UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ASSESSMENT OF WIRE EDM PARAMETERS ON STAINLESS STEEL

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

by

MOHD FITRI BIN JAMALUDIN

FACULTY OF MANUFACTURING ENGINEERING

2009

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PSM

TAJUK:

"ASSESSMENT OF WIRE EDM PARAMETERS ON STAINLESS STEEL"

SESI PENGAJIAN:
2008/2009 Semester 2

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N04, JALAN PERDANA 4/7,
TAMAN PUCHONG PERDANA,
47100 PUCHONG,
SELANGOR.

Tarikh: 14/05/09

Cop Rasmi:
DR. BAGAS WARDONO
Pensyarah Kanan
Fakulti Kejuruteraan Pembuatan
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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 (*Faculty of Manufacturing Engineering*). The members of the supervisory committee are as follow:

DR BAGAS WARDONO

(Main Supervisor)

10 APRIL 2009

ABSTRACT

The optimum selection of manufacturing conditions is very important in manufacturing processes. This research presents the surface roughness, tolerance and machining time analysis using a wire cut machine Mitsubishi Ra 90 series. The materials used are stainless steel 304. This research is mainly focused on aspects related to surface quality, tolerance and machining time, which are one of the most important parameters form the point of view of selecting the optimum condition of process. The investigated machining parameters were voltage gap, peak current, wire tension and wire speed. Design of Experiment method analysis was used to find out the parameters affecting surface roughness, tolerance and machining time. The surface roughness of the sample has been measured by using Profilometer SJ-301 tester, tolerance measurement will be performed using micrometer and machining time will be taken using digital watch.

ABSTRAK

Pemilihan optimum terhadap keadaan pengeluaran adalah sangat penting didalam proses pembuatan. Kajian ini merangkumi analisis terhadap permukaan selepas pemesianan, had terima dan masa pemotongan dengan menggunakan mesin Mitubishi Ra 90 series. Bahan kerja yang digunakan adalah stainless steel 304. Kajian ini kebanyakkannya tertumpu pada aspek yang berkaitan dengan kualiti permukaan, had terima dan masa pemotongan dimana adalah salah satu daripada parameter yang penting dalam membentuk sudut pandangan pemilihan keadaan proses yang optimum. Parameter pemesinan yang dikaji adalah jarak voltan, arus puncak, ketegangan wayar dan kelajuan wayar. Kaedah analisis rekabentuk eksperimen digunakan untuk mengetahui parameter yang mempengaruhi permukaan selepas pemesinan, had terima dan masa pemesinan. Permukaan selepas pemesinan akan diukur menggunakan Profilometer SJ-301, had terima diukur menggunakan micrometer dan masa pemotongan diambil menggunakan jam digital.

DEDICATION

This is my special dedication to my parent En. Jamaludin Bin Rejab and Pn.Hamidah Binti Hamidon for their support for my study at UTeM. Also thanks to my PSM Supervisor, Dr. Bagas Wardono for guide me for this project and I'll not forget my entire classmate and lecture for help me so much. Thank you

ACKNOWLEDGEMENT

Alhamdulillah, thank to Allah the Almighty God for giving me strength and patience to work on this Final Year Project Report.

I would like to take this opportunity to express my sincere and deepest gratitude to my Project Supervisor; Dr. Bagas Wardono for his guidance and opinion in the cause of completing this report.

My greatest thanks to my beloved family for their prayers, support, and encouragement to me for throughout this entire period of these Final Year Project 1 and 2. I would like to thanks, Dean of Faculty of Manufacturing Engineering, University Technical Malaysia, Melaka, my academic supervisor, and to all the lectures in the faculty.

I also would like to convey my biggest thanks to all FKP technicians for supporting me throughout my project especially Mr. Khairul Affendi. The knowledge and experience I gained from you all will not be forgotten.

I'm also obliged to everyone who had directly and indirectly involve through contributions of ideas, as well as materials and professional opinions.

Last but not least, all my friends out there for their moral support and valuable help that they have provided me throughout my project.

