NATIONAL TECHNICAL UNIVERSITY COLLEGE OF MALAYSIA

Comparative Study on the Performance of AC and DC Welding Machine

Thesis submitted in accordance with the requirements of the
National Technical University College of Malaysia for the Degree of
Bachelor of Manufacturing Engineering (Honors) (Manufacturing Process)

By

Florence Raymon

Faculty of Manufacturing Engineering

June 2006

KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA

BORANG PENGESAHAN STATUS TESIS*

JUDUL: Comparative Study on Performance of AC and DC Welding Machine

SESI PENGAJIAN : 2002-2006

Saya FLORENCE RAYMON
(HURUF BESAR)

mengaku membenarkan tesis (PSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM) dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Kolej Universiti Teknikal Kebangsaan Malaysia.
2. Perpustakaan Kolej Universiti Teknikal Kebangsaan Malaysia dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	TIDAK TERHAD	

Disahkan oleh:

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat Tetap:
c/o Franklyn Raymon, PPK Baram,
98050, Marudi, Baram, Sarawak.

Cop Rasmi:
ABDUL RAHIM BIN SAMSUDIN
Penyelaras Program Pengajian Diploma
Fakulti Kejuruteraan Pembuatan
Kolej Universiti Teknikal Kebangsaan Malaysia
Karung Berkunci 1200, Ayer Keroh
Melaka

Tarikh: 16.05.2006

Tarikh: 16.05.2006

* Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).
**Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declare this thesis entitled "Comparative Study on Performance of AC and DC Welding Machine" is the results of my own research except as cited in the reference.

Signature : ....

Author's Name : Florence Raymon

Date : 16.05.2006

APPROVAL

This thesis submitted to the senate of KUTKM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Engineering (Honours) Manufacturing (Process). The members of the supervisory committee are as follows:

....

Main supervisor

Faculty of Manufacturing Engineering

ABDUL RAHIM BIN SAMSUDIN
Penyelaras Program Pengajian Diploma
Fakulti Kejuruteraan Pembuatan
Kolej Universiti Teknikal Kebangsaan Malaysia
Karung Berkunci 1200, Ayer Keroh
Melaka

ABSRACT

The main objectives of this research were to investigate the performance of Alternating Current (AC) and Direct Current (DC) Welding Machine under various parameters. Parameters included in this study were electrode diameter and current. This experimental research was carried out where materials were welded using manual metal arc welding. To compare the performance of both welding machine, the sample which have been welded then need to go through some testing method. Testing method that has been used in this research was hardness test and ultimate tensile strength test. The data which has been collected will be analyzed to determine which machine will perform better and what parameters have involved. Lastly from this research project, a list of the best operating conditions for both welding machine will be produced as a reference for other user.

DEDICATION

For my beloved parents, sister and brothers.

Last but not least, this thesis dedicate also to my lovely nephews and nieces.

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Mr. Abdul Rahim Bin Samsudin. There are no other words that I can except for thank you for the supervision given. All this time, I've been looking for the right way to produce and completed this thesis. I will not have been able to finish everything if not there a lot of help from him. Thank you so much.

I also would like to thank some of the technician who helped me a lot during the completion of this thesis. I would like to thank faculty's best welder, Mr. Asari Abdul Rahim for helping during the welding process. Not forgotten also to Mr. Azhar for helping me during the testing process of my welding samples.

Lastly, for my parents, who always is there when I really need help during the completion of this thesis. Not forgotten for some friends who always there to help. Iskandar, Atikah, Antasya and Dzuhairi. Thank you very much.

Sincerely yours,

Florence Raymon.
B050210005.
BMFP 02/06

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND NOMENCLATURE

AC	-	Alternating Current
DC	-	Direct Current
SMAW	-	Shielded Metal Arc Welding
UTM	-	Universal Testing Machine
KN	-	Kilo Newton

CHAPTER 1
INTRODUCTION

1.1 Background of the Research

This research project is about Comparative Study on the Performance of AC and DC Welding Machine. Basically, this research needs to be done in experimental way where welding process need to be performed based on the parameters that have been selected.

Welding process that has been specified for this research project was manual metal arc welding which also known as Shielded Metal Arc Welding (SMAW). This welding type required a highly skilled welder to produce a high quality weld bead. SMAW process can be performed by this two main sources, Alternating Current (AC) and Direct Current (DC) welding machine.

