SURFACE INTEGRITY OF MILD STEEL IN WIRE ELECTRICAL DISCHARGE MACHINING

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

Signature
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Date:

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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I humbly dedicate this thesis to

my lovely mom and dad, Musalmah Bt Ibrahim and Kamari Bin Ahmad
my lecturers and friends
who always trust me, love me and had been a great source of support and motivation.

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ABSTRACT

This project deals with machining Mild Steel work piece using Wire Electric Discharge Machine (WEDM). The objective of the project is to determine the surface integrity of material when machining with different parameters. In this particular project, five parameters are being used which are on time, off time, peak current, servo voltage and wire speeds. From the experiment, the surface roughness was measured using perthometer. The machining of Mild Steel work piece was performs using Wire-EDM Sodick AQ535L. Then, the analysis was done using the Statistica software. By doing this project using WEDM for mild steel AISI 1020, it will aid people to estimate the surface roughness for selected parameters and avoid using try and error method. From the analysis, on time and peak current are the significance parameters to the mild steel's surface roughness. The lower value of on time and peak current used,, the result for surface roughness are better. By considers all of these parameters, the good machining condition can be performed.

ABSTRAK

Projek ini membahas pemesinan *Mild Steel* menggunakan *Wire Electric Discharge Machine (WEDM)*. Tujuan dari projek ini adalah untuk menentukan integriti permukaan material ketika pemesinan dengan parameter yang berbeza. Dalam projek ini, lima parameter yang digunakan yang tepat waktu, waktu rehat, puncak arus, voltan servo dan kelajuan kawat. Dari percubaan, kekasaran permukaan diukur dengan menggunakan perthometer. Pemesinan Mild Steel dilakukan dengan menggunakan Wire-EDM Sodick AQ535L. Kemudian, analisis dilakukan dengan menggunakan perisian Statistica. Dengan melakukan projek ini menggunakan WEDM untuk *Mild Steel*, itu akan membantu orang untuk mengestimasi parameter kekasaran permukaan untuk dipilih dan mengelakkan penggunaan kaedah error. Analisis meunujukkan parameter yang dapat memberi kesan tertinggi kepada permukaan *Mild Steel* ialah *on time* dan *peak current*. Nilai *on time* dan *peak current* yang rendah dapat memberi kesan kekasaran permukaan yang lebih baik Dengan mempertimbangkan semua parameter, keadaan pemesinan yang baik dapat dilakukan.

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

According to Huang J.T. et al. (1997) wire electrical discharge machining (WEDM) plays an important role in precision manufacturing. Since the introduction of CNC wire electrical discharge machining (wire-EDM) machines to the market in the 1970s, the continuous development of machinery, CNC system, power supply, wire electrodes and process technology have enabled the wire-EDM process to be widely applied not only in tool and die-making industry, but also in the fields of medicine, electronics and the automotive industry. The profiting with wire-EDM is its ability to precisely produce intricate shapes and varying tapers in all electrically conductive materials irrespective of their hardness and toughness. Furthermore, wire-EDM is capable of producing a fine, precise, corrosion-resistant and wear resistant surface (Mu-Tian Yan et al., 2007). The machine used in this study is Wire-EDM Sodick AQ535L machine and material used is a mild steel with ASTM grade is 1020 steel. This study is to investigate surface integrity of mild steel in Electrical-discharge machining.

1.2 IMPORTANCE OF RESEARCH

i) Determine the specific parameter that might be major factor of defect during cutting by WEDM.

ii) Enhance the quality surface finish of cutting material by Wire Electrical discharge machine (WEDM)

iii) Analyzing the effects and behaviors of mild steel in application of WEDM machine under various parameters machining.

