UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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EXPERIMENTAL INVESTIGATION OF ELECTRODE DIAMETERS ON SURFACE QUALITY OF MILD STEEL IN WEDM

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

by

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ABSTRAK

Kertas kerja ini membentangkan siasatan ujikaji dengan garis pusat elektrod pada kekasaran permukaan keluli lembut dalam WEDM. Terdapat dua objektif projek ini yang perlu dicapai. Pertama untuk menentukan hubungan antara kekasan permukaan keluli terhadap garis pusat dawai tembaga dan mencadangkan garis pusat elektrod terbaik untuk bahan kerja keluli lembut. 5 bahan kerja pemesinan dan 15 bacaan kekasaran permukaan diambil untuk setiap saiz garis pusat wayar. Selepas mengumpulkan semua data atau nilai yang diperlukan, dua analisis yang telah dijalankan. Dari t-ujian Minitab analisis perisian, garis pusat wayar yang lebih kecil terbukti mempunyai kekasaran permukaan rendah. P-nilai menunjukkan bahawa terdapat perbezaan yang signifikan antara 0.10mm dan 0.20mm garis pusat dawai tembaga dan kekasaran permukaan bahagian pemotongan benda kerja keluli lembut dengan menggunakan 95% selang keyakinan. Analisis daripada t-ujian juga menunjukkan wayar yang terbaik adalah wayar tembaga dengan garis pusat 0.10mm.

ABSTRACT

This paper presents an experimental investigation of electrode diameters on surface roughness of mild steel in Wire Electrical Discharge Machine (WEDM). There are two objective of this project that needs to be accomplished. First to determine the relationship between mild steel surfaces roughness against brass wire diameters and to recommends the best electrode diameter to machine mild steel work piece material. 5 work pieces are machining and 15 readings of surface roughness are taken for every size of diameter of wire. After gathered all data or value that needed, two analysis are been performed. From the t-test Minitab software analysis, the smaller diameter of wire is proving to be the lower surface roughness. The p-value indicated that there is significant difference between 0.10mm and 0.20mm diameters of brass wire and surface roughness of the cutting part of mild steel work piece with using 95% confident intervals. The analysis from t-test also indicated the best wire is brass wire with 0.10mm diameter.

DEDICATION

To my beloved mother and father

ACKNOWLEDGEMENT

By the name of ALLAH, the Most Gracious and Most Merciful

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ANOM	-	Analysis of Means
CNC	-	Computer Numerical Control
EDM	-	Electrical Discharge Machine
H_0	-	Null Hypothesis
MMR	-	Material Removal Rate
NC	-	Numerical Control
Ra	-	Arithmetic Mean Surface Roughness
Rmr	-	Material Proportion of the Profile
RSm	-	Average Groove Width
Rt	-	Total Height of the Roughness Profile
Rz_1	-	Maximum Height of the Roughness Profile
Rz_1max	-	Maximum Surface Roughness
Rz	-	Surface roughness depth
WEDM	-	Wire Electrical Discharge Machining

CHAPTER 1
INTRODUCTION

Wire Electrical Discharge Machining (WEDM), also known as Wire-cut EDM that use a thin single-strand metal wire is to cut the work piece. Brass material is commonly used as a wire electrode. The work piece should be submerged in a tank of dielectric fluid, typically deionised water. WEDM is a controlled machining process typically used to cut work piece as thick as 300mm and capable to make punches tools and dies from hard metals that are difficult to machine with other methods. In addition, complex shapes that are difficult to machine using conventional machining are able to be machined. WEDM also able to machine extremely hard materials that have very close tolerances and small work piece. (Posittec.com, 2014).

According to Krishna et al. 2010, many improvements in the technology of wire electrical discharge machining (WEDM) to satisfy the requirements in various manufacturing fields. In the field of conductive material machining, WEDM has been found to be an extremely potential electro-thermal process. WEDM has many applications in manufacturing field such as aerospace, automotive and medical industries to produce complex and intricate shapes. The most important performance factors in the study of WEDM are material removal rate (MRR), surface finish and cutting width (kerf). They depend on machining parameters such as discharge current, pulse duration, pulse frequency, wire speed, wire tension and type of dielectric fluid. (Krishna, et. al. 2010). The cost of machining is higher due to a high initial investment for the machine. By using WEDM, the cutting process for complex work pieces and difficult to machine materials are more economical because in manufacturing of mould and die components in sheet metal press dies and extrusion are commonly used in WEDM.

Surface roughness of work piece cutting surface is one of the most important outputs in manufacturing applications. Various investigations have been carried out to improve the surface roughness by the WEDM process. Previous research shows that surface roughness at the cutting area is depending on the machining parameter.

