EFFECT OF COLD ARC TO DEFLECTION IN CONTINUOUS WELDING OF THIN PLATE

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

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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 (Manufacturing Process) (Hons.). The members of the supervisory committee are as follow:

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(Principal Supervisor)

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(Co-Supervisor)

ABSTRAK

Industri kapal dan automotif menggunakan plat nipis untuk pembinaan kapal dan badan kereta secara meluas. Masalah herotan meningkat dengan penggunaan plat nipis dalam industri kapal dan automotif. Proses kimpalan dengan input haba yang rendah boleh mengurangkan herotan, sebagai contoh, proses kimpalan 'Cold arc'. Oleh itu, proses kimpalan 'Cold arc' digunakan dalam eksperimen ini. Objektif untuk kajian ini adalah untuk mengkaji kesan parameter proses kimpalan 'Cold arc' kepada herotan, mencadangkan parameter terbaik untuk proses kimpalan 'Cold arc' menurut sifat-sifat kekuatan tegangan, dan membandingkan herotan yang berlaku dalam eksperimen kepada keputusan simulasi. Yang pertama, nilai parameter dipilih adalah arus elektrik, voltan dan kelajuan kimpalan. Selepas proses kampilan, herotan diukur dengan pembaris dan ujian kekuatan tegangan dijalankan untuk mengetahui sifat kekuatan tegangan. Selepas itu, keputusan diperolehi daripada eksperimen dikumpulkan dan dibincangkan. Kemudian, ABAQUS digunakan untuk mensimulasikan herotan dan keputusan simulasi ini dibandingkan dengan keputusan eksperimen. Hasil kajian menunjukkan proses kimpalan 'Cold arc' mengurangkan masalah herotan dengan berkesan dan input haba mempengaruhi sifat kekuatan tegangan.

ABSTRACT

Thin plates are widely used by ship and automotive manufacturers for constructing ship and car body. The amount of distortion increase because increasing use of thin plates in ship and automotive industries. Low heat input welding process like cold arc welding process can reduce the distortion problem. Therefore, cold arc welding technology was used in the experiment. The objectives of this study are to study the effect of cold arc welding parameters to distortion of welded thin plate, suggest the optimum set of parameters for cold arc welding process according to tensile properties, and compare the distortion from experimental results to the simulation results. Firstly, the importance parameters were selected, which were current, voltage and welding speed. After the experiment was carried out, welding distortion was measured by using ruler. Besides, the tensile testing was carried out for finding out the related tensile properties. Then, all the results obtained from experiment were collected and discussed. After that, ABAQUS was used for simulating welding distortion and the simulated results was compared to experimental results. The results revealed that distortion could be reduced effectively by using cold arc welding process and heat input had effect on tensile properties of welded plates.

DEDICATION

To my beloved parents

Lee Tow Huat

Tan Le Hoon

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

GMAW	-	Gas Metal Arc Welding
GTAW	-	Gas Tungsten Arc Welding
SAW	-	Submerged Arc Welding
CMT	-	Cold Metal Transfer
T-GMAW	-	Tandem Gas Metal Arc Welding
HSLA	-	High Strength Low Alloy
DP	-	Dual-phase
HAZ	-	Heat Affected Zone
LVDT	-	Linear Variable Differential Transformer
η	-	Efficiency factor for welding process
$R_m^{welding}$	-	Minimum tensile strength after welding

CHAPTER 1
INTRODUCTION

1.1 Background Study

In recent years, ship and automotive manufacturers tend to use thin plates for constructing ship and automotive body. Thin plates are popular among the manufacturers because it will minimize transports' weight and reduce the fabrication work. When the weight of the ship or car body reduced, the fuel cost will be reducing simultaneously. Besides, the increased use of higher strength steel and aluminium alloys becomes one of the reasons that the manufacturers choose thinner plates in ship and car structure (Shen, 2013) (Sakurai, 2008). However, the increased of thin plate will cause the increased of distortion. This is because thinner material is more susceptible, as it has less stiffness (Beardsley, 2009).

