UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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TAILOR ORBITAL WELDING ON ALUMINIUM ALLOY 6063

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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I hereby, declared this report entitled "**TAILOR ORBITAL WELDING ON ALUMINIUM ALLOY 6063**" is the results of my own research except as cited in references.

Signature	:	………………………………………
Author's Name	:	**AISYAH BINTI SHARUM**
Date	:	1 July 2015

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) with Honours. The member of the supervisory committee is as follow:

…………………………………….

(DR. NUR IZAN SYAHRIAH BINTI HUSSEIN)

……………………………………

(EN. MOHAMMAD NIZAM BIN AYOF)

ABSTRAK

Matlamat utama projek ini adalah untuk 'Membangunkan Parameter Dioptimalisasi untuk Kimpalan Orbital pada Aloi Aluminum 6061' dan juga untuk mengaitkan kesan kekerasan dan kekuatan kepada mikrostruktur aloi aluminium 6061. Parameter digunakan sebagai pembolehubah dimanipulasi adalah arus puncak dan kelajuan perjalanan kimpalan. Satu eksperimen telah dijalankan untuk mencari nilai mengoptimumkan kedua-dua parameter yang dipilih. Kajian ini diuji apabila arus puncak adalah 230 A menyebabkan penembusan tidak lengkap dan juga kekurangan pelakuran manakala jika arus puncak tersebut 250 A menyebabkan percikan dan juga kepanasan melampau. Dari segi kelajuan perjalanan kimpalan, apabila kelajuan perjalanan yang mengambil masa sebanyak 50cm/min, ia menyebabkan manik kimpalan bersaiz 5mm yang memberi kesan kimpalan lemah. Ia juga menyebabkan penembusan kurang baik. Apabila kelajuan perjalanan kimpalan yang terlalu rendah, ia akan cerucuk sehingga logam kimpal dan boleh menyebabkan terlalu banyak penembusan. Reka bentuk eksperimen kajian ini adalah berdasarkan kaedah pemfaktoran. Reka bentuk Two Level Factorial digunakan untuk mengatur parameter eksperimen iaitu arus puncak dengan julat dari 230 hingga 250 A, kelajuan perjalanan kimpalan dari 30 hingga 50 cm/min. Berdasarkan kepada keputusan, nilai ujian tegangan maksimum dihasilkan oleh arus puncak (240.82 A) dan kelajuan perjalanan kimpalan (30 cm/min).

ABSTRACT

The main goal of this project is to 'Develop the Optimized Parameter for Orbital Welding on Aluminum Alloy 6061' and also to relate the hardness effect and tensile properties to the microstructure of the aluminum alloy 6061. The parameters used as manipulated variable are the peak current and travel speed. An experiment was conducted to find the optimize value of these two selected parameters. The present study tested that when peak current is 230 A resulting incomplete penetration and also lack of fusion while if the peak current is 250 A resulting spatters and also overheating. In term of travel speed, when the travel speed is 50 cm/min, it causes welding bead with small size, 5mm which resulting weak weld. It also causes poor penetration. When the travel speed is 30 cm/min, it piling up the weld metal and can cause too much penetration. Experimental design of this study based on Factorial method. Two Level Factorial design was selected to arrange the welding parameters of peak current with range of 230 to 250 A, travel speed of welding with 30 to 50 cm/min, and wire speed is constant (80 cm/min). The values were recorded from tensile test and microhardness test. From the results, maximum tensile test (60.23MPa) and microhardness value (56.40 HV) obtained by peak current of 240.82 A and travel speed of 30 cm/min.

DEDICATION

To my beloved mother and father, who were always encouraged me to follow my dreams and be my guides to a happy and successful life and my sister, who always be there for me when I upside down…

ACKNOWLEDGEMENT

Alhamdulillah, praised to Allah for His blessings in giving me the opportunity to completing this report. To my mother who always be there for me whenever I am in need and also for her unyielding continuous of support through my hard times. Without her prayers, I will never make it in completing this report. To my supervisor, Dr. Nur Izan Syahriah Bt Hussein, for guiding and motivate me in most of the step in completing this report. To welding technician, En Nizamul who always guide me throughout lab session. Without whom, this report may not be succeed. To my friends who always supporting me in my up and down and always helping when I ever in need help. For everyone who involve in my report making, a million thanks for make everything possible.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

This chapter elaborates about background of study, problem statement, objectives, scopes, project organization and planning. This project is carried out to study the effect of welding parameters. Objectives and scopes are clearly stated in this chapter to ensure the project run parallel with the objective and prevent the project from out of scope. A planning is constructed. Gantt chart is for activities in FYP 1 (Final Year Project 1) and FYP 2 (Final Year Project 2).

