UNIVERSITI TEKNIKAL MALAYSIA MELAKA

# THE OPTIMIZATION OF FRICTION STIR WELDING PARAMETER FOR ALUMINIUM 5052 BY USING FULL FACTORIAL DESIGN

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

By

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2017

# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

**TAJUK: THE OPTIMIZATION OF FRICTION STIR WELDING PARAMETER FOR ALUMINIUM 5052 BY USING FULL FACTORIAL DESIGN**

SESI PENGAJIAN: **2017/2018**

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I hereby, declared this project report entitled "The Optimization of Friction Stir Welding Parameter for Aluminium 5052 by using Full Factorial Design" is the results of my own research except as cited in references

**Signature** :

**Author's Name** : **NOR FAIZAH BINTI ABDUL HALIM**

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# 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 in Manufacturing Engineering Technology (Process and Technology) with Honours. The member of the supervisory is as follow:

…….

(Mohd Hairizal Bin Osman)

# ABSTRAK

Mesin kimpalan geseran (FSW), adalah teknik penyambungan pepejal , yang digunakan secara meluas dengan penggabungan AI, Cu, Ti dan aloi yang sama. Proses (FSW) ini dicipta dan terbukti di The Welding Institude (TWI) di UK, pada tahun 1991, merupakan proses deskriptif yang pertama. Mesin kimpalan geseran (FSW) juga memberi manfaat dalam bidang pembuatan, seperti Aluminium, salah satunya dalam proses penyambungan utama dalam industri penerbangan. Kajian ini membentangkan proses mengoptimumkan parameter (FSW) pada Aluminium 5052 dengan menggunakan –"*Full Factorial Design"*. Parameter yang digunakan adalah seperti pengumpar kimpalan dan kimpalan kadar. Hasilnya , menunjukkan bahawa parameter yang digunakan dengan menggunakan –"*Full Factorial Design"* ini dapat di analisis menggunakan (ANOVA). Ketepatan parameter yang di kaji ini , dapat dibuktikan dengan menggunakan kaedah perisian Minitab 15.

# ABSTRACT

The Friction Stir Welding (FSW), is a solid state joining process, is widely used in the consolidation of the same AI, Cu, Ti, and alloys. This process (FSW) was created and proved at The Welding Institute (TWI) in the UK, since 1991, it was the first most descriptive process. The Friction Stir Welding (FSW) also benefits in the field of manufacturing of products, such as Aluminium, one of which is in the main connecting process in the aircraft industry. This study presents about The Process of Optimizing Parameters (FSW) on Aluminium by using Full Factorial Design. The parameters used are spindle speed and weld rate. The result demonstrate that, the parameters used can be optimized by using Full Factorial Design, and analyze using ANOVA and Minitab 15 software method. It can prove the parameter accuracy that is being studied by the production of the data.

# DEDICATION

The dedication I want to thanks to all people that hard to help me in complete my thesis. Special appreciation to my beloved mother Fatimah Binti Saad and my family, that always gives a moral support. Also, thanks to my friends Riduan Bin Hairus,Madiha Husna Binti Ahmad,Nur Fatihah Binti Nasrudin and Nur Fazreeha Ameelya Binti A.Fadzil. Not to forget to my supervisor Mr Mohd Hairizal Bin Osman always help me.

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# ACKNOWLEDGEMENTS

Bismillahirrahmanirrahim,

Alhamdulilah, I would like to thanks Allah S.W.T the Most Merciful and blessing me through all the obstacle that I faced during the work of this project. As my individual project, this project would not have been possible without considerable guidance and support. I would like to record my gratitude to my Supervisor, Mr. Mohd Hairizal Bin Osman as well as my Co-Supervisor, Mr Salleh Bin Aboo Hassan, the advice, guide me and giving me extraordinary experiences throughout the work. I gratefully acknowledge my family as they are the backbone of this project to become successful. Thank you for the contributions and helping me in my final year project. Lastly, it is a pleasure to express my gratitude whole heartedly to lecturers, classmate and friends who contributed to this project directly and indirectly.

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| | | |
|---|---|---|
| AI | - | Aluminium |
| ANOVA | - | Analysis of Variance |
| AA | - | Aluminium Alloys |
| FSW | - | Friction Stir Welding |
| TWI | - | The Welding Institude |
| AWS | - | American Welding Society |
| ASTM | - | American Society for Testing and Materials |
| UTS | - | Ultimate Tensile Strength |
| RS | - | Rotational Speed |
| TS | - | Transverse Speed |
| DOE | - | Design of Experiment |
| DF | - | Degrees of Freedom |
| Seq SS | - | Sequential Sums of Squares |
| Adj SS | - | Adjusted Sums of Squares |
| Adj MS | - | Adjusted Mean Squares |
| F | - | F-value |
| P | - | P-value |
| % of Total | - | Percentage of the Total Variance Contribution |

# CHAPTER 1

# INTRODUCTION

## 1.0 Background

Friction stir welding (FSW) is a solid state joining process that uses a non-consumable device two confronting work piece without dissolving the work piece material. Heat is generated by friction between the rotating tool and the work piece material, which leads to a softened region near the FSW tool. While the devise is traversed along the joint line, it mechanically intermixes the two pieces of metal and produce the hot and softened metal by the mechanical pressure, which is applied by the tool, much like joining clay, or mixture. It is essential utilized on expelled aluminium and especially for structures which require high weld quality.