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LIST OF ABBREVIATIONS

EDM	-	Electrical Discharge Machining
WEDM	-	Wire Electrical Discharge Machining
CNC	-	Computer Numerical Control
AT	-	Automatic Wire Threading
DOE	-	Design of Experiment
ANOVA	-	Analysis of Variance
SEM	-	Scanning Electron Microscope
EDS	-	Energy Dispersive Spectrometer

CHAPTER 1
INTRODUCTION

Electrical Discharge Machining, EDM is one of the most accurate manufacturing processes available for creating complex or simple shapes and geometries within parts and assemblies. The main limitation of EDM is that it can only cut materials that are electrically conductive**.** The EDM process is commonly used in the tool and dies industry for mold-making, however in recent years EDM has become an integral part for making prototype and production parts**.**

There are two types of EDM processes, namely wire and die sinker. Wire EDM uses a metal wire as the tool electrode. It can generate two or three dimensional shapes on the workpiece for making punch dies and other mechanical parts. Die sinker are generally used for complex geometries where the EDM machine uses a machined graphite or copper electrode to erode the desired shape into the part or assembly.

In this research, wire EDM is chosen for improvement the performance in industries. The research for WEDM remains going on because of shortage information about WEDM machining. The most important performance measures in wire EDM are surface finish and tolerance.

1.1 Project Background

Wire Electrical Discharge Machining (WEDM) is used primarily for cutting shapes through a selected part and assembly. A very thin moving wire serves as the electrode to cut the material that follows a programmed path. WEDM making tools and dies with the highest degree of dimensional accuracy and surface finish quality.

Surface roughness is one of important thing in manufacturing when the product has completed WEDM process. Various investigation and experiment have been made to further improvement the surface roughness in WEDM. The main focus for this research is to determine the dependency of the surface roughness and tolerance obtained on the machining parameters. The material used in this project is stainless steel and an experiment with WEDM will be performed using different parameters.

WEDM is a high cost machining because it required parameters to be set correctly to get a good surface roughness. WEDM can provide a good accuracy and surface quality as compared with other machining process. The WEDM has become a mature technology but the researches and improvement of the process are still going on especially in surface roughness.

1.2 Problem Statement

WEDM is a rapidly-growing machining method used for high-precision metallic cutting of hard materials. The published papers available now do not provide specific parameter setting and material for various machining conditions. Since WEDM is used in industries, the machining parameters need to be set for optimum machining with the knowledge of the effect of the machining parameters on the surface roughness of the process, as a result of the experimental study.

In this study, the influence of voltage gap, peak current, wire speed and wire tension on main cutting force component is investigated.

1.3 Objective

The main objectives of this study are as the following:-

- To gain basic knowledge on WEDM machining.
- To know basic principle of WEDM machine.
- To study the importance of WEDM parameter in machining process.
- To investigate the WEDM parameter towards the result in term of surface roughness and the resulting tolerance.
- To implement design of experiment (DOE) in order to determine the significant of the parameters studied.

1.4 Scope

The main focus of this project is study WEDM process on stainless steel which will cover four parameters on cutting condition and analyze the surface roughness, resulting tolerance and time machining. The parameter considered includes the peak current, voltage gap, wire tension and wire speed. For the cutting tool, the material used is brass wire 0.25mm and the thickness of material is 5mm.

CHAPTER 2
LITERATURE RIVIEW

A literature review was conducted to gain knowledge about the wire EDM and previous researches related with this study. The following sections present discussions on topics related with WEDM process, such as the concept of WEDM technology, the machining parameters, and the material used. At the end of the chapter, several results of previous study are presented.

2.1 WEDM Process

WEDM process is similar with contour cutting using a band saw, except that a slowly moving wire travels along a prescribed path, cutting the workpiece. The wire-cut process uses water as its dielectric with the water's resistivity and other electrical properties carefully controlled by filters and de-ionizer units. The water also serves the very critical purpose of flushing the cut debris away from the cutting zone. Flushing is an important determining factor in the maximum feed rate available in a given material thickness, and poor flushing situations necessitate the reduction of the feed rate.

WEDM is a process for eroding and removing material using the heat created by a transient action of electric sparks between electrically conductive materials. This process is achieved by applying consecutive spark discharges between a workpiece and an electrode immersed in a dielectric liquid and separated by a small gap. Eroded particles are then flushed away by the dielectric fluid. The result of this process is that each discharge leaves a small crater on both the workpiece and the electrode. This crater affects final surface quality [1].