Welding process will be performed according to parameters that have been selected and testing process for that welding process will be conducted next. Lastly, with all of data that have been collected, analyzing process can be performed and comparison between both welding machines can be made.

1.2 Objectives of the research

The main objective of this research was to investigate the performance of AC and DC welding machine.

The investigation of the performance of these both welding machines will be evaluated under various parameters such as metal thickness, current, materials and electrode diameter.

Means here, the main purpose of this research is to determine:

(i) What parameters of SMAW process affect the performance of AC and DC welding machine, and:

(ii) To what extend the performance of AC and DC welding machine is affected by SMAW parameters.

1.3 Significance of the Research

To achieve the objectives of this research, various task needs to be performed during the research periods given. The tasks are collecting literature review, determine types of materials and electrodes to be tested, determine at what level of current was appropriate for welding that needs to be performed, practicing to develop a skill for SMAW welding process and testing the sample by some destructive testing methods. The destructive testing methods that will be used for testing of the sample were hardness test, tensile test and scanning process.

The fact that both this welding machine might have a different performance makes this research become significant. By the end of this research, the analysis will shows a pattern on what will be the differences between these two types of machine. Then, a conclusion can be made on which machine performed better than the other and in what conditions.

1.4 Scope of the Research

To complete this research, certain scopes have been stated.

The scopes mean a lot in this research project because the research which is out of scope will produce an unwanted result.

The scopes for this research project were:

(i) Perform welding test using AC and DC welding machine under welding parameters such as current and electrode diameters.

(ii) Make comparison of both AC and DC welding machine performance.

(iii) Produce a list of the best operating conditions for both AC and DC welding machine.

1.5 Welding Machine Used For the Research

To accomplish welding test for this research, a welding machine was needed to weld a sample to be tested. Below was the information about the welding machine which has been used during this research period.

1.6 General Information about Machine

Table 1: General information of the machine

General Information	
Machine Name	Inverter Arc Welding
Manufacturer	Fronius Austria
Identification No.	FKP / WSL / IAW / 01 / 001
Supplier	Science Tech
Pt. No.	0086
Delivery Date	05 / 09 / 2002
Commissioning Date	28 / 10 / 2002
Location	Welding Lab

Table 2: Machine specification

Machine Specification	
Model No.	EN 50199
Serial No.	13121873
Brand Name	Fronius Magic Wave 3000
Year of Manufacture	2000
Machine Made	Austria
Voltage	400 V
Frequency	50 / 60 Hz
Power	30 Amp
Machine Size	(595 x 290 x 480) mm
Machine Weight	120 kg
DC	5 – 400 Amps

Application of the machine was for joining mild steel, cast iron, copper and alloy. Lastly, this machine was included with electrode holder and ground cable which can be suited for used at maximum rated current.

Fig. 1.1 Fronius Magic Wave 3000, Welding Machine

1.7 Schedule of Research Project

Table 3: Schedule of Research Project

Task	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
First meeting with supervisor regarding about the research project.	√														
Provide a schedule about flow of research during period of time given.		√													
Literature review about SMAW welding process.			√	√	√	√	√	√	√	√					
Familiarize with the machine in the welding lab and cutting material.								√	√	√	√	√			
Provide sample of suitable current for Direct Current										√	√				
Provide sample of suitable current for Alternating Current											√				
Testing sample for hardness and tensile strength												√			
Analysis of data													√		
Report writing									√	√	√	√	√	√	
Submit report															√

CHAPTER 2
LITERATURE REVIEW

2.1 History of Welding

For centuries, the only method man had for metallurgical joining metals was forge welding, a crude and cumbersome black-smith type operation in which heated metals were pounded or rammed together until they bonded. Then, within the span of a few years prior to 1900, three new processes cam into existence. Arc welding and resistance welding were developed in the late 1880's and put to work in industry a few years later (The James Lincoln Arc Welding Foundation, 2000a).

The working and hardening of steel – advanced arts that doubtless took centuries to evolve – were commonly practiced 30 centuries ago in Greece. But primitive tribes on different continents, and with no apparent means of communication, developed the same basic methods for smelting, shaping, and treating iron. Thus, the principles of welding probably were discovered, lost, and rediscovered repeatedly by ancient people (The James Lincoln Arc Welding Foundation, 2000b).

