the angle does not perform at the accurate angle that has been desired after machining process. It tends to build a fillet at the angle. This problem could be very critical when the product needed to be very precise especially when it needs to be assembling with another part. It could give a very bad impact to the industry when it is produced in a very big volume. Thus, this problem needs to be fixed so that the product produced can be obtained under the quality control and easier the part to be assembled with another part.

1.3 Objectives of study

The objectives of this study are:

(a) To study the cutting process of sharp edge

(b) To study the relationship of sharp edge error, surface roughness and dimensional accuracy between two different angle

(c) To propose the optimum condition for machining sharp edge

1.4 Scope and limitation

Wire EDM machine, Mitsubishi RA 90 model will be used as the main machine to perform all the results in this report. Any other types of wire EDM machine are not applicable since different machine capability and errors for every different machine that will affect the findings of this study. This machine is located at CNC laboratory in UTeM. Only brass wire at 0.25mm in diameter will be used as the electrode of wire EDM machine (Mitsubishi RA 90 model). The material will be used as the workpiece is mild steel at 10mm in thickness. This research is will study the effects of peak current, wire tension and wire speed at angle 30^{o} and 120^{o}.

1.5 Importance of study

The importances of this study are as follows:

(a) To enhance the machining ability in order to produce sharp edge at approximate angle using wire EDM machine (Model Mitsubishi RA 90).
(b) To discover the best approach and optimum condition to produce better results in terms of surface finish, sharp edge angle and dimensional accuracy using wire EDM machine (Model Mitsubishi RA 90).
(c) To diminish scrap due to failure of the workpiece to achieve the desired dimensional accuracy during the machining process

1.6 Outline of study

This report in total is about a study on the machining parameter needed to execute the best quality for a sharp edge at certain angle. Basically, this report is divided into 5 chapters which lead to different contents in each chapter. Chapter 1 give an account of narrate introduction and brief circumstances on the study that will be conducted. It is consist of background, problem statement, objective of study, scope and limitation, important of study and study outline. Next, chapter 2 is mainly about the literature review which will covers the definition of the term and converse about wire EDM

machine and other machines that will be used to carried out the results. This chapter also will intent explain on the functions, characteristics and operation of the machine used. On chapter 3, the outline on methodology of this study will be described where the operation method, types of material and optimum conditions are the main elements that will be determined in this chapter. Then, chapter 4 will affix all the findings gathered all the data into the tables while chapter 5 analyzed on the results obtained via graphs. Last but not least is chapter 6 will conclude all the observations and findings. This chapter also consists of recommendation as the suggestion to improve dimensional accuracy of the corner using wire EDM machine.

CHAPTER 2

LITERATURE REVIEW

In this literature review, the author will discusses published information in this study and evaluate the sources find by the author related to the study that the author wants to focus. In this chapter, all information of the Discharge Machining, EDM especially wire EDM machine is covered to give the ideas to the readers on what wire EDM is all about. The authors also gathers all the facts that related to this study to explain to the readers why this study is carried out and the briefly clarify the scope of this studies so that the readers can get the concept of this entire study.

2.1 Electrical Energy Processes

Evolution of the technology nowadays makes it possible to the enlargement of new harder metals but which cannot be economically machined by conventional methods. Besides that, more complex shape and very small tolerance demanded have led to difficulties in conventionally fabricating and machining varieties of shapes. Due to this reason, the author finds that it is a need to find a process that could produce a product more effectively with lower cost. The developments high heat resistant alloys as the tool material for machining is widely and frequently used in industrial field could cause a large capital investment to be produced. Thus, a new concept needs to be used to reduce the manufacturing cost of a product and improve the tool making techniques. These new needs have resulted in introduction of several new electrical machining concepts. Lascoe O. D., 1973 classified the electrical machining concepts into five main categories which are:

(a) **Electro-Discharge Machining (EDM)** (Figure: 2.1)**;** which removing the metal through the action of an electrical discharge of very short duration and high current density between electrode and the work.

