UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

THE INFLUENCE OF GAS METAL ARC WELDING ON ANGULAR DISTORTION OF T-JOINT

Nor Afandi bin Sharif

MSc. in Manufacturing Engineering

2014

THE INFLUENCE OF GAS METAL ARC WELDING ON ANGULAR DISTORTION OF T-JOINT

NOR AFANDI BIN SHARIF

A thesis submitted
in fulfillment of the requirements for degree of Master of Science
in Manufacturing Engineering

Faculty of Manufacturing Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

DECLARATION

I declare that this thesis entitle “The Influence of Gas Metal Arc Welding on Angular Distortion of T-Joint” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	....
Name	:	....
Date	:	....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering.

Signature :……………. ....

Supervisor Name :……………………… ....

Date :…………………….. ....

DEDICATION

To my beloved father, mother, wife and my late grandmother.

ABSTRACT

Gas Metal Arc Welding (GMAW) or gas metal arc welding is one of the joining technologies and widely used in metal fabrication. The quality of a joint is greatly influenced by the selection of parameter setting of GMAW. One of the quality issues faced in welding is angular distortion. This research focused on angular distortion issues due to welding that happened in the car chassis manufacturing process at EPMB Manufacturing Sdn. Bhd. The distortion resulted in high reject and rework rate. Conventional approach to optimize the welding process parameter in solving this issue has yet to result in significant improvement. The aims of this research is to study the relationship of welding speed, welding angle, welding current and the resultant angular distortion using Response Surface Methodology (RSM) approach. The experiment was carried out using welding manipulator (robotic) type AVII V6, OTC DAIHEN. The weld joint consist of SAPH S45C work piece with T joint arrangement and steel electrode as filler. This is in accordance to the welding process set up at EPMB Manufacturing Sdn. Bhd. The angular distortion was measured using Olympus STM stereo measuring microscope and the analysis using RSM approach was done using design expert version 8.0.7. Based on the result, the interaction between welding angle and speed is the most significant factors that influence the angular distortion. The optimum settings to minimize distortion are 169 Amp (welding current), 42.00 mm/s (welding speed) and 41.0° (welding angle).

ABSTRAK

Kimpalan arka perlindungan gas (GMAW) adalah merupakan salah satu teknik sambungan yang biasa digunakan dalam fabrikasi logam. Kualiti sesuatu sambungan itu amatlah bergantung kepada pemilihan dalam pelarasan parameter kimpalan. Satu daripada masalah yang dihadapi dalam kimpalan adalah menentukan herotan dalam proses pembuatan chasis kereta di EPMB Manufacturing Sdn. Bhd. Herotan menyebabkan masalah kualiti dan proses pembaikan yang tinggi. Kaedah kovensional bagi mengoptimumkan parameter proses kimpalan masih menemui jalan buntu. Hala tuju utama penyelidikan ini adalah untuk mengkaji hubungan diantara kelajuan kimpalan, sudut kimpalan dan penyelarasan arus kimpalan dan kesan herotan menggunakan pendekatan RSM (response surface methodology). Eksperimen yang telah dijalankan menggunakan lengan robot jenis AVII V6, OTC DAIHEN. Kaedah penyambungan menggunakan bahan SAPH S45C dalam sambungan jenis 'T' sebagai bahan uji dan bahan penambah jenis keluli digunakan. Ini adalah merujuk kepada proses kimpalan yang dijalankan di EPMB Manufacturing Sdn. Bhd. Herotan diukur dengan menggunakan Olympus STM (Stereo Measuring Microscope) dan analisis menggunakan RSM. Perisian yang diguna pakai adalah perisian Design Expert Version 8.0.7. Berdasarkan kepada keputusan eksperimen, persilangan antara parameter sudut kimpalan dan halaju kimpalan ialah faktor yang paling signifikan yang mempengaruhi herotan. Penyelerasan optimum bagi mengurangkan herotan pada kimpalan adalah 169 Amp (arus kimpalan), 42.00 mm/s weld (halaju kimplan) dan 41.0° (sudut kimplan).

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful

Alhamdulillah, all praises to Allah for the strengths and His blessing in completing this thesis. Special appreciation goes to my supervisor, Associate Professor Dr. Md. Nizam bin Abd. Rahman for his supervision and constant support. He provided me unflinching encouragement and support in various ways. His truly scientist intuition has made him as a constant oasis of ideas and passions in science, which exceptionally inspire and enrich my growth as a student, a researcher and a scientist want to be. I would like to express my appreciation to the Dean, Faculty of manufacturing engineering, Associate Professor Dr. Mohd Rizal B. Salleh for his support and help towards my postgraduate affairs.

Many thanks go in to colleague in particular to production and testing department in helping me completing the experiment. I am grateful in every possible way and hope to keep up our collaboration in the future.