1.1 Background

Both aluminium and its alloys are frequently used in manufacturing industry other than many other industries depends on its usage. For example, structural and transportation are also used aluminium or aluminium alloys in their industries. This is mainly because of its mechanical characteristics and also many others characteristics such as corrosion resistance acceptance, light weight, high in term of strength and also good weldability not to mention great thoughness. A 6063 alloy from the 6xxx series comes from its initial development not until 1963 where the border of an alloy are widen hence its development comes to born with the fusion of 6062. Alloy 6082 are more popular among Europeans than of 6063 mainly due to its used of chromium and manganese in its composition although it contains about similar characteristics. The present of both composition is because its ease of crystallization control.

Robert (2001) state that due to the resistance against corrosion after welding, 6063 alloy are commonly used in the railroad and applications in the marine. Not only that, it also used for many other products. The common advantage in 6063 in forged automotive or machinery and truck wheels are the ease during hot working and also contain low sensitivity of quenching. Other than that, structural sheet and tooling plate are also made from alloy 6063 for producing the flat-rolled products in the market, extruded structural shapes, rod and bar, tubing and automotive or machinery drive shafts.

Aluminium alloy 6063 is one of the mostly used in the 6000 series (Al-Mg-Si-Fe alloy system) which this alloy are well known for their strong properties which are high specific strength, good corosion resistance and weldability (Rajabi, 2013). It is also one of the high strength heat treatable. It has excellent corrosion resistance to the atmostpheric pressure and corrosion resistance to the sea water, good toughness characteristics and very good weldability. Somehow, this alloy has a low formability at the room temperature. In the role of industrialization of the alloy, the plastic deformation behaviour of the 6xxx series is useful to increase the workability in the industry.

Aluminium alloy 6063 is easily welded and joined by various commercial methods. There are several applications that aluminium alloy is regularly used such as tubing and piping, Transportation, phylon and tower, ship building, aerospace applications including helicopter rotor skins, motorboats, rivets and bridges and military bridges

1.2 Problem statement

Many alloys involving aluminium is proves to be difficult to weld due to its chemical composition and lack of conductivity. Even though 6063 alloy could probably lose its strength when welded, they can undergoes the re-heat-treated process and artificially aged again to regain some strength, making this one of the superior alloys.

Cracking is a major concern in welding aluminium alloys pipe. This is because the relatively high thermal expansion of aluminium, the large change in volume upon solidification and the wide solidification-temperature range (Zhang, 1999). High heat input resulted the high current and slow welding speeds increase the thermal stress, solidification shrinkage and partially melted region, then it will contribute to both the weld solidification cracking and HAZ liquation cracking. Although the weld solidification crack can be controlled by using selected filler metal, the additives modify the alloy or base metal constituents may not always desirable.

1.2 Objectives

Objectives of this study are:

i. To investigate the effect of orbital welding parameters to the tensile properties and hardness properties of aluminium alloy 6063 pipe.
ii. To suggest optimum parameter of welding by using Tungsten Inert Gas (TIG).
iii. To relate the effect of hardness and tensile properties to the microstructure of aluminium alloy 6063 pipe.

1.4 Scope of project

This project is focus on welding method on aluminium alloy to generate positive effects on productivity, cost and weld quality. In this study, parameter, constant variable, equipment of the welding process, preparation of the material and specimen and also the test that have been carried out will be considered.

CHAPTER 2

LITERATURE REVIEW

This chapter explains on the literature review on the tailor orbital welding of aluminium alloy 6063. In this chapter contains information of welding process which more specific on the tailor orbital. This chapter also include the information of aluminium alloy in group of 6000 series and some information about the application of the material. On the other hand, this chapter also contains the orbital welding consideration. The main source information obtained from research journal, online article, reference books or thesis.

2.1 Aluminum Alloy

Aluminium alloys are essential engineering materials, and designers need to know some of their characteristics, how to use and perform as expected. Aluminium was first produced in the laboratory in 1825 by reducing aluminium chloride (Kenneth, 2010). However, wide acceptance of aluminium as an engineering material did not occur until World War II. Aluminium is the most abundant metal in nature. According to Kenneth (2010) aluminium is good electrical conductor, it is ductile and can be readily cast and machined. A second important property of aluminium is its thermal and electrical conductivity. The third property that is responsible for the wide use of aluminium alloy is corrosion resistance.

