



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**THE OPTIMIZATION OF WELDING PARAMETER FOR  
JOINING MILD STEEL 1020 USING ABB METAL INERT GAS  
(MIG) ROBOT WELDING**

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

by

**NUR FATIHAH BINTI NASRUDIN**

**B071410549**

**951117105118**

FACULTY OF ENGINEERING TECHNOLOGY

2017

**BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA**

**TAJUK: The Optimization of Welding Parameter for Joining Mild Steel 1020 Using ABB Metal Inert Gas (MIG) Robot Welding**

**SESI PENGAJIAN: 2017/2018 Semester 1**

Saya **NUR FATIAH BINTI NASRUDIN**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **\*\*Sila tandakan (✓)**

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

Disahkan oleh:

\_\_\_\_\_  
NUR FATIAH BINTI NASRUDIN

\_\_\_\_\_  
MOHD HAIRIZAL BIN OSMAN

No. 3, Jalan P8E/5, Presint 8,

Cop Rasmi:

Putrajaya

62250, W.P. Putrajaya

Tarikh: 10 JANUARI 2018

**\*\* Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai**

## DECLARATION

I hereby, declared this report entitled “The Optimization of Welding Parameter For Joining Mild Steel 1020 Using ABB Metal Inert Gas (MIG) Robot” is the results of my own research except as cited in references.

Signature : .....

Author's Name : NUR FATIHAH BINTI NASRUDIN

Date : .....

## **APPROVAL**

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Process and Technology) with Honours. The member of the supervisory is as follow:

.....

(MR MOHD HAIRIZAL BIN OSMAN)

## **ABSTRAK**

Laporan ini adalah hasil daripada eksperimen untuk mengenal pasti kekuatan tegangan pada kawasan kimpalan. Dengan menggunakan Robot Kimpalan ABB Gas Lengai Logam untuk mengoptimumkan tetapan pada parameter kimpalan pada arus elektrik, voltan, kelajuan kimpalan dan corak kimpalan pada keluli lembut AISI 1020 sebagai bahan kerja. Umumnya, parameter kimpalan akan mempengaruhi keputusan kekuatan tegangan untuk bahan kimpalan. Corak eksperimen menggunakan Kaedah Taguchi dibina, nisbah isyarat bunyi digunakan untuk mempelajari kesan parameter kimpalan pada bahan yang dikimpal.

## **ABSTRACT**

This report is the result of an experiment to investigate the tensile strength of the welding area. By using ABB Metal Inert Gas(MIG) Robot Welding to optimize the setting of welding parameter of voltage, welding speed and welding pattern on tensile strength of welding area of Mild Steel AISI 1020 as a workpiece material. In the main, the welding parameter will be influenced the result of tensile strength of welding material. The design of experiment by using Taguchi Method was created, the signal to noise ratio was used to study the welding parameter effect to tensile strength of the welding part.

## **DEDICATIONS**

This project was dedicated to my parents, Mr. Nasrudin Bin Abdullah and Mrs Suriati Binti Ibrahim, all my siblings and my friends. Not to forget, to my supervisor Mr. Mohd Hairizal Bin Osman. Thank you for your idea and support so that the report can be completed successfully.

## **ACKNOWLEDGEMENT**

In the name of Allah S.W.T, The Most Beneficial and The Most Merciful. It is with deepest serve gratitude of the Al-Mighty that gives me strength and ability to complete this final year project report.

First of all, I would like to take this opportunity to express my special thanks to my supervisor, Mr. Mohd Hairizal Bin Osman for the guidance, assistance, advise, kindness and also being helpful to guide me all the way through the development and progress of my final year project. Above all and the most needed, he provided me unflinching encouragement and support in various ways.

My appreciation also goes to my friends for their advice, supervision, and crucial contribution, which made them a backbone of this project to become successfully. Thank you for lending hands during progress of the project.

Finally, I also would like to express my exceptional thanks to my beloved parents for their support and unending prayers and helps me directly or indirectly in successful finishing of my final year project.



