UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ASSESSMENT OF WIRE EDM PARAMETERS ON ALUMINUM

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

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process). The member of the supervisory committee is as follow:

…….

Dr. Bagas Wardono

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ABSTRACT

The aim of this research is to study the affect parameter cutting of Wire Electrical Discharge Machine (WEDM) of surface roughness, tolerance and machining time for aluminum plates. The material use in this experiment is Aluminum 5083. For this assessment, the experiments were conducted on the Mitsubishi RA 90 wire electrical discharge machine. Design of Experiment (DOE) will be employed to determine the significance of the affecting parameters toward the response variables. The parameters studied include voltage gap, peak current, wire speed, and wire tension. The response variables investigated are the surface roughness, tolerance width and machining time. The surface roughness obtain is measured using Mitutoyo S-J 301, while the tolerance of the cutting is measured by micrometer. The roughness profile used in this study is roughness average, (Ra). The significance of the study is to achieve the desirable surface roughness and the resulting tolerance after cutting by wire EDM is done on the workpiece. A better surface roughness can improve the quality and the value of the component produced in the manufacturing industry.

ABSTRAK

Tujuan kajian ini dijalankan adalah untuk mengkaji kesan pemotongan pada kekasaran permukaan logam aluminium, had terima dan masa pemesinan pada parameter yang berlainan menggunakan mesin Wire EDM. Bahan kerja yang digunakan dalam eksperimen ini ialah Aluminum 5083. Untuk menjalankan kajian ini, eksperimen akan di jalankan menggunakan mesin Wire EDM dari jenis Mitsubishi RA 90. Di dalam eksperimen ini, kaedah *Design of Experiment* atau DOE akan digunakan untuk menentukan kepentingan parameter mesin terhadap tindak balas pembolehubah yang berbeza-beza. Parameter yang akan digunakan untuk eksperimen ini termasuklah jurang voltan, arus puncak, kelajuan dawai, dan ketegangan dawai. Kesan tindak balas yang akan dikaji daripada eksperimen ini ialah kekasaran purata pada bahan kerja, had terima lebar bahan kajian dan masa yang diambil untuk pemesinan. Parameter kekasaran yang diukur adalah kekasaran purata (Ra). Kepentingan kajian adalah untuk mengkaji kekasaran permukaan, had terima pemotongan dan masa pemesinan yang lebih baik selepas bahan kerja dipotong menggunakan mesin Wire EDM. Kekasaran permukaan yang lebih baik dapat memperbaiki kualiti dan nilai produk yang dikeluarkan dalam industri pembuatan.

DEDICATION

Specially dedicated to my dearest mum, dad, brother and sister for their love and constant support and also all my friends. Thank you very much for your continuous support and effort towards the publication of this thesis.

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LIST OF ABBREVIATIONS

EDM	-	Electrical Discharge Machining
DOE	-	Design of Experiment
CNC	-	Computer Numerical Controller
UTeM	-	Universiti Teknikal Malaysia Melaka
WEDM	-	Wire Electrical Discharge Machining
AL	-	Aluminum 5083
ANSI	-	American National Standard Institute
Ra	-	Roughness Average
AA	-	Arithmetic Average
CLA	-	Center Line Average
ANOVA	-	Analysis of variance
OA	-	Orthogonal Array
Ravg	-	Roughness Average
Tavg	-	Tolerance Average

CHAPTER I

INTRODUCTION

Electrical Discharge Machining (or EDM) is a machining technique primarily used for hard metals or those that would be impossible to machine with traditional techniques. One critical restriction, however, is that EDM only works with materials that are electrically conductive, and generally those materials are ferrous alloys. EDM can cut intricate contours or cavities in pre-hardened steel, small or odd-shaped angles without the need for heat treatment to soften and re-harden them as well as exotic metals for example hastalloy, kovar, titanium, and inconel [1].

Occasionally referred to as spark machining or spark eroding, EDM is a non-traditional method of removing material by a series of rapidly recurring electric arcing discharges between an electrode (the cutting tool) and the workpiece, in the presence of an energetic electric field. Following sparks produce a series of micro-craters on the work piece and remove material along the cutting path by melting and vaporization. The EDM cutting tool is guided along the desired path very close to the work but it does not touch the piece. The particles are washed away by the continuously flushing dielectric fluid. It is also significant to note that a similar micro-crater is formed on the surface of the electrode, the debris from which must also be flushed away. These micro-craters result in the gradual erosion of the electrode, many times necessitating several different electrodes of varying tolerances to be used, or, in the case of wire EDM machining, constant replacement of the wire by feeding from a spool [1].