According to Kenneth (2010) there are hundreds of commercially available aluminium alloys, but the more readily available alloys are listed in Figure 2.0. Wrought aluminium products include foil, sheet, plate, bar, rode, wire, tubing, powder metals, and structural shape such as channels and angles. Open and close die forgings are used for many aerospace and aircraft applications.

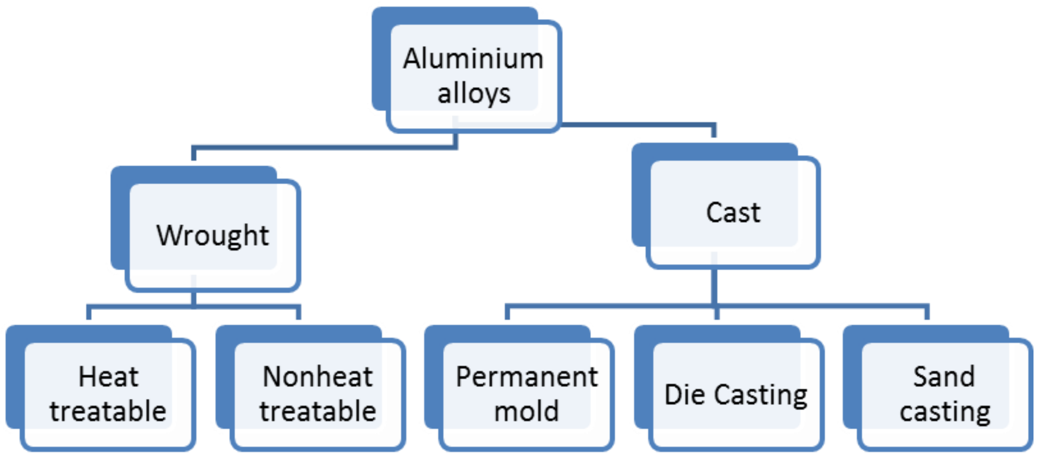

Figure 2.1: Useful cast and wrought aluminium alloys – Aluminium Association designantion and UNS number

2.1.1 Aluminum Alloy 6063

According to Meng (2014) aluminium alloy 6063 is widely used in the production of large scale complex cross-sections architecture profiles and industrial profiles due to its characteristics of moderate intensity, nice plasticity, favourable solderability and corrosion resistance. The complex cross-section profile has a wide range of application in the aerospace, train and hull structure. He also said, as for variations in thickness, shape especially asymmetric structure and the inability to cool inside the hollow section, there is non-uniform cooling both across the section and along the length of the section during the online quenching process. This non-uniform cooling may lead to large temperature gradients, and cause high residual stresses and thermally induce distortions, such as warping and twisting.

For the 6xxx series, these heat-treatable metals have an ultimate tensile strength of 18,000 PSI to 58,000 PSI. They contain a small amount of magnesium and silicon—around 1.0 percent. They are used widely throughout the welding fabrication industry, predominantly in the form of extrusions, and incorporated in many structural components. Solution heat treatment improves their strength. These alloys are solidification crack-sensitive, and for this reason should not be arc welded autogenously (without filler material). The filler metal dilutes the base material, thereby preventing hot cracking. They are welded with both 4xxx and 5xxx filler materials, depending on the application and service requirements (Tony, 2009).

2.2 Welding Heat Source

The heat source in TIG welding is an electrical arc generated between the work piece and the tungsten electrode. The pool and the electrode are protected by a shielding gas, which flows from a gas cup in which the electrode is centrally placed. After the improvement, TIG became a process of high quality and relatively high cost used in various applications (Marques et al., 2007).

According to Ogino (2011) the heat source characteristics, such as the heat input density and the arc pressure distribution, changed significantly when the electrode separation was varied. The maximum arc pressure of the two-electrode TIG arc was much lower than that of a single-electrode TIG. However, the total heat input of the two-electrode TIG arc was nearly constant and was independent of the electrode spacing. These heat source characteristics of the two-electrode TIG arc are useful for controlling the heat input distribution at a low arc pressure. Therefore, these results indicate the possibility of a heat source based on a two-electrode TIG arc that is capable of high heat input at low pressures.