# TABLE OF CONTENT

ABSTRAK	III
ABSTRACT	IV
DEDICATIONS	IV
ACKNOWLEDGEMENT	VI
TABLE OF CONTENT	VII
LIST OF TABLE	XI
LIST OF FIGURES	XII
LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE	XVI
<b>CHAPTER 1 : INTRODUCTION</b>	<b>1</b>
1.0 Introduction	1
1.1 Background of study	1
1.2 Problem Statement	2
1.3 Objective	3
1.4 Scopes	3
<b>CHAPTER 2: LITERATURE REVIEW</b>	<b>5</b>
2.0 Introduction	5
2.1 Joining Technology	5
2.1.1 Welding	6
2.1.2 Brazing	6
2.1.2.1 Torch Brazing	7
2.1.2.2 Furnace Brazing	8
2.1.2.3 Silver Brazing	10
2.1.2.4 Dip Brazing	11
2.1.3 Soldering	12
2.1.3.1 Silver Soldering	13
2.1.3.2 Induction 14	

2.1.4	Adhesive Bonding	15
2.1.5	Mechanical Fastening	16
2.2	Introduction to Welding	17
2.2.1	Geometry of Welding	18
2.2.2	Quality of Welding	19
2.2.3	Heat Affected Zone	20
2.2.4	Safety issues	20
2.3	Types of welding	20
2.3.1	Shielded-Metal Arc (SMAW) or Stick Welding	21
2.3.2	Gas-Metal Arc Welding (GMAW)	21
2.3.3	Friction Welding	23
2.3.4	Spot Welding	23
2.4	Welding Parameter for MIG Welding	24
2.4.1	Current	25
2.4.2	Voltage	25
2.5	Carbon Steel	28
2.5.1	Low Carbon Steel	28
2.5.2	Medium Carbon Steel	28
2.5.3	High Carbon Steel	29
2.5.4	Very High Carbon Steel	29
2.7	Applications of Low Carbon Steel 1020	30
2.8	Minitab Software	30
2.9	Taguchi Method	32
2.10	Analysis of Variance (ANOVA)	43
2.10.1	Statistic Test for ANOVA	50
2.11	Tensile Strength	53
	<b>CHAPTER 3: METHODOLOGY</b>	<b>55</b>
3.0	Introduction	55
3.1	Methodology	55
3.2	Flow Chart of Research	56

3.3	Preparation for Experiment	58
3.3.1.	Material	58
3.3.2	MIG Robot Welding	59
3.4	Preparation process	60
3.4.1	Mild Steel Plate Preparation	60
3.5	Welding Parameter Setup	62
3.5.1	Parameter Setting	62
3.5.2	Taguchi Method	63
3.6	Welding process	67
3.6	Cut into ‘dogbone’ Process	69
3.7	Tensile Testing Process	70
3.8	Analyze Data	73
<b>CHAPTER 4: RESULT AND ANALYSIS</b>		<b>76</b>
4.0	Introduction	76
4.1	Result of the Experiment	76
4.1.1	Graph Obtained from Tensile Test	78
4.1.1	The Average Tensile Strength	87
4.1.2	Results of Signal to Ratio and Mean	91
4.1.3	Main effects plot for S/N Ratio and Means	91
4.1.4	Response Table for S/N Ratio and Mean	94
4.2	Taguchi Analysis Prediction	97
4.3	Confirmation Test	98
4.4	Analysis of Variances (ANOVA)	99
<b>CHAPTER 5: CONCLUSIONS</b>		<b>102</b>
5.0	Introduction	102
5.1	Summary of Research	102
5.2	Achievement of Research Objectives	103
5.3	Recommendation	103