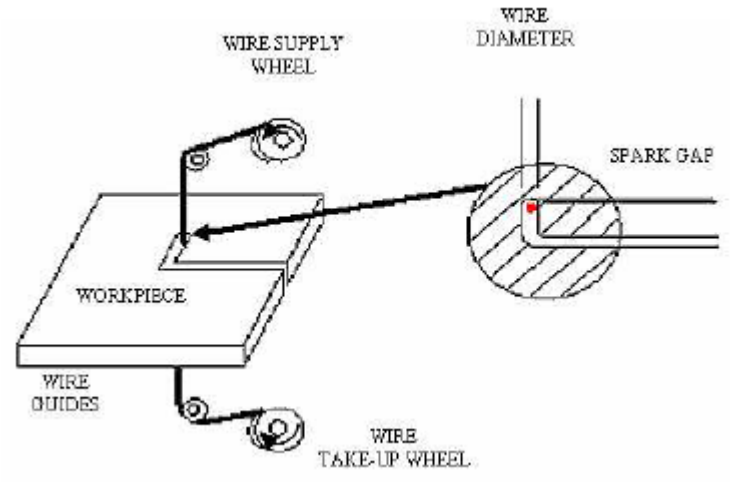

Figure 2.1: WEDM process [13].

2.1.1 Wire EDM

Wire is an important component in WEDM machining. EDM wire is used as electrode to generate spark erosion between the wire and the workpiece. The wire is usually made of brass, cooper, tungsten, or molybdenum. The wire diameter is typically about 0.30 mm for roughing cuts and 0.20 mm for finishing cuts. The wire is electrically charged at very high voltage and cut the material. The wire passes from one spool to another and is guided by an upper and lower guide as it cuts.

Brass wire was the first engineered wire for WEDM. These brass manufacturers discovered that the addition of zinc (zinc + copper = brass) improved cutting performance and speed when compared to the copper in several ways. During the cutting process, the zinc in the brass wire actually boils off, which helps cool the wire and delivers more usable energy to the work zone. Brass wire is available in different strengths and properties, including elongation, electrical conductivity and alloy mixture. Zinc-coated wires are available with copper or brass cores.

Brass wire is available in different tensile strengths and properties, including:

- **Elongation**: amount of stretch before breaking
- **Electrical Conductivity**: rated as a percentage of copper, which is rated at 100
- **Alloy Mixture**: some brass wires also include small amounts of other metals such as aluminum or magnesium to improve tensile strength or performance [2].

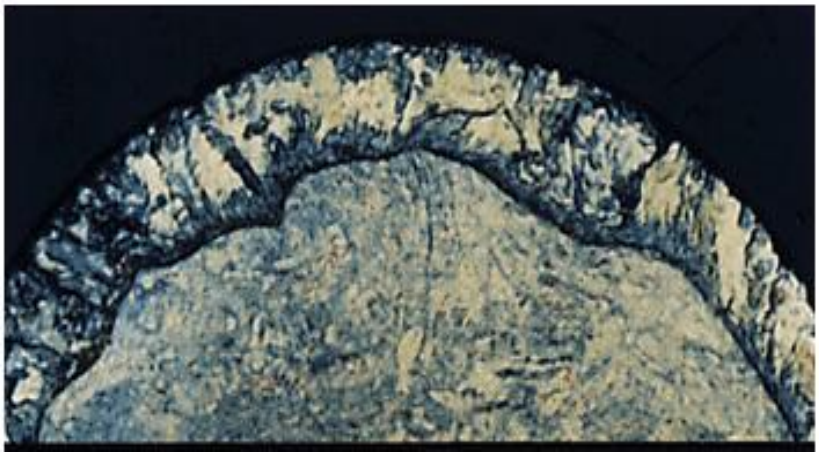

Figure 2.2: Zinc Coated EDM wire [2].

2.1.2 Spark Generator

One of the central elements of any spark erosion machine is the generator, which supplies the necessary working energy. The spark generator has the function voltage values with the relevant waveforms required for the erosion process and controls the erosion gap. It is extremely important for the gap between the wheel electrode and the workpiece to be kept constant. In order to achieve the required surface finish values, the gap should be kept as small as possible. Currently, the computer-aided spark generators are used to control the spark.