1.3 PROBLEM STATEMENT

Wire electrical discharge machining (WEDM) is a specialised 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. The innovations of WEDM have been largely improved progress in recent years owing to the requirements in various manufacturing fields, especially in the precision die industry. But there is limitation in every progress of WEDM that we could observe:

i) Cause cracks during superfine machining by WEDM
ii) Decreasing number of grains and increase micro cracks
iii) It 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

1.4 OBJECTIVE OF RESEARCH

There are several main objectives occurred in this project are stated below:

1) Finding the optimum parameter of Wire EDM machine to find quality surface finish on the surface of mild steel work piece
2) Determine the surface roughness of mild steel when perform on various parameters machining
3) Measure the significance parameters for the machining process to the materials

1.5 SCOPE OF PROJECT

The scope for this project is based on the previous objective, in evaluate the microstructure defect of the mild steel and determine the surface integrity that was investigated in this experiment was surface roughness using the perthometer machine. We have to decrease the defects and surface roughness of the surface work piece, and then the parameter of machining process should be control. The parameter of machining process are peak current, voltage, frequency, the arch gap and on-time duration, by setting the one of the parameter and holding the other parameter constant, it can determine the major factor of parameter that influence the defect on the surface work piece. From that, the optimum parameter also can determine.

1.6 PROJECT FLOW CHART

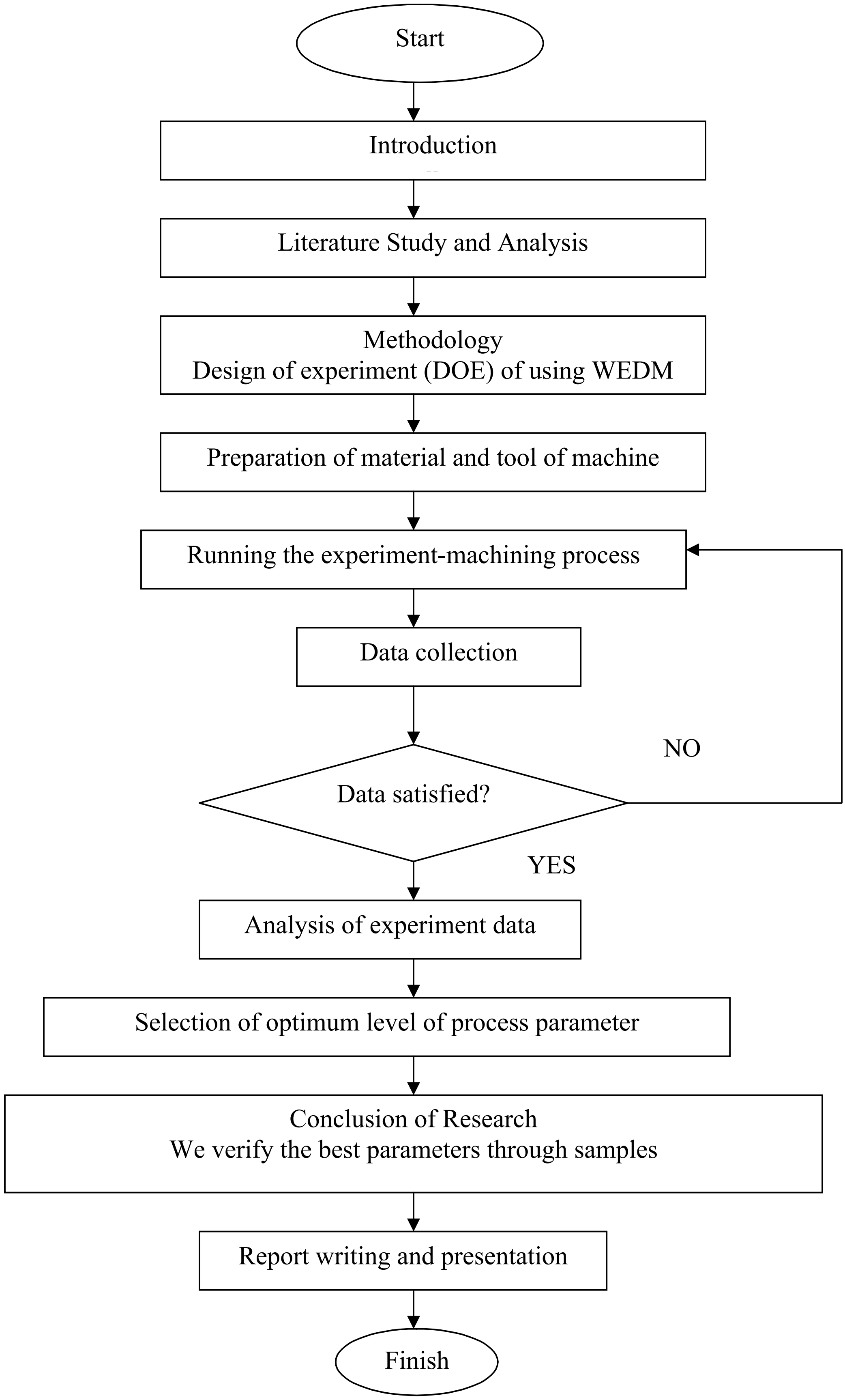

Figure 1.1: Flow Chart of Project

CHAPTER 2

LITERATURE STUDY

2.1 INTRODUCTION

Surface Integrity is define the inherent or enhanced condition of a surface produce in machining or other surface generation operation. Their subsequent comprehensive review of surface integrity issues that are encountered in machined components was among the first the first in the published literature. The term surface integrity is used to describe the quality and condition of the surface region of a component. The combination of stress and elevated temperatures generated during machining can lead to defects, or alterations of the microstructure, micro hardness, cause surface cracking, craters, folds, inclusions, plastic deformation and residual stresses in the finished part (Davim J.P 2010).

In general, surface integrity can be divided into two aspects: the external topography of surfaces (surface finish); and the microstructure, mechanical properties and residual stresses of internal subsurface layers (Brian J.G.2001). Performance characteristics that are usually sensitive to surface integrity include; fatigue strength, fracture strength, corrosion rate, and tribological behavior (such as friction, wear and lubrication, and dimensional accuracy).