<b>REFERENCES</b>	<b>104</b>
<b>APPENDICES</b>	<b>111</b>

## LIST OF TABLE

1.1	Type of parameter	2
1.2	Experimental layout using Taguchi Method	3
2.1	Example of $L_9(3^2)$ Array	36
2.2	Example of $L_4(2^3)$ Array	37
2.3	Example of $L_9(4^4)$ Array	38
2.4	Example of $L_9(3^2)$ Array	38
2.5	Signal to Noise Ratio	40
2.6	Summary of ANOVA	50
3.1	Machining Parameter	62
3.2	The Parameter of three factor	63
3.3	The Experimental Design using $L_9$ Orthogonal Array	65
3.4	Welding Parameter using Taguchi Method	66
4.1	Level of Parameter and Observed Value	77
4.2	Experimental Layout using Taguchi Method	77
4.3	The Taken Value Tensile Test for Every Specimen	87
4.4	The Value of Average Tensile Test for Each Specimen	88
4.5	The Result for Means and S/N Ratio	91
4.6	Response Table for S/N Ratio	94
4.7	Response Table for Means	95
4.8	The result for optimum parameter	98
4.9	Percentage of contribution for each factor	100

## LIST OF FIGURES

2.1	The Brazing Schematic	7
2.2	Process of Torch Brazing	8
2.3	Furnace Brazing Schematic	9
2.4	Furnace Brazing Process	9
2.5	Silver Brazing using Silver Alloys	10
2.6	Dip Brazing Schematic	11
2.7	Dip Brazing Process	11
2.8	The Soldering Process	12
2.9	Silver Soldering Process on Silver	13
2.10	The Induction Brazing Process	14
2.11	Structure of Adhesive Bonding	15
2.12	Types of Mechanical Fastening	16
2.13	Example of the Mechanical Fastening	17
2.14	Types of Welding Joint	18
2.15	An Illustration of Good Welding Quality	19
2.16	Shielded-Metal Arc	20
2.17	Gas-Metal Arc Welding (GMAW)	21
2.18	Friction Welding	23
2.19	Spot Welding	24
2.20	Image of Different Welding Quality using Different Current	25
2.21	Image of Different Welding Quality using Different Voltage	26

2.22	Image of Different Welding Quality using Different Welding Speed	27
2.23	Image of Different Welding Quality using Different Gas Flow Rate	27
2.24	Composition of steel and iron for each type of carbon steel	29
2.25	Logo of Minitab Software	31
2.26	Dr Genichi Taguchi	32
2.27	F- Distribution Graph	44
2.28	Example of ANOVA	45
3.1	Project Flow Chart	56
3.2	Process Flow Chart	57
3.3	Simulation Diagram of Robot Arc Welding using Metal Inert Gas	59
3.4	MIG Robot Welding	59
3.5	Mild Steel plate dimension	61
3.6	Mild Steel plate after grooving process	61
3.7	The selection in Minitab for Taguchi Method	63
3.8	The Assign Factor and Level	64
3.9	Orthogonal Array Design	64
3.10	Taguchi Method Arrangement using Minitab	66
3.11	The Position of the Plate for Welding Operation	67
3.12	The Plate after Welding Process	67
3.13	Welding Process	68
3.14	Flow Chart for Welding Process	68
3.15	The Dimensions of the Part for Testing Process	69
3.16	Cutting Process Using Laser Cut Machine	69

3.17	The Specimens after Cut	70
3.18	Tensile Test Machine INSTRON 600DX	71
3.19	The Tensile Testing Process	71
3.20	Example of the Graph Obtained From the Test	72
3.21	Flowchart for Tensile Test	72
3.22	The Specimen after Tensile Test	73
3.23	The Selection in Minitab for Anlyze Data	74
3.24	Selection for Signal to Noise Ratio	74
3.25	The Factor and Level Input to get the Predicted Value	75
4.1	Result of the First Specimen from Experiment 1	78
4.2	Result of the Second Specimen from Experiment 1	78
4.3	Result of the Third Specimen from Experiment 1	78
4.4	Result of the First Specimen from Experiment 2	79
4.5	Result of the Second Specimen from Experiment 2	79
4.6	Result of the Third Specimen from Experiment 2	79
4.7	Result of the First Specimen from Experiment 3	80
4.8	Result of the Second Specimen from Experiment 3	80
4.9	Result of the Third Specimen from Experiment 3	80
4.10	Result of the First Specimen from Experiment 4	81
4.11	Result of the Second Specimen from Experiment 4	81
4.12	Result of the Third Specimen from Experiment 4	81
4.13	Result of the First Specimen from Experiment 5	82
4.14	Result of the Second Specimen from Experiment 5	82