Cold arc welding process is the variant of Gas Metal Arc Welding (GMAW) and these two welding processes are short arc process. Cold arc welding process is a low heat input process. With the low heat input, distortion and spatter will be reduced significantly. The heat input of cold arc welding process is lower as compared to others welding process like GMAW, Gas Tungsten Arc Welding (GTAW) and Submerged Arc Welding (SAW). Cold arc welding can be used for joining thinnest sheets from 0.3 mm thickness. Besides, cold arc welding can be used on many types of materials for example zinc coated sheets and aluminium alloys. Moreover, cold arc welding process can be used for joining difference material for example steel-aluminium and steel-magnesium (Rosado et al., 2008).

1.2 Problem Statement

Nowadays, an increased use of aluminium and steel thin plates with the thickness of less than 10 mm in panel fabrications has resulted in significant increased of distortion (Mandal, 2004a). When more manufacturers use thin plate for building naval ship and automotive body, the amount of distortion will increase because thinner material is more susceptible, as it has less stiffness (Beardsley, 2009). The minimum thickness of thin plates is 3 mm for naval ship and 0.3 mm for automotive body (Mandal, 2004a). Welding will produce residual stress and this stress may cause distortion. Uneven temperature distribution caused by the intense heat source is the main reason that distortion will occurred (Mandal, 2004a).

When distortion happened, rework will be carried out. This causes wasting a lot of money. A good example that showing the rework cost spent on the distortion parts which is the thin-plate distortion rectification work on the Arleigh Burke Destroyer class in US Navy. It cost 2.5 million Europe Dollar for the whole rework process (Gray, 2014). EWM deliver an innovative welding process, cold arc welding process, which can reduce the distortion problem to the least. Therefore, it is important to understand the effect of adjusting the parameters of cold arc welding process to the distortion.

1.3 Objectives

Objectives of this study are:

i. To study the effect of cold arc welding parameters to distortion of welded thin plate
ii. To suggest the optimum set of parameters for cold arc welding process according to tensile properties
iii. To compare the distortion from experimental results to the simulation results

1.4 Scope of Study

Scopes of this study are:

- Raw material is thin aluminium alloy sheet that is AA 5250.
- Thin sheet thickness is 2 mm.
- Cold arc welding process was used throughout the entire project.
- Parameters which have been studied were current (80-100 A), voltage (16-19 V), and welding travel speed (0.65-1.0 m/min).
- Thermo-elastic-plastic finite element method based on ABAQUS code was used to simulate distortion.

1.5 Significance of Study

The study of the effect of continuously cold arc welding process on thin plate is important because many manufacturers use aluminium alloys and steel thin plate to construct their products by welding process. This study can give significant benefit for ship and vehicle construction industry. Shipbuilding industry wasting a lot of money in the rectification work on distortion, for example, shipbuilding industry cost seven figures on a medium-range destroyer for rectification works (McPherson, 2007). Therefore, cold arc welding process can reduce distortion problems on steel thin plate; simultaneously this welding process can reduce the rectification costs.

Besides, this study will benefit the automotive industry. Nowadays, the plate thicknesses in automotive construction industry are becoming increasingly thin, the plates used for constructing a vehicle are just 0.3 mm (Goecke, 2005). Along the trend of increasing thin plates were used in automotive industry; cold arc welding with low heat input is suitable for the thin plate construction work on car body.

1.6 Project Planning

Activity planning of this study is outlined in two Gantt chart as in Appendix A and Appendix B, which are Gantt chart for PSM 1 and Gantt chart for PSM 2.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Firstly, basic of welding was reviewed. Welding can be classified into few categories such as arc welding, oxyfuel gas welding, resistance welding, solid-state welding and others. After that, variant of GMAW, cold arc welding process was described. Next, type of material and the thickness of the thin plate are importance elements of this study; therefore, these two importance elements were explored. Moreover, the parameters of cold arc welding process were focused because these parameters will minimize the welding distortion. Finally, distortion was reviewed because distortion is one of the welding defects that will often occur on the thin plate. From the above reviewing, literature review was divided into few importance sub-topics. For example, arc welding, cold arc welding, material and application, welding parameters and distortion.

2.2 Arc Welding

Arc welding process is the welding process that use electric arc as the heat source and join metals. The welding arc is an electric current flow in between electrode and work piece through ionized column of gas called plasma. A positively charged anode and negatively charged cathode produce the intense heat source. The electrode can be consumable wire and non-consumable carbon or tungsten wire (Feng, 2005a).