In order to specify and produce surfaces free from damage it is necessary to understand how metallurgy, machines ability, and mechanical testing interrelate. These interrelations make up what is now universally known as surface integrity. The study of surface integrity is concerned with all those alterations that may occur in a surface layer in the course of manufacture, as well as with their effects on the properties of the material and on the behavior of the surface under working conditions. One then seeks surface integrity by judiciously selecting the manufacturing processes, by predicting their effects on the significant characteristics of the work material, and by moderating them as required (Davim J.P 2010).

Surface integrity entails the study and control of surface topography, as well as of surface metallurgy. Both factors affect the quality of the surface and sub-surface machined, and become extremely significant in the manufacture of structural components that will have to withstand high dynamic and static stresses. For example, when dynamic load is one of the main factors in design, the useful strength is in many cases limited by the fatigue characteristics of the materials. Faults owing to fatigue originate nearly always at or close to the surface of a component. Stress corrosion is likewise a surface phenomenon. Hence the nature of the surface, from the point of view of topography and of metallurgy, is important in the design and production of critical components. The following are general definition of the major surface defects on the process EDM (Davim J.P 2010):

i) Crack may be external or internal; cracks that require a magnification of 10X or higher to be seen by the naked eye are called micro cracks.
ii) Craters are shallow depressions.
iii) Metallurgical transformation involve micro structural changes caused by temperature cycling the material; these may consist of phase transformations, recrystallization, alloy depletion, decarburization, and molten and then recast, resolidified, or redeposited material

2.2 WIRE ELECTRICAL DISCHARGE MACHINE

Wire Electrical Discharge Machine (WEDM) is a discharge machine that use CNC movement to produce the desired contour or shape. It doesn't require a special shaped electrode; instead it uses a continuous-traveling wire under tension as the electrode (Steve F.K et al., 2003). The wire electrical discharge machining (WEDM), also known as wire-cut EDM and wire cutting a thin single-strand metal wire, usually brass, is fed through the work piece, submerged in a tank of dielectric fluid, typically deionizer water The EDM process was invented by two Russian scientists, Dr. B.R. Lazarenko and Dr. N.I. Lazarenko in 1943 according to E.M. Levinson In et al 1964. Agie launches in 1969 the world's first numerically controlled wire-cut EDM machine .Seibu developed the world first CNC wire EDM machine 1972 and the first system manufactured in Japan. Material is removed from the work piece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage. One of the electrodes is called the tool-electrode, or simply the 'tool' or 'electrode', while the other is called the work piece-electrode, or 'work piece'.