WEDM is a necessary process with a high cost and it is required that the appropriate machining parameters are selected for an economical machining operation. The machining parameters optimization is important in order to obtain the best machining with the knowledge of the effect of the surface roughness.

1.1 Statement of the Purpose

The purposes of the research are to find out the effects and relationship of electrode wire diameters on cutting surface roughness.

1.2 Problem Statement

WEDM is a controlled machining process capable to machining complex shapes with great accuracy, good surface finish and difficult to achieve using conventional machining process. Based on previous research, the data of electrode wire diameters effect on surface roughness is still lacking. The surface roughness on mild steel using brass wire 0.2mm and 0.3mm in diameters produces average 2.5μm and3.5μm respectively. (Ahsan, 2006). So far, that is the only data available discussed on the effects. There for, in comparisons, wire diameters of 0.10 mm and 0.20 mm of brass electrode wire will be analyzed.

1.3 Objective

In order to complete the Final Year Project, there are some objectives that must be accomplished. The objectives are as followed:

i. To determine the relationship between mild steel surfaces roughness against brass wire diameters.

ii. To recommend the best electrode diameter to machine mild steel work piece material application.

1.4 Work Scope

The scope of the project, in evaluate surface roughness of mild steel using different electrode wire diameters which are brass and copper. Machine used is Sodick VZ300L Wire Electrical Discharge Machining (WEDM). Dielectric material use during machining is deionised water. Brass wires of diameters 0.20 mm and 0.10 mm and mild steel as electrodes and work piece materials respectively. To determine the surface roughness, Portable Surface Roughness Tester, SJ-301 is used.

CHAPTER 2
LITERATURE REVIEW

Literature review discussed the relevant topics and as a guide for studies. This section will give part in order to get more information about Wire Electrical Discharge Machining (WEDM) and will give idea how to operate the machine. At early stage of the studies, some gap analysis has been carried out in order to ensure the relevance of this research. References of books, research journals and online conference article were the main source in the thesis guides. This section will include the principle of WEDM, machining properties and surface roughness at the cutting area. History of the WEDM will be story little bit in this section.

2.1 Working Principle of WEDM

Wire Electrical Discharge Machining (WEDM) is non–traditional machining techniques that have high accuracy although complicated shapes especially for the parts that are difficult to be machined. From WEDM can make tools and dies and is an alternative of producing small scale parts with the great dimensional accuracy and surface finish quality. In WEDM, wire is used as electrode that made of thin copper, brass or tungsten that have diameter 0.05 mm until 0.3 mm which is capable of achieving very small radius of corner. By using mechanical tensioning device, the wire is kept in tension and can reduce to produce inaccurate parts. (Xu, 2012).

In WEDM, the conductive materials are machined with electrical discharging that will produce sparks between an accurately positioned of electrode wire and the work piece. According to Buhlmann.com, accessed on 9 May 2014, the high frequency pulses of alternating or direct current is discharged from the electrode wire with a small gap or spark through a dielectric fluid. Sparks can be observed and the actual discharging occur more than one hundred thousand times per second and lasting in the range of 1/1000000 of a second or less.

A volume of work piece has been removed during this short period of spark discharge depends on the desired cutting speed and the surface finish required. Estimated at around 15000 to 21000 Fahrenheit to heat of each electrical spark and erode away a bit of material that is vaporized and melted from the work piece. (Buhlmann.com, accessed 9 May 2014). The chips are flushed away from the cut with a stream of deionised water through the top and bottom flushing nozzles. The heat build-up in the work piece is prevented by deionised water. (Buhlmann.com, accessed on 9 May 2014). Without this cooling system, thermal expansion of the work piece would affect size and positioning accuracy.

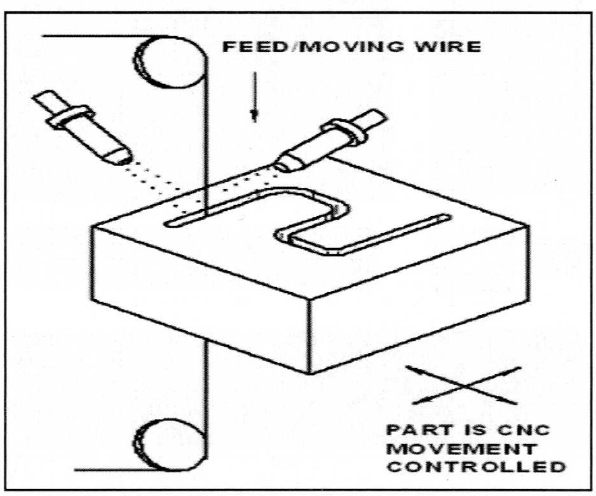

Figure 2.1: The movement of electrode wire against work piece

Source: Buhlman.com, Wire EDM-The Fundamentals.