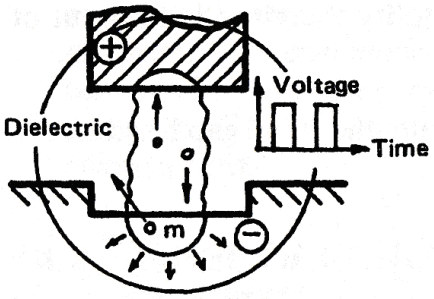

Figure 2.1: Schematic of Electro-Discharge Machining (EDM) (Lascoe O. D.,1973)

(b) **Electro-Chemical Machining (ECM)** (Figure: 2.2); which is an electrolysis process where electro-chemical reaction dissolves metal from a workpiece into an electrolyte solution.

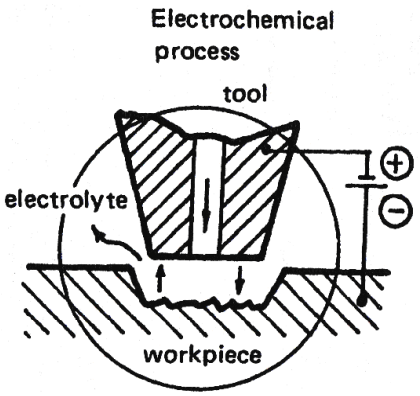

Figure 2.2: Schematic of Electro-Chemical Machining (ECM) (Lascoe O. D.,1973)

(c) **Ultrasonic Machining (USM)** (Figure: 2.3); which use high frequency mechanical vibration transmitted through a shaped tool to an abrasive grit to remove material.

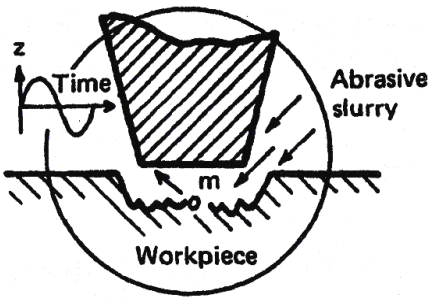

Figure 2.3: Schematic of Ultrasonic Machining (USM) (Lascoe O. D.,1973)

(d) **Magnetic Pulse Forming** (Figure: 2.4); which operates with precisely controlled electro-magnetic forces. The interaction of the magnetic field and the eddy current will create a uniform central force.

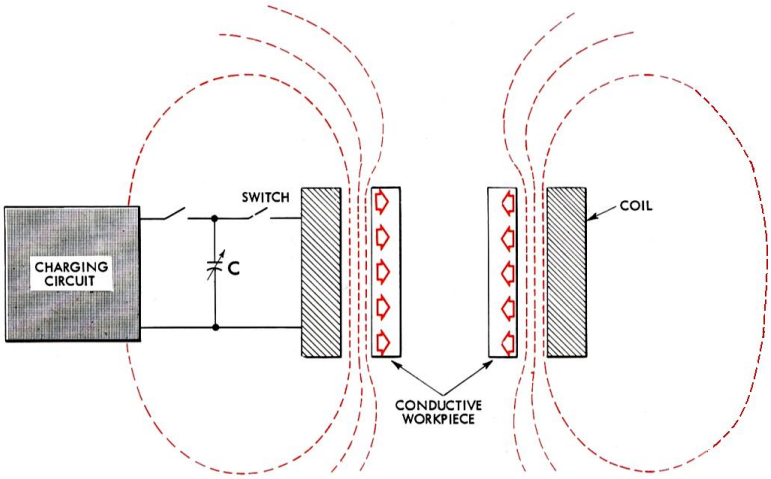

Figure 2.4: Schematic of Magnetic Pulse Forming (Lascoe O. D.,1973)

(e) **Electrolytic Grinding (EG)** (Figure: 2.5); which is a reverse or depleting method of grinding employing metal-bonded diamond wheels and electrolytic coolant supply.