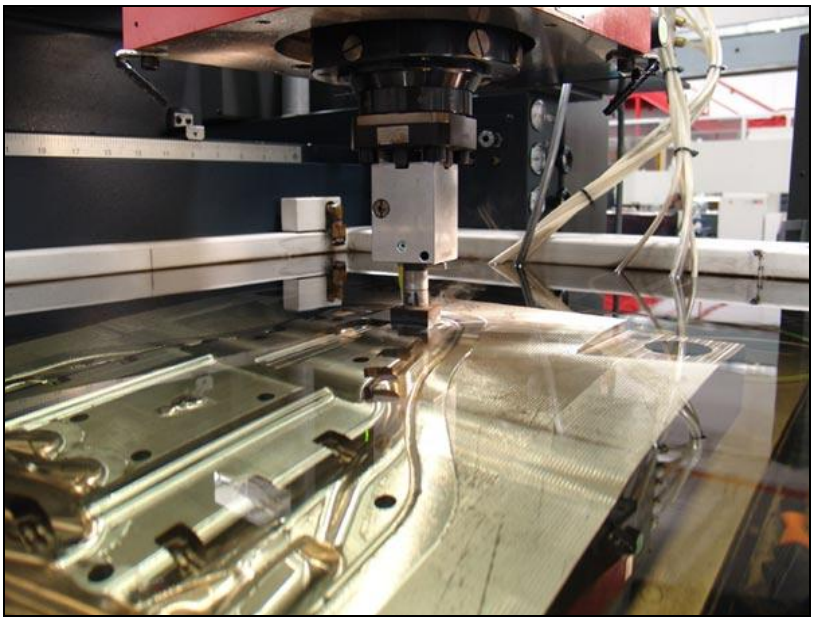

Figure 1.1: Electrical Discharge Machine [1].

There are two main types of EDM machines: Sinker EDM (also called Conventional EDM and Ram EDM) and Wire EDM.

For this assessment, a wire EDM machine is use for cutting a material. With using a wire EDM, the analysis from the surface roughness, tolerance and machining time response result can be obtained. Surface roughness includes of fine irregularities in the surface texture, usually including those resulting from the inherent action of the production process.

In this assessment, the parameter cutting using wire EDM machine includes, voltage gap (VG), peak current (IP), wire speed (WS), and wire tension (WT). Different of machining parameters will affect of the surface roughness, tolerance and machining time.

1.1 Problem Statement

Previous studies have shown that the surface integrity of the material processed by wire EDM is affected by the combination of the affecting parameter. The investigation of this experiment is to determine the effect of machining parameters like a voltage gap (VG), peak current (IP), wire speed (WS), and wire tension (WT). The effect of surface roughness we can know after get a good setting parameter on aluminum work piece. The analysis we can make and can find out the parameter affecting the surface roughness. From the experiment, we can know a good setting parameter for making cutting process by EDM wire cut on aluminum. The suitable parameter for cutting workpiece is depending to metal characteristic. In this experiment, the problem comes is how to setting a low and high parameter in four parameter before make a cutting by wire EDM. The trial of this experiment is 16 trial before complete the experiment and can became problem to investigator to get a good selection of parameter. So, the Design of Experiment (DOE) is important to help an investigator to solve problem of how to setting a parameter.

1.2 Objectives

The objectives of the study of Wire EDM cutting on Aluminum are:

- To gain basic knowledge on advance machining especially Wire Electrical Discharge Machine (WEDM) at CNC lab in UTeM.
- To know basic principles of Wire EDM.
- To determine basic machining characteristic of wire EDM.
- To determine the optimum parameter involves in wire EDM machining.
- To apply statistical analysis of experiment (DOE) using suitable designs method to select the best parameter combination.
- To evaluate surface roughness, tolerance and machining time of workpiece (aluminum) upon cutting using wire EDM.

1.3 Scope

The scope of this project is to investigate affecting parameter of wire EDM on Aluminum 5083, in terms of the surface roughness, tolerances of the cutting and machining time. The parameter studied includes voltage gap (VG), peak current (IP), wire speed (WS), and wire tension (WT). The response variables investigated are the surface roughness, cutting tolerance and machining time. The surface roughness obtain is measured using Mitutoyo S-J 301, while the tolerance of the cutting is measured by micrometer. The machining time response is taking a time from start until finish machining for each samples of 16 runs. To analyze the results, a statistical approach, namely Design of Experiment (DOE) will be employed to determine the significance of the affecting parameters toward the response variables.

