

UNIVERSITI TEKNOLOGI MARA

**PREDICTION OF DISTORTION
ON MULTIPASS GMAW PROCESS
USING FEM AND EXPERIMENTAL
VALIDATION**

ROBERT NGENDANG ANAK LIDAM

Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science

Faculty of Mechanical Engineering

October 2013

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.


Name of Student : Robert Ngendang Anak Lidam

Student I.D. No. : 2010816504

Programme : Master of Science

Faculty : Faculty of Mechanical Engineering

Title : Prediction of Distortion on Multipass GMAW Process
using FEM and Experimental Validation

Signature of Student : 

Date : October 2013

ABSTRACT

This thesis investigated the behaviour of angular distortion due to multipass GMAW process using finite element method (FEM). Various cases studies were conducted started with basic welding structure of butt and T-joint which is considered as the preliminary study to develop the fundamental numerical model. Further, the study was continued on the combined butt and T-joint to test the numerical model developed in the basic study of butt and T-joint before the models were applied on the ship panel application. Finally, the study was conducted on the ship panel (Laboratory Mock-up). In the simulation study, the distortion was analysed using 2D and 3D analysis based on thermo-elastic-plastic approach using FE software package SYSWELD 2010. It was found out that, 2D multipass analysis could be employed to obtain the fast average result of angular distortion while 3D multipass analysis to produce more accurate and complete results. To validate the simulation study, experimental investigations were conducted using fully automated robotic welding process. Almost all the simulation results were in good agreement with the experiments, except in 2D analysis on complex and large geometry. This result of the study indicates that the simulation study is reliable tool in predicting the welding induced distortion on the particular geometry and welding joint in this study. The effects of the clamping and welding sequence on distortion were also investigated in this study, and it was found out that the clamping condition and the welding sequences play a considerable factor in angular distortion.

TABLE OF CONTENTS

	Page
AUTHOR'S DECLARATION	ii
ABSTRACT	iii
ACKNOWLEDGEMENT	iv
TABLE OF CONTENT	v
LIST OF TABLES	viii
LIST OF FIGURES	ix
LIST OF ABBREVIATIONS	xii
CHAPTER ONE: INTRODUCTION	
1.1 Background of the Study	1
1.2 Problem Statement	2
1.3 Objectives of the Study	3
1.4 Scope of the Study	3
1.5 Significance of the Study	4
CHAPTER TWO: LITERATURE REVIEW	
2.1 Fundamental Theory of Welding Distortion	6
2.1.1 Major Types of Shrinkages Induced by Welding	7
2.1.1.1 Transverse Shrinkage	8
2.1.1.2 Longitudinal Shrinkage	9
2.1.1.3 Angular Distortion	11
2.1.2 Significance of Material Properties on Distortion	12
2.1.3 Effect of Welding Process and Procedures	14
2.1.4 Effect of Clamping Condition	15
2.2 FEM Approach in Welding Simulation	16
2.2.1 Linear Elastic Approach	17
2.2.2 Thermal-Elastic-Plastic Approach	17

2.2.2.1	Basic Principles of Thermo-Elastic Plastic	17
---------	--	----

CHAPTER THREE: RESEARCH METHODOLOGY

3.1	Simulation Procedures of Multipass Welding using SYSWELD	26
3.1.1	Material Modelling	30
3.1.2	Geometry Modelling	34
3.1.2.1	2D Local Model for Heat Source Fitting (HSF)	34
3.1.2.2	2D Local Mesh Analysis for Thermal Cycle Extraction	36
3.1.2.3	2D Global Mesh for 2D Multipass Analysis	38
3.1.2.4	3D Global Mesh for 3D Multipass Analysis	39
3.1.3	Boundary Condition	41
3.1.4	Heat Input Modelling	45
3.1.5	Multipass Welding Analysis	49
3.1.6	Post processing	49
3.2	Experimental Investigation for Simulation Validation	49
3.2.1	Specimen Preparation	50
3.2.2	Experimental Set-up and Procedure	50
3.2.3	Preliminary Investigation on Welding Parameters	54
3.2.4	Distortion Investigation and Measurement	54
3.2.4.1	Distortion Measurement by using Coordinate Measuring Machine	55
3.2.4.2	Distortion Measurement by using Digital Dial Gauge	55

CHAPTER FOUR: CASE STUDIES

4.1	Case Study 1: Distortion Analysis on Butt Joint	58
4.2	Case Study 2: Distortion Analysis on T-Joint	60
4.3	Case Study 3: Distortion Analysis on Combined Butt and T-Joint	61
4.4	Case Study 4: Investigation on Ship Panel (Laboratory Mock-up)	64

CHAPTER FIVE: RESULTS AND DISCUSSIONS

5.1	Distortion Analysis on Butt Joint	68
5.2	Distortion Analysis on T-Joint	70
5.3	Distortion Analysis on Combined Butt and T-Joint	73
5.4	Investigation on Ship Panel (Laboratory Mock-up)	76