My parents merit special mention for their inseparable support and prayers. My parent, Sharif bin Ebok and Rosni bte. Mahadi, in the first place is the person who put the fundament my learning character, showing me the joy of intellectual pursuit ever since I was a child. Nurshahira, Norliyana and Nur Nadia Izati thank for your supportive sibling. To my wife Hazwani bte. Ruhani whose dedication, love and persistent confidence in me, has taken the load off my shoulder. I owe her for being unselfishly let her intelligence, passions, and ambitions collide with mine.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ANOVA	-	Analysis Of Variance
CC	-	Constant Current
CCD	-	Central Composite Design
CTWD	-	Contact Tip To Work Distance
CV	-	Constant Voltage
DC	-	Direct Current
DOE	-	Design Of Experiment
DWP	-	Direct Welding Parameter
FEA	-	Finite Element Analysis
FEM	-	Finite Element Method
FSW	-	Friction Stir Welding
GMAW	-	Gas Metal Arc Welding
GTA	-	Gas Tungsten Arc
HAZ	-	Heat Affected Zone
IWP	-	Indirect Welding Parameter
MAG	-	Metal Active gas
MIG	-	Metal Inert Gas
PVD	-	Physical Vapors Deposition

RSM	-	Response Surface Methodology
TIG	-	Tungsten Inert Gas

LIST OF PUBLICATION

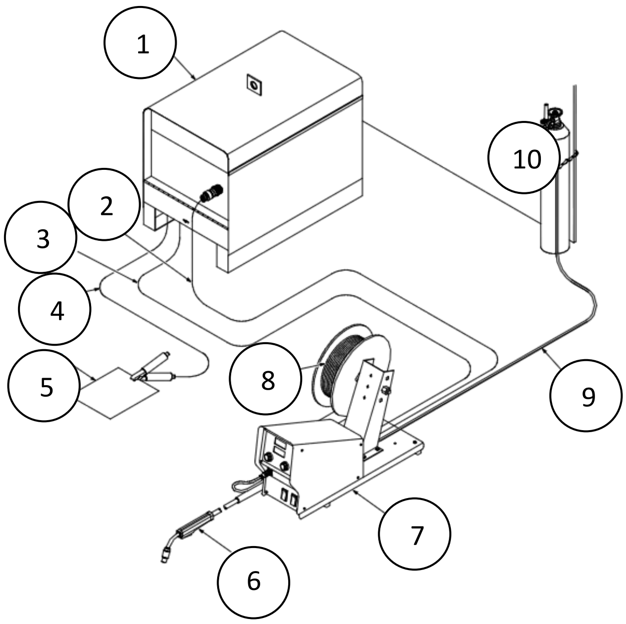
1. P. Swanson, **S. Nor Afandi**, Md Nizam, Jan – June 2014, Modelling of Gas Metal Arc Welding Process on Angular Distortion of T Joint, *Journal of Advance Manufacturing Technology*, Volume 8, Number 1, Page number 79.

CHAPTER 1

INTRODUCTION

1.1 Background of study

Welding is more than a century old technology. In the early 19th century, electricity was developed and at the same time, welding technology was remarkably changed by the introduction of electric arc welding (Thwe et al., 2010). Metal arc inert gas shielded welding, also known as MIG, MAGS or GMAW, was first in the USA in the mid 1940s. Since then, the process has been used extensively in a wide range of industries. Gas Metal Arc Welding (GMAW) machine as shown in Figure 1.0 is the most widely used arc welding process in industry. The benefits such as high production rates, high weld quality, ease of automation, and the ability to weld many metals make it attractive to manufacturer (Mathers, 2002).



1. Constant Voltage (CV) Welding Power Source
2. Contactor Control/Power Cord
3. Weld Cable To Feeder
4. Ground Cable To Workpiece
5. Workpiece
6. Welding Gun
7. Constant Speed Wire Feeder
8. Electrode Wire
9. Gas Hose
10. Shielding Gas Cylinder

Figure 1.0 Basic GMAW set up (Miller, 2010)

GMAW is a process in which the source of heat, arcing (sparking) between consumable metal electrode and the work piece as show in Figure 1.1, is used to produce molten puddle of work-piece material. The molten puddle are protected from contamination by the atmosphere (i.e. oxygen and nitrogen) with an externally supplied shielding gases either inert such as argon, helium or an argon-helium mixture or active gaseous such as carbon dioxide, argon-carbon dioxide mixture (Singla et al., 2010).

The welding parameters are the most important factors affecting the quality, productivity and cost of welding joint. Besides that weld bead size and shape are also important considerations for design and manufacturing engineers in the manufacturing industry (Jaime and Juarez, 2010).