2.2.1 Arc Welding Power Sources

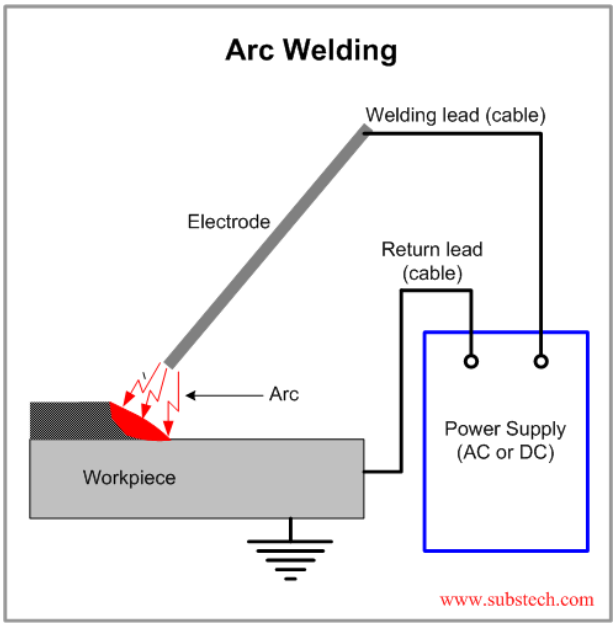

Figure 2.1: Basic arc welding circuit (Kopeliovich, 2012)

Figure 2.1 shows the basic arc welding circuit, AC or DC power source is connected to the work piece and the electrode holder (Anonymous, 2015). Normally, arc welding is used with low-voltage and high current in between the electrode and work piece. Generally, voltage is reduced to a suitable voltage range 20 to 80 V by arc welding power source. With the same power source, current is adjusted to a suitable current range from 50 to 1500 A (Mandal, 2004b).

2.2.2 Types of Arc Welding

GMAW, also known as Metal Inert Gas (MIG) is classified as consumable electrode method. GMAW can be operated under semiautomatic and fully automatic condition. GMAW can produces good quality welds and almost all types of metals can be welded. All the positions of the work piece can be reached and welded by using GMAW (Mandal, 2004c).

Submerged Arc Welding (SAW) is operated under a fact that was the welding arc in between the electrode and the base metal was 'submerged' under a layer of granular fusible flux. Flux is fed from a flux hopper in a stable condition for keeping the arc and molten pool area submerged from the atmospheric oxygen and nitrogen. The flux provides a layer of slag on the surface of filler metal. SAW can be operated under either semi-automatic or automatic mode (Gibson, 1997a).

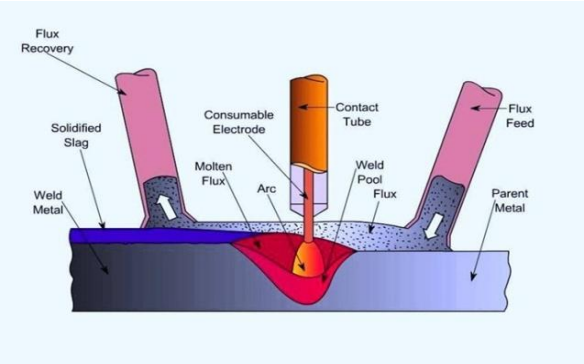

Figure 2.2: The operation of SAW (Admin, 2015)

Gas Tungsten Arc Welding (GTAW) also known as Tungsten Inert Gas Welding (TIG). An electric arc provides the heat source in between the non-consumable tungsten electrode and the base metal. A shielding gas protects the electrode and molten weld pool from atmosphere oxygen and nitrogen. Normally, argon and helium, or the mixture of argon and helium are used as the shielding gas. The most used mixture is 85% argon/ 15% hydrogen (Gibson, 1997b).

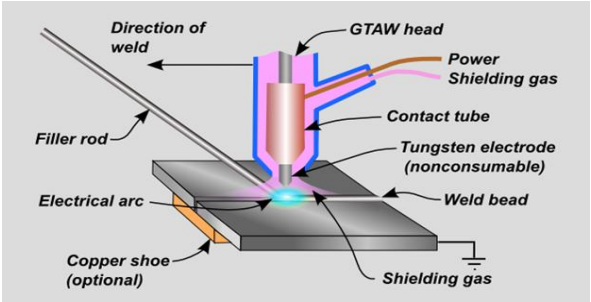

Figure 2.3: The operation of GTAW (Anonymous, n.d.)