2.1.1 Computer Numerical Control (CNC)

The first major in the evolution of WEDM is numerical control (NC). Today's numerical control is produced due to the needs of the mind of operator.

Programs, machine coordinates, cutting speeds, graphics and relevant information are displayed on a colour monitor, with an easy use menu. According to Jameson, 2001, the control unit displays menu's that is designed to give top priority to operability. By using the keyboard, input the characters and commands. This system allows the operator to quickly familiar with it and easier to use.

Besides executing NC data for positioning the movement of axes, the control of movements when using offsets, tapering, scaling, rotation, mirror images or axis exchange. The control also to determine if there is any pitch error compensation or any backlash error in the axes drives to ensure high accuracy positioning. The machine has multiple coordinate systems and jobs can be programmed in absolute or incremental modes saving valuable programming time. For example, multiple jobs can be set-up on the work table, while storing the separate reference points or locations of these jobs in specific coordinate registers.

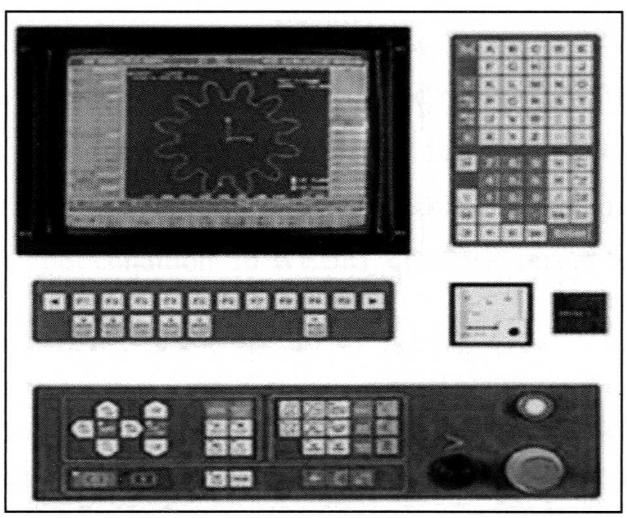

Figure 2.2: Programs are input through the floppy disk unit, or keyboard

Source: Jameson, E. Electrical Discharge Machining

2.1.2 Power Supply

Direct current pulse power generator is provided during WEDM process. The WEDM power system can be classified into RC, LC, RLC and transistorized types.

In transistorized EDM power systems have provided square of waveform pulses with the pulse on-time usually have range from 1 to 2000 msec, peak voltage ranging from 40 to 400V, and peak discharge current ranging from 0.5 to 500A. By using RC, LC or RLC type of power system, the discharge energy comes from a capacitor that is connected in parallel with the machining gap. (Engineersedge.com, accessed on 9 May 2014).

Usually WEDM power generator is a transistor-controlled capacitive power system that can reduces the wire rupture risk. In this power system, the discharge frequency can be controlled by adjusting the on-time and off time of the transistors that control the charging pulse for the capacitor connected in parallel with the machining gap.

2.1.3 Dielectric System

According to Filtration fundamentals, accessed on 9 May 2014, the function of the dielectric is as a medium through which the discharge occurs, solidify and flush away the debris from the electrode wire and work piece and keep the electrode wire and work piece in cool condition. In WEDM, dielectric serves two functions as both an insulator and conductor.

To the discharge, the dielectric acts as insulator that electrical potential are allowed between the electrode wire and the work piece to build without it effect through the fluid. The dielectric breaks down and forms an electrical conductive if the electrical path between the electrode potential wire and the work piece occurs at certain intensity. The energy of the spark is allowed by the conductive path that can be transferred from the electrode wire to the work piece for metal removal. By maintaining a constant condition of the dielectric will obtained consistent result of the WEDM process.

2.1.3.1 WEDM Dielectric System Basics

In WEDM process, deionised water is used as dielectric material. According to Benedict (1987), deionised water is used due to low viscosity, high cooling rate, high material removal rate and no fire hazard. In addition, deionised water can remove heat from the cutting area more efficiently than dielectric oils.

Although the wear rate on the wire electrode is high, the material removal rates also high when using water as the dielectric. The high tool wear rate is do not have consequence because the wire electrode is cannot be reused again. There is no fire hazard problem if use water as dielectric fluid. (Benedict, 1987).