Kuang (2013) said during welding, a weldment is locally delivered with an affecting heat source, such as an electric arc, laser beam, or electron beam that causes the temperature distribution to be inconsistent. The fusion zone (FZ) and heat-affected zone (HAZ) are normally at a temperature that is substantially higher than that of the unaffected base metal. Heat transfer and strongly non-uniform temperature fields in both the heating and cooling cycles cause nonuniform thermal expansion and contraction, resulting in inhomogeneous plastic deformation in the weld metal and surrounding areas. Consequently, tensile residual stress is enduringly produced in both the FZ and HAZ that can impact the brittle fracture, fracture toughness, fatigue strength, creep strength, and stress corrosion cracking of the weldment.

Peter (1991) state that it is generally considered in the welding industry that aluminium, magnesium and their alloys should always be welded by the AC (Alternative Current) TIG process. It is true to say that the AC mode is more successful because the alternating current has some cleaning effect on the weld bead, bringing unwanted oxides to the surface.

This mode is particularly successful for thicker metals using filler wire and is almost mandatory where aluminium filler wire or rods are being used. One slight disadvantage is that AC TIG can sometimes produce considerable sparking and spatter but even this can be minimized with proper cleaning of weld preparation. Aluminium should be welded

2.3 Orbital Welding

2.3.1 Tungtsen Inert Gas

According to Mandal (2009) Tungsten Inert Welding (TIG) is also known as Gas Tungsten Arc Welding (GTAW), the required heat for fusion is generated from an inert gas an arc between a non-consumable tungsten electrode and the base metal. As is evident from the name of TIG, an inert gas is used as a shielding medium for the arc and the molten weld pool. This process may be used with or without filler metal. A TIG process is shown in Figure 2.1. The shielding gas which surrounds the arc and the weld pool must also protect the electrode at the prevailing high temperature. The tungsten gets readily oxidized if it comes in contact with oxygen. Hence the shielding gas can only be of inert gas.

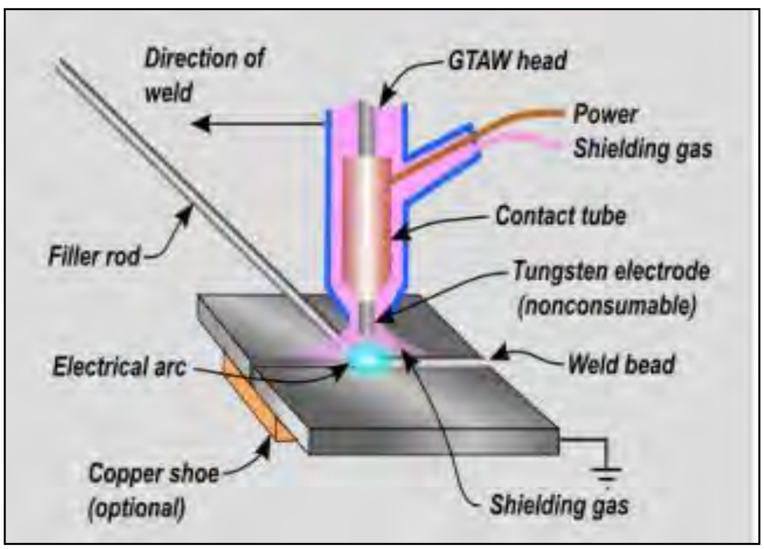

Figure 2.1: Tungsten Inert Gas (TIG) operation (Naitik, 2014)

The most commonly used shielding gas is argon. It is heavier than air and its density is 1.7837 gm/l at standard temperature and pressure. The welding grade argon is refined to a minimum purity of 99.9995%. It is chemically inert, colourless, odorless, tasteless, and nontoxic gas.

To prevent oxygen and nitrogen in the air form contaminating the weld, either argon or helium, or mixture of both, is used as a shielding gas (Hoobasar, 2003). The prime factor that influences shielding gas effectiveness is the gas density (Mandal, 2009). Hoobasar (2003) state that argon is widely used since it is easier to obtain and because it is heavier gas, thus providing better protection, or shielding at lower flow rate. Argon is approximately 1.3 times as heavy as air 10 times heavier than helium. After leaving the gas nozzle, its tends to form a blanket over the weld area (Mandal, 2009). Argon is used more extensively than helium because of the following advantages:

i. Easier arc initiation
ii. Better control of the molten weld pool
iii. Smoother and quieter arc action
iv. Lower cost and greater availability
v. Better cross – draft resistance due to higher density
vi. Lower flow rates for shielding
vii. Cleaning action when welding materials such as aluminium and magnesium with AC and DCEP
viii. Reduced penetration