Welding technology is one of the main joining technique used in industry due to its many advantages such as lightweight and low cost. However, welding involves complex interactions between thermal, metallurgical and mechanical phenomena and therefore, leads to residual stresses and distortions which must be controlled.

Localized heating during welding, followed by rapid cooling generates residual stress and distortion in the weld and base metal. In the last few decades, various research efforts have been directed towards the control of welding process parameters aiming at reducing the residual stress and distortion (Sundar et al., 2005).

The conventional optimisation method of the welding process with respect to distortion requires trial and error methods which are expensive and time consuming. However, without optimization the process will result in rejected parts or additional processing after welding.

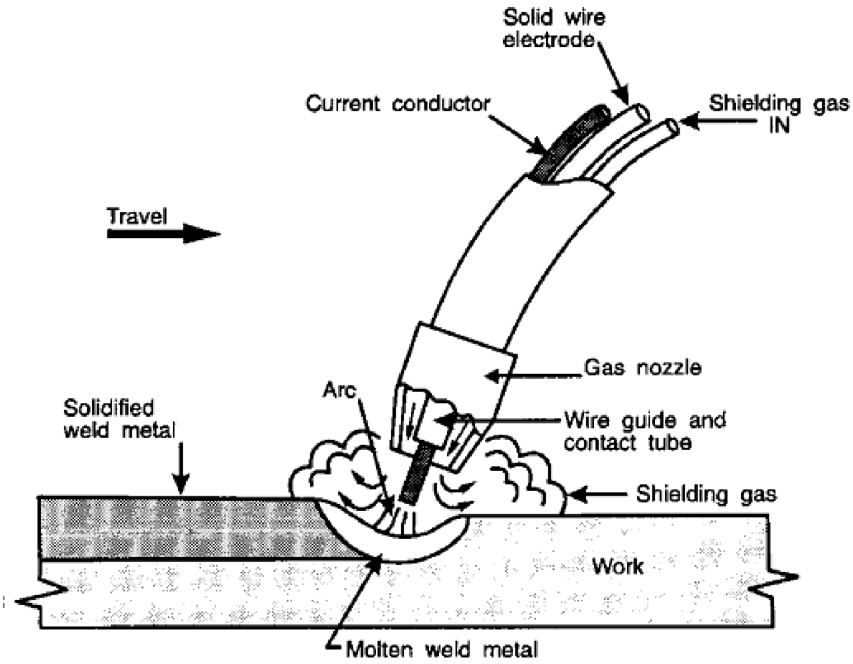


Figure 1.1 Gas Metal Arc Welding (GMAW) (Blodgett and Miller, 1996)

1.2 Problem statement

This research is an industrial application based research to address distortion phenomena due to welding process in car chassis manufacturing at EPMB Manufacturing Sdn. Bhd. which caused high reject and rework rate. The conventional approach to optimise process parameters to address this problem has yet to result in significant improvement. Holistic research looking into angular distortion minimization by optimization of process parameter is lacking. The aim of this research is to study the effect of welding process parameters on the distortion of work-piece through Design of Experiment (DOE) method, namely Response Surface Methodology (RSM).

1.3 Research objectives

The aim of this research is to study the effect of welding process parameters on the distortion of work-piece through Response Surface Methodology (RSM) approach. The specific objectives of this research are:

1. To determine the effect of welding current, torch angle, and welding speed on the angular distortion using RSM.
2. To determine the optimum welding parameters with respect to angular distortion minimization.
3. To develop and validate empirical mathematical model using Response Surface Methodology (RSM) that relate the input parameter and angular distortion.

1.4 Scope of study

This research focuses on studying the effect of GMAW process parameters on the angular distortion of work-piece using Response Surface Methodology (RSM) approach. The welding parameters studied are welding speed, welding current, and torch angle. The experiments were conducted using robotic welding system and hydraulic welding fixture to minimize experiment process variability.

The work-piece specimen used during the experiment are made of low carbon steel (SAPH S45C) and constructed to form T-joint test piece. This material is a common low carbon steel in car chassis manufacturing. This is to simulate the actual welding joint used in the chassis welding process. The output response of this experiment was the distortion angle to reflect the severity of the distortion.

1.5 Structure of the thesis

This thesis has been structured into 5 chapters. The first chapter is an introduction. A literature review of previous research in various fields which are relevant to this research is presented in chapter 2. The literature review started with the comprehensive literature review on distortion defect on various welding processes. The methodology of the research work is presented in chapter 3. It is composed of proposed structure of research works, proposed selection in Design of Experiment (DOE) and analytical hierarchy of analysis procedure in Response Surface Methodology (RSM) as the statistical tool. Chapter 4 presents the result and discussion on the experiment. Finally, chapter 5 presents the conclusion and recommendation for further study.