Forge welding of iron developed into a recognized industry. But the joining of large, heavy piece required great skill and much labor, for they could be brought to the required temperature only if a fire maintained around them. When the two parts were not hot enough, they were forced together by various means, and were often hung from cranes for this operation. The ends were struck repeatedly with a sledge hammer while the heat was maintained. Then the work was withdrawn from the fire and finished on anvil. Forge welding is still practiced today, but to a very limited extent (The James Lincoln Arc Welding Foundation, 2000c).

Of the three new processes developed just prior to the Twentieth Century, arc welding has emerged as the most widely used and commercially important method. There is evidence that a Professor G. Lichtenberg may have joined metals by electric fusion as early as 1782 in Germany, but most accounts trace the history of electric welding back to discovery of the electric arc by Sir Humphrey Davy. In 1801, while experimenting with the infant science of electricity, Davy discovered that an arc could be created with a high voltage electric circuit by bringing the two terminals near each other. This arc which cast a bright light and gave off considerable heat, could be struck and maintained at will, and its length and intensity could be varied within limits determined by the circuit voltage and by the type of terminals used. Davy demonstrated the arc at the Royal Institute of England in 1808, where his discovery aroused a great deal of interest. For many years, however, it remained a scientific plaything; there appeared to be no practical use for the phenomenon. In fact, Davy did not apply the term "arc" to his discovery until 20 years later. After the discovery of the arc, the first person known to intentionally join metals by electric welding was Englishman named Wilde. In the early 1860's he melted together small pieces of the iron, and, in 1865, he was granted a patent on his process – the first patent relating to the electric welding (The James Lincoln Arc Welding Foundation, 2000d).

The first really practical welding process used the heat of an arc between a carbon electrode and the work piece. This was the subject of UK patent No. 12984 of 1885 in the name of Benados and Olszewski. The heat of the arc melted the metal where the joint was required and when the arc was removed the heat flowed away into the surrounding metal causing the molten pool to solidify, thereby unifying the pieces (Houldcroft and John, 1989a).

Some year's later arc welding was developed further when a steel rod was substituted for the carbon electrode and now the process of heating was accompanied by the deposition on to the work piece of metal melted from the end of the rod (Houldcroft and John, 1989b).

In the 1930s, new methods were developed. Up until then, all metal-arc welding had been carried out manually. Attempt was made to automate the process usng a continuous wire. The most successful process was submerge arc welding (SAW) where the arc was submerged in a blanket of granular fusible flux. 1940, some experiments was made using an electrode of tungsten. The arc could be struck without melting the electrode, which made it possible to weld with or without filler material. The method called TIG welding (Tungsten Inert Gas) (Weman, 2003a).

Some years later, the MIG welding process (Metal Inert Gas) was also developed using the continuous fed metal wire as the electrode. Initially, the shielding gases were inert such as helium or argon. Zaruba and Potapevski tried to use CO_2 as this was much easier to obtain and by using the 'dip transfer' method they did manage to reduce some of the problems caused by the intense generation of spatter; however when using a relatively reactive gas such as CO_2 or mixed gases such as argon/CO_2, the process is generally called MAG welding (Metal Active Gas) (Weman, 2003b).

2.2 Arc Welding Fundamentals

Arc welding is one of several fusions welding process for joining metals. By the application of intense heat, metal at the joint between two parts is melted and caused to intermix – directly or more commonly, with an intermediate molten filler metal. Upon cooling and solidification, a metal metallurgical bond results. Since the joining is by intermixture of the substance of one part with the substance of the other part, with or without intermediate of like substance, the final weldment has the potential for exhibiting at the joint the same strength properties as the metal of the parts. This is in sharp contrast to nonfusion processes of joining – such as soldering, brazing, or adhesive bonding – in which the mechanical and physical properties of the base materials cannot be duplicated at the joint (The James Lincoln Arc Welding Foundation, 2000e).

The basic arc welding circuit is illustrated in Figure 2.1. An AC or DC power source, fitted with whatever controls may be needed, is connected by a work cable to the work piece and by a "hot" cable to an electrode holder of some type, which makes electrical contact with the welding electrode.