1.4 Importance of the Study

The importance of the study is to achieve the desirable surface roughness and the resulting tolerance after cutting by wire EDM is done on the workpiece. A better surface roughness can improve the quality and the value of the component produced in the manufacturing industry. A good surface finish can be obtained when the optimum parameters of cutting EDM is achieved.

CHAPTER 2
LITERATURE REVIEW

Many of the studies that had been conducted before on the cutting process mainly focuses on parameters such as the voltage gap, peak current, wire speed and wire tension. The main objectives include the study on surface roughness. In the following sections, a brief discussion on EDM and related topics are presented. Several results of previous study are also presented.

2.1 Introduction of EDM Machine

2.1.1 EDM (Sinker EDM)

In the Sinker EDM, it consists of an electrode and workpiece that are submerged in an insulating liquid such as oil. The electrode and workpiece are connected to a suitable power supply. The power supply generates an electrical potential between the two parts. As the electrode approaches the workpiece, dielectric breakdown occurs in the fluid, and a small spark jumps. The resulting heat and cavitation vaporize the base material, and to some extent, the electrode. These sparks strike one at a time in huge numbers at seemingly random locations across the electrode. As the base metal is eroded, and the spark gap subsequently increased, the electrode is lowered automatically by the machine so that the process can continue uninterrupted. Several hundred thousand sparks occur per second in this process, with the actual duty cycle being carefully controlled by the setup parameters. The typical part geometry is to cut small or odd shaped angles.

Vertical, orbital, vectorial, directional, helical, conical, rotational, spin and indexing machining cycles are also used. The typical work materials are ferrous alloys [1].

Figure 2.1: EDM die sinker.

2.1.2 Wire EDM

Wire electrical discharge machining (WEDM) is a specific thermal machining process capable of accurately machining parts with varying hardness or complex shapes, which have sharp edges that are very difficult to be machined by the main stream machining processes. This practical technology of the WEDM process is based on the conventional EDM sparking phenomenon utilizing the widely accepted non-contact technique of material removal. Since the introduction of the process, WEDM has evolved from a simple means of making tools and dies to the best alternative of producing micro-scale parts with the highest degree of dimensional accuracy and surface finish quality [2].

Over the years, the WEDM process has remained as a competitive and economical machining option fulfilling the demanding machining requirements imposed by the short product development cycles and the growing cost pressures. However, the risk of wire breakage and bending has undermined the full potential of the process drastically reducing the efficiency and accuracy of the WEDM operation [2].

Figure 2.2: Wire EDM Machine.

Wire EDM is used to cut shapes through a selected conductive part or assembly. After the part has a hole drilled into it, the thin wire, which is used as the electrode, is fed through the hole in order to complete the machining. Because there is no physical contact between the machined part and the wire, the hardness of the work piece has no effect on cutting speed. The wire is surrounded by de-ionized water and is charged rapidly to a voltage. Once it is at the right level, a spark will jump from the wire to the work piece, melting a small part of it. The water then flushes away the particles in the gap and cools the piece.

Wire EDM is extremely accurate (up to +/-.0001”), so it is commonly used for high tolerances. In addition to hard materials, wire EDM is a solution for delicate parts because there are no cutting forces used and, in turn, there is a lesser chance of damaging the parts. Since there are no burrs created in the process, no tooling is required after the forming of the piece, making delivery times fast. Wire EDM is performed after the piece has been heat-treated so that heat does not distort the dimensional accuracy.

Difficult shapes are often formed by wire EDM. Both simple and complex two-dimensional shapes can be created with cutouts, thin walls, tight radius contours and intricate openings. Wire EDM has been used for production processes including mold-

making and can also be used for form tools. Parts smaller than a penny to parts as large as molds for hard hats can all be made through wire EDM.

2.1.2.1 Wire of EDM (Electrode)

A variation of EDM is wire EDM or electrically discharge wire cutting. In this process, which is similar to contour cutting with a band saw, a slowly moving wire travels along prescribed path, cutting the work piece.

The wire usually is made of brass, copper, tungsten, or molybdenum; zinc-or brass coated and multi-coated wires also are used. The wire diameter is typically about 0.30 mm for roughing cut and 0.20 for finishing cuts. The wire should have high electrical conductivity and tensile strength, as the tension on it is typically 60% of its tensile strength.

The wire usually is used only once, as it is relatively inexpensive compared to type of operation it performs. It travel at a constant velocity in the range of 0.15 to 9 m/min, and a constant gap (kerf) is maintained during the cut. The trend in the use of dielectric fluids is toward clear, low-viscosity fluids [3].