Wire electrical discharge machining (wire-EDM) is a widely accepted non-traditional material removal process in tool and mold industry because of its excellence in precisely produce intricate shapes and varying tapers in all electrically conductive materials irrespective of their hardness and toughness. Since deionized water is used as a dielectric liquid and previous wire electrode has a negative polarity in previous wire-EDM direct current passing through water causes ions to react chemically with the machined part and an electrolytic effect increases the chemical erosion effect of the water dielectric. The occurrence of the recast layer is unavoidable and critical, since surface quality degeneration directly affects fatigue strength, surface roughness, surface integrity and premature failure of the machined part (Mu-Tian Yan et al., 2009).

In order to reduce the recast layer and the electrolytic and corrosive effect as well as obtain better surface quality, some machine tool builders have been devoting their effort in developing new pulse generators using water dielectrics and anti-electrolysis circuitry previous Wire-EDM term machines equipped with multi-generators have also been presented to supply high energy to the machining gap during roughing and lower energy for finish machining while connecting the previous term wire next term electrode to the positive pole. A new high-frequency AC power supply using intermittent waveform circuit haspresented to reduce electrostatic force during machining as well as achieve super-fine surface of 0.3–0.5 μm Rz and machining accuracy of 1–2 μm. A study has shown that a discharge current with short pulse duration and high peak value can generate better surface roughness, which cannot be achieved with a discharge current with long pulse duration and low peak value (Mu-Tian Yan et al., 2009).

An envelope of feasible wire EDM process parameters is identified for each work-material. This envelope can be applied to setup the EDM process for efficient, high MRR machining. A rough surface with a thick recast layer is usually generated in high MRR EDM. Another application of the wire EDM envelope is the selection of process parameters for slow, low MRR EDM cutting to generate better surface roughness and enable the machining of micro-features. The setup of the wire EDM machine and experimental procedure are first discussed. Work-materials investigated in this study are introduced. Experimental and regression modeling results as well as envelopes of feasible EDM process for different work-materials are then presented (Jain V.K.2002).

2.3 EQUIPMENT

2.3.1 Type of Tools

WEDM utilizes a continuously traveling wire electrode made of thin copper, brass or tungsten of diameter 0.05–0.3 mm, which is capable of achieving very small corner radii. The WEDM cutting tools is follow as Figure 1:

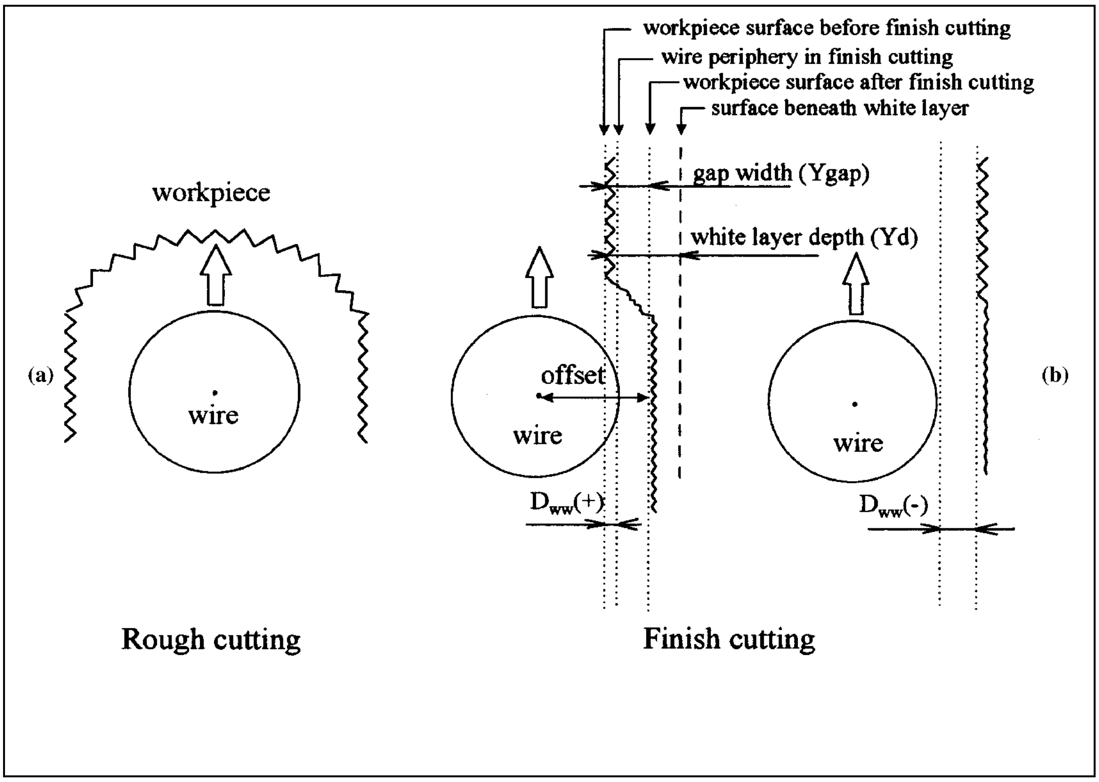

Figure 2.1: A schematic plan view; (a) rough and (b) finish, cutting of WEDM

Source : Huang J.T. (1997)

2.4 MILD STEEL

Mild steel is a type of steel alloy that contains a high amount of carbon as a major constituent. An alloy is a mixture of metals and non-metals, designed to have specific properties. Alloys make it possible to compensate for the shortcomings of a pure metal by adding other elements. To get what mild steel is, one must know what the alloys that are combined to make steel are. So, let us see what we mean by steel, which will help us in understanding what mild steel is and also in understanding the properties of mild steel (P.J Blau et al., 2003).

2.5 PARAMETER INVOLVES

The selection of EDM parameters is important in determines the accuracy and surface finish obtained for a particular application. Parameters are manually selected on most EDM systems, although some recently available systems use CNC units or programmable controller to adjust and match parameters for various applications. There are parameters that have been discovered:

2.5.1 On time

The duration of time (μs) the current is allowed to flow per-cycle. The higher value is input for “On time”, the electrical discharge energy become larger, machining may be made quickly. However, the discharging gap is widened and may result in poor surface roughness or wire breakage. Material removal is directly proportional to the amount of energy applied during this on-time. This energy is really controlled by the peak current and the length of the on-time.

2.5.2 Off time

It is the duration of time (µs) between the sparks. This time allows the molten material to solidify and to be wash out of the arc gap. This parameter affected the speed and the stability of the cut. Thus, if the off time is to short, it will cause sparks to be unstable.

2.5.3 Peak Current

Increasing spark frequency and holding all the parameters constant, results in a decrease in surface roughness. This is because the energy available for material removal during a given period is shared by a larger number of sparks; hence the corresponding crater size is reduced. The frequency capability of WEDM machines ranges from a low of 180 Hz when performing roughing cuts, to a high several hundred kilohertz when generating the fine finishes required for finishing cut.

2.5.4 Servo Voltage

Servo Voltage (SV) is used to controlling advances and retracts of the wire. During machining, the mean machining voltage varies depending on the state of machining between the work piece and the electrode. SV established the reference voltage for controlling advances and retracts of the wire.

SV can be value ranging from 0 to 255. The higher the value is, the wider the gap between the work piece and the electrode becomes. A higher value for SV also decreases the number of electrical sparks, stabilizing electric discharge, although the machining rate is slowed down. When a smaller value is set for SV, the mean gap becomes narrower, which leads to an increase in number of electric sparks. It can speed up the machining rate; however the state of machining at the gap may become unstable, resulting wire breakage

2.4.5 Wire Speeds

The distance between the wire and the work piece also called spark gap. The spark gap is determined by the spark voltage and current. Typical values for the gap range from 0.012 to 0.050mm (0.0005 to 0.002 in). The smaller gap and close accuracy with a better finish and slower material removal rate.

The range for Wire Speeds (WS) is 0~255. WS is controls wire speeds. The value when WS= 100, the wire speeds is 10m/min. When the value of WS= 150, the wire speeds is 15m/min (Sodick Manual, 2000).