4.15	Result of the Third Specimen from Experiment 5	82
4.16	Result of the First Specimen from Experiment 6	83
4.17	Result of the Second Specimen from Experiment 6	83
4.18	Result of the Third Specimen from Experiment 6	83
4.19	Result of the First Speciment from Experiment 7	84
4.20	Result of the Second Specimen from Experiment 7	84
4.21	Result of the Third Specimen from Experiment 7	84
4.22	Result of the First Specimen from Experiment 8	85
4.23	Result of the Second Specimen from Experiment 8	85
4.24	Result of the Third Specimen from Experiment 8	85
4.25	Result of the First Specimen from Experiment 9	86
4.26	Result of the Second Specimen from Experiment 9	86
4.27	Result of the Third Specimen from Experiment 9	86
4.28	Main Effects Plots for S/N ratios	93
4.29	Main Effects Plots for Means	93
4.30	The prediction value for optimum parameter	97
4.31	Analysis of Variances for S/N Ratios	100

## **LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE**

ANOVA	-	Analysis of Variance
Al	-	Aluminium
MIG	-	Metal Inert Gas
GMAW	-	Gas Metal Arc Welding
HAZ	-	Heat Affected Zone
SMAW	-	Shielded-Metal Arc Welding
OA	-	Orthogonal Arrays
DoE	-	Design of experiment
S/N	-	Signal-to-Noise ratios
AISI	-	America Iron and Steel Institute
ASTM	-	American Standard Testing and Material
UTS	-	Ultimate Tensile Strength
DF	-	Degree of Freedom

# **CHAPTER 1**

## **INTRODUCTION**

### **1.0 Introduction**

This chapter includes the background of the study, problem statement, objective and scope. This chapter is an initiation to the whole project about joining low carbon steel 1020 using Metal statement, objectives that is expected to be achieved and the scope of the study that is going to be conducted.

### **1.1 Background of study**

Low carbon steels generally contain less than 0.25% carbon and cannot be strengthened by heat-treating. The low carbon material is relatively soft and weak, but has outstanding ductility and toughness. In addition, it is machinable, weld-able, and is relatively inexpensive to produce. Low carbon steel is widely used in high volume screw machine parts applications, such as shafts, spindles, pins, rods, sprocket assemblies, and an incredibly wide variety of component parts. Robotic Metal Inert Gas (MIG) welding, also known as Gas Metal Arc Welding (GMAW) is a commonly used, high deposition rate process that involves feeding a wire continuously toward the heated weld tip. It is considered a semi-automatic welding process. MIG welding is one of the most popular forms of welding in industrial applications and is an easy process to integrate to a robot

system. MIG welding provides a faster process than other forms of welding, especially when robots are incorporated. The first robot welding machine established is when the automotive industry began using robots extensively for spot welding. This welding machine was used widely because it gave better result than manpower itself. The accuracy and precision of robot welding give the best output. MIG welding robots are capable in all position, this factor helps the welding system to be more flexible, higher quality welds can be and more efficient processes are just some of the advantages of MIG welding automation. The factor of safety for the welder is also increases as it is safe from dangerous fumes, higher quality welds can be improved and the efficiency of the welding process can be enhanced. Tensile test is also known as tension test is probably the most fundamental type of mechanical test that can be performing on welding part to see the strength of welding area. Tensile tests are simple, relatively inexpensive, and fully standardized. By pulling on something, you will very quickly determine how the material will react to forces being applied in tension.