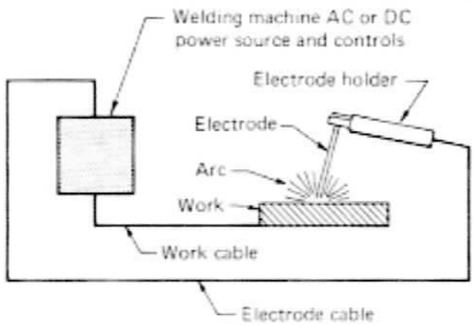

Fig 2.1 The basic arc-welding circuit (The James Lincoln Arc Welding Foundation, 2000)

An arc is created across the gap when the energized circuit and the electrode tip touches the work piece and is withdrawn, yet still with in close contact. The arc produces a temperature of about 6500°F at the tip. This heat melts both the base metal and the electrode, producing a pool of molten metal sometimes called a "crater." The crater solidifies behind the electrode as it is moved along the joint. The result is a fusion bond (The James Lincoln Arc Welding Foundation, 2000f).

Joining metal with the heat of an electric arc, however, requires more than the moving of the electrode with respect to the weld joint. Metals at high temperature are reactive chemically with the main constituents of air – oxygen and nitrogen. Should the metal in the molten pool come in contact with air, oxides and nitrides would be formed, which upon the solidification of the molten pool would destroy the strength and toughness properties of the weld joint. For this reason, the various arc-welding processes provide some means for covering the arc and the molten pool with a protective shield of gas, vapor, or slag. This referred to as arc shielding. Arc shielding may be accomplished by various techniques, such as the use of vapor-generating or slag. Shielding also may improve the weld. An example is a granular flux, which actually adds deoxidizers to the weld. Figure 2.2 illustrates the shielding of the welding arc and molten pool with a Stick electrode. The extruded covering on the filler metal rod, provides a shielding gas at the point of contact while the slag protects the fresh weld from the air (The James Lincoln Arc Welding Foundation, 2000g).

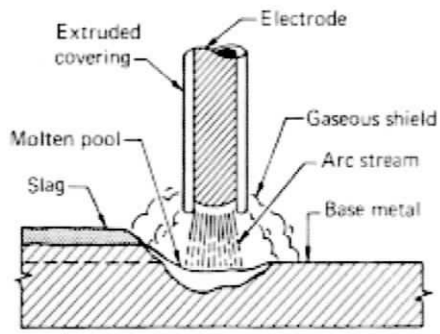

Fig. 2.2 This shows how the coating on a coated (stick) electrode provides a gaseous shield around the arc and a slag covering on the hot weld deposit. (The James Lincoln Arc Welding Foundation, 2000)

2.3 Shielded Metal Arc Welding (SMAW)

Long R.E. (1980) state in her research report titled 'The Effect of Shielded Metal Arc Welding Process Variables on Delta Ferrite Control in Austenitic Stainless Steel Weld Metal' that Shielded Metal Arc Welding (SMAW) can be defined as an arc welding process which produces coalescences of metals by heating them with an arc between a covered metal electrode and the work. Shielding is obtained from decomposition of the electrode covering. Pressure is not used and filler metal is obtained from the electrode.

He also stated in the same research paper that covered electrode was a composite filler metal electrode consisting of a core of a bare electrode or metal cored electrode to which a covering sufficient to provide a slag layer on the weld metal has been applied. The covering may contain materials providing such functions as shielding from the atmosphere, de-oxidation and arc stabilization, and can serve as a source of metallic additions to the weld.

In the latest volume of the Welding Handbook which is published by the American Welding Society (AWS) (7th Ed, Vol. II, 1978), SMAW is listed as one of the most widely used welding processes particularly for short welds in production, maintenance, repair and field construction, Long R.E. (1980). From this research paper also, have been stated that Cary (1979) said there were seven factors for maintaining high quality welding with the SMAW process are:

1. Correct electrode type
2. Correct electrode size
3. Correct current
4. Correct arc length
5. Correct travel speed
6. Correct electrode angle
7. Correct electrode manipulation

Houldcroft and John (1989c) state that once the arc has been struck, by a motion like the striking of a match, the electrode will begin to melt and a downward motion of the electrode holder is required to keep a constant arc length. When all but about 50 mm (2 in.) of the electrode has been consumed welding must stop the holder. While this is being done the weld bead freezes forming a crater. At this point, it is usual to remove the slag by chipping and to begin the new deposit by moving the electrode momentarily back up the crater away from the direction of the welding. This ensures that cracks or porosity in the crater are melted out. Many constructional jobs require welds to be made in a number of different locations remote from the source of power. This type of application is ideal fro the manual metal arc process, the