Wire cut sparking occurs between the side and machined surfaces of the workpiece. Spark length is set by the machine controls. The sparking area consists of only the front 180º of the electrode diameter as it progresses into the cut. A clearance equal to the spark length is machined on each side of the wire electrode. This side clearance is the spark overcut. The total width of the machined opening consists of the electrode diameter, plus two times the spark length. The total width of the machined opening is the kerf [3].

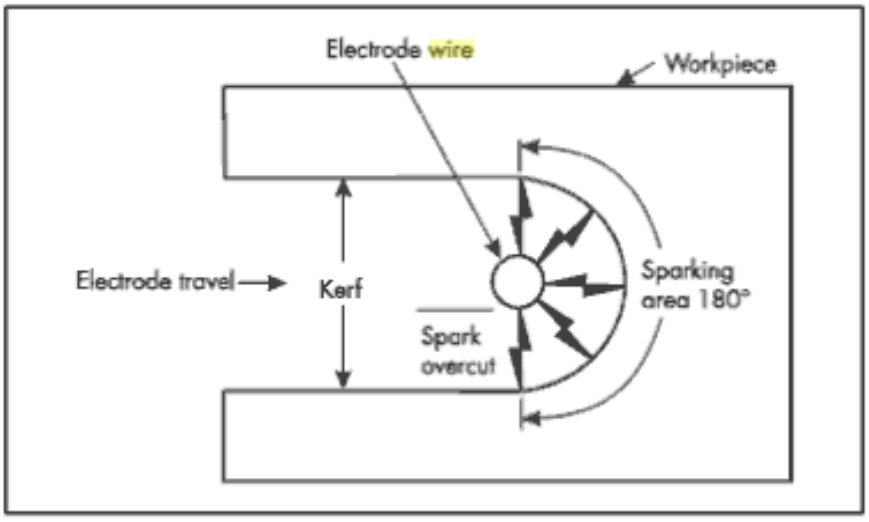

Figure 2.3: Wire-cut sparking area [3].

2.1.3 Dielectric System

Deionizer water is the dielectric used for the wire-EDM process. Deionizer water used for four reasons: low viscosity, high cooling rate, high material removal rate and no fire hazard. The small cutting gap used with wire EDM mandates that a low-viscosity dielectric be used to ensure adequate flushing. Water meets this creation. Water can also move heat from the cutting area much more efficiency than conventional dielectric oils. More efficient cooling results in extremely thin recast layers [4].

The dielectric water must also provide the optimum conditions for the creation of an electrical field as quickly as possible in order to maintain the shield of deionizer water between the wire and the workpiece. A filter is used to remove the suspended solids and a resin is used to control the electrical conductivity of the water. A cooler keeps the liquid at a constant temperature to maintain machine accuracy [1].

2.2 WEDM Machine

In WEDM machine, many type and various machine has been used currently in industries. Most WEDM machine today is CNC controlled tools. The modern wire EDM machines rely solely upon computers to guide the wires to cut away only the metal that needs to be removed.

There are two major components required for the WEDM machine, which is the wire used to remove the metal in order to shape the product being manufactured and the metal being worked is commonly inserted and in a tub of fluid. These two components are important to checking before starting the process cutting to avoid any problem happen.

In this study, RA90 series machine is used for the experiment. RA90 Series is a non-submerged entry level wire EDM with or without AT unit providing high machining speeds at a low-cost.

Figure 2.4: Ra90 Series

2.2.1 Process Capabilities

Wire-EDM is a specialized process that is capable of machining electrically conductive workpieces to produce fine finishes, extremely high accuracies and cut edges that have a smooth, matte finish [4].

Many wire-EDM machines are available with positioning resolution of 0.001mm (0.000040 in.) and can routinely obtain accuracies of ±0.007mm. With special care, accuracies of ±0.0025mm over 152mm (±0.0001 in. over 6 in.) are possible. However to achieve such results, care must be taken to ensure the uniformity of the wire diameter, and the temperature and resistivity of the dielectric must be closely controlled [4].