## **1.2 Problem Statement**

In welding process, the parameter is one of the important factors that affect the welding strength. The parameter consists such as voltage, welding speed and welding pattern. By using Taguchi Method, we are going to achieve the optimize parameter for welding low carbon steel 1020 using four variables at three levels. Different kind of parameter will produce different result, so the parts that have been welded will be tested using tensile test machine. The best parameters will be presented with a good result of tensile test.

### 1.3 Objective

The objective of this project includes the main point of the research and the result that we can get from the research. These are the following objectives:

- I. Examine the strength of the welding area for the different specimen using different parameter.
- II. To examine the factor that gives more contribution on welding strength
- III. To determine the optimum welding parameter for joining Mild Steel plate 1020.

### 1.4 Scopes

Firstly, cut the raw material to the needed dimensions is 140mm (length) x 130mm (width) x 6mm (thickness). On every pair of plate, there will be a groove (30°). The welding parameter will be setup on the machine, there will be nine samples with different parameter. The welding process is fully conducted using MIG robot welding. After the welding process, each of the samples will go through the tensile test. The result for each plate with different parameter will be examined.

Table 1.1: Type of parameter

PARAMETERS	LEVELS			OBSERVED VALUES (MPa)
Voltage (V)	21	22	23	Tensile Strength
Welding Speed (m/mm)	4.5	5.5	6.5	
Welding Pattern	Straight	Triangle	Spiral	

Table 1.2: Experimental layout using Taguchi Method

Part	Voltage	Welding speed	Welding pattern
1	21	4.5	Straight
2	22	5.5	Triangle
3	23	6.5	Spiral
4	21	4.5	Spiral
5	22	5.5	Straight
6	23	6.5	Triangle
7	21	4.5	Triangle
8	22	5.5	Spiral
9	23	6.5	Straight

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.0 Introduction**

In this chapter, it consists of literature review by the previous researched based on articles, books, journal and other sources. The explanation of this chapter included about the Metal Inert Gas (MIG) Welding, welding parameter, and material of mild steel and design of the experiment. It covers all the information that has been used in this research and project.

#### **2.1 Joining Technology**

Joining process is processes which combine two parts to become one part, this technology usually used in manufacturing process as it is one of the most processes that can upgrade strength of one part. Several parts is also too big to make it as one part, so joining process could takes place and combine the small part into something big such as underground pipeline. The manufacturer cannot produce such a long pipeline using one process, so they make it in small part and join the parts using joining process. The other reasons the products that using joining process can be disassembled for maintenance likes engine's part. The most familiar joining process that involve in joining process is welding, brazing, soldering, adhesive bonding and mechanical fastening.

### **2.1.1 Welding**

Welding process usually takes place in joining metal because it required a high temperature during the process. Two or more parts are joined permanently at their touching surfaces by a suitable application of heat. Usually used a filler material as a molten material to form a joint between the parts.

### **2.1.2 Brazing**

Brazing is different from welding because it does not melt the base metal. Brazing process takes place by melting the filler and flowing through the gap of the part. The filler metal flows into the gap between close-fitting parts by capillary action. The filler metal is brought slightly above its melting temperature while protected by a suitable atmosphere, usually a flux. It then flows over the base metal and is then cooled to join the work pieces together (Groover, Mikell P., 2007).

In a journal from 1989, Scwartz state that high quality brazed joints requires that parts be closely fitted, and the base metals exceptionally clean and free of oxides. Cleanliness of the brazing surfaces is also important, as any contamination can cause poor wetting flow. The two main methods for cleaning parts, prior to brazing, are chemical cleaning and abrasive or mechanical cleaning. Other than that, the other consideration that has to take control while brazing is the effect of temperature and time on the quality of brazed joints. When the temperature of the braze alloy increasing, the alloying and wetting action of the filler metal increases as well.

For the filler materials, variety of alloys are used for brazing depends on the applications method. Usually, it made up of three metal to form an alloy that give the desired properties. The filler material usually come out in rod, ribbon,