Dielectric system's function is to maintain a constant condition of the dielectric in the machine. The electrical discharge process contaminates the dielectric with the re-solidified electrode wire and work piece material that is the product of the discharge. The solid contaminant is removed by the filter subsystem of the WEDM dielectric system. (Filtration fundamentals, accessed on 9 May 2014).

The filter subsystem is usually comprised of:

i. Dirty tank – reservoir for contaminated dielectric fluid
ii. Filter pump – supplies pressurized dielectric fluid to the filter assembly
iii. Filter assembly – cleans the dielectric fluid
iv. Clean tank – reservoir for clean dielectric fluid

2.1.4 Mild Steel as Work Piece

Mild steel is material that made of low carbon and iron, with much more of iron than carbon. Mild steel is commonly used as construction materials and it is known as mild because of the relatively low carbon content. Mild steel also made of low carbon components of ingot iron. This is pure chemical type of iron that will heat with coke and gypsum or lime at high temperatures in a blast furnace. The right balance of carbon in the mixture must be obtained and if there is too much will make the steel brittle while too little will make it too soft. (Ask.com, accessed on 2 May 2014).

According to Anon, accessed on 24 April 2014, mild steel is not expensive and it will found in almost every product created from metal. It is durable although it rusts and it is relatively hard and easily annealed. Mild steel is poor resistance to corrosion. To prevent from rusts, this material must be protected by painting or sealed it.

2.1.5 Wire Electrodes

A variation of EDM is WEDM or electrical discharge wire cutting. In WEDM process, this almost similar to contour cutting with a band saw. The wire travels slowly along a prescribed path and the work piece is cutting with discharge sparks. The wire can cut a work piece as thick as 300 mm and usually being used to make a mould, punches, tool and dies from hard metal. Intricate components for the electronics industries also will be cut. According to Xacted.com, accessed on 5 May 2014, WEDM is a machine to cut material with a thin wire electrode that follows a programmed path. The wires are usually made of brass, copper or tungsten. Zinc or brass coated wires are also being used. The wire diameter is typically about 0.30 mm for roughing cut and 0.20 mm for finishing cut.

There is no effect on cutting speed even the work piece material is hardness and no physical contact between the wire and part being machined. The important factors in selecting brass and copper are ability to generate an electric discharge, mechanical strength at high temperature, high electrical conductivity and high heat conductivity. The wire also should have sufficient tensile strength and fracture toughness as well as high electrical conductivity and capacity to flush away the debris produces during the cutting. (Xacted.com, accessed on 5 May 2014).

2.2 Differences Between WEDM and Conventional EDM

There are two types of EDM which is conventional and wire cut. According to Thomasnet.com, accessed on 24 April 2014, in Conventional EDM process, a tool is used to disperse the electric current. This tool or electrode is a cathode that is runs along the work piece as anode and the electrical current reacts to melt or vaporize the metal. As a result of the dielectric fluid, a little debris produced and washes away from the work piece.

During electricity through a taut thin wire in WEDM process which acts as the cathode and is guided alongside the desired cutting path, or kerfs. The work piece and electrode wire will be submerging in the dielectric fluid. The taut thin layer allows precision cuts with kerfs as wide as three inches and position of accuracy of +/- 0.0002". This high precision allows for complex, three dimensional cuts and produces highly accurate punches, dies and stripper plates.

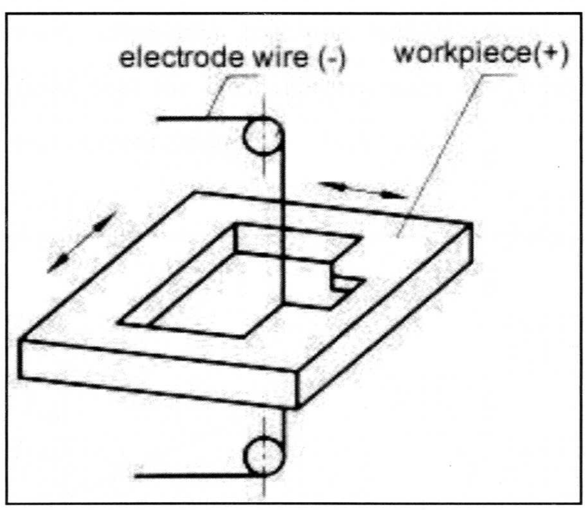

Figure 2.3: Polarity of electrode wire and work piece

Source: Thomasnet.com, Wire Cut EDM (Electrical Discharge Machining)

Equipment of WEDM is run by Computer Numerically Controlled (CNC), which can provide greater flexibility if control the wire on a three-dimensional axis. Conventional EDM cannot always produce small radius of corners or very complex patterns, but in WEDM process can increase precision that allows for complex