A rotating cylindrical tool which a profiled probe is fed into a butt joint between two clamped work pieces until the shoulder, which has a bigger width than the pin, touches the surface of the work pieces the probe is slightly shorter than the weld depth required, with the tool shoulder riding a best the work surface. After a short dwell time, the tool is pushed ahead along the joint line at the pre-set welding speed. This procedure of the tool navigating along the weld line in a plasticized tubular shaft of metal outcomes in solid state deformation including dynamic recrystallized of the base material. Friction Stir Welding is a process which produces welds of high quality in hard to weld materials, for example as aluminium and is fast becoming the process of

choice for assembling lightweight transport structures such as boats, trains and aeroplanes.

Friction Stir Welding (FSW) can be utilized on several welding configuration techniques which include butt joints, lap joints, T joints and fillet joints (R.S.Mishra and Z.Y.Ma, 2005). Friction Stir Welding (FSW) consumes non-consumable rotating tool consists of a pin probe and a plunge shoulder. High speed of rotating tool generates frictional heat between the tool shoulder and two plate surfaces. There are two stir welding parameter factors to be considered names tool rotational speed and welding speed. Full Factorial is design of experiment is selected in this study due to their simplicity.

## 1.1 Objective

The objectives of this project are mainly focus:

1. To determine the significant factor affecting the parameter process on tensile by using Friction Stir Welding.
2. To optimize of the tensile strength of material Aluminium 5052 by using Friction Stir Welding
3. To determine the most significant level of parameter using the Taguchi and ANOVA method

## 1.2 Project Scope

Scopes for this project is based on objectives that have stated and there are the several scopes considered in this study.

The research has focused on the Optimization Friction Stir Welding (FSW) parameter for Aluminium 5052 by using Full Factorial Design. There are, two types of process parameter were used. There are spindle speed and weld rate. Material used is Aluminium 5052 with thickness 2mm .The machining process was conducted by using Friction Stir Welding (FSW) machine. This research applied design of experiment under Full Factorial Design approach by Full Factorial Design method, it have to find the optimum cutting condition by using Minitab 15 software. At the end, all the data and result analysis were discussed accordingly.

## 1.3 Problem Statement

High quality precipitation hardening high-strength low-alloy, for example AI 5052 is utilized broadly in aerospace industry. Aluminium alloy 5052 contains nominally 2.5%, magnesium and 0.25% chromium. It has good workability, medium static strength, high fatigue strength, good weldability and good corrosion resistance. The AA 5052 series alloy a warmth treble with ultimate tensile strength of 28,000psi. There is the increase strength of quality aluminium combination. The alloys are frequently utilized as a part of high application, for example automotive and aerospace industry. One of the significant concerns regarding to this type of solid state welding in industries because this process has a lot of variables and parameter conditions that can affect the quality of a weld joint. The nature of fusion welding is great when contrasted with the other combination welding procedure. A much discussed inquiry is whether the fundamental impact parameter in Friction Stir Welding (FSW) process is rotational speed welding navigating velocity and dive profundity connected against the joint.

## 1.4 Summary of project flow

**Chapter 1:**

Based on this chapter, it is describes the introduction of the project starting with the project background, objective, project scope, problem statement, and summary of this project. The objective is focuses to solve the problem solving

**Chapter 2:**

This chapter is cover on the literature review. It is describes the related research from the journal, website, article and book. This chapter is starting with introduction, Full Factorial Design Method, Welding, Friction Stir Welding, Universal Testing Machine (UTM), and Analysis of Variance

**Chapter 3:**

This chapter based on the methodology. It was explaining the method and process that are required to be following to complete this project. It is also detailed report that is study to achieve the aim objective of this project and the explanation of the procedure of current development of the project.

**Chapter 4:**

This chapter presents the results and the findings of the study, the result from the experiments that are presented in tables, figures and graphs and are discussed elaborately in the chapter. Several observations are also projected from the findings.

**Chapter 5:**

This chapter summarizes the outcomes of this experiment. The chapter also outlines several recommendations for further development and improvement on the design. Suggestions for future inventor are also provided within the chapter.

# CHAPTER 2

# LITERATURE REVIEW

## 2.0 Introduction

In this chapter will be discussing about journal that are linked about this project. Resistance welding process in which combination of faying surfaces of a butt joint is accomplished at one area by restricting of hardware. Generally used in mass production of automotive components and aerospace. As the aerospace industry produces new and more efficient airframes, the need to provide high-strength, lightweight alloys that meet the aggressive design objectives for mechanical performance, manufacturability and service life arises (C. Hamilton, S. Dymek, 2011).

The research of the Optimization of Friction Stir Welding Parameter for Aluminium 5052 by using Full Factorial Design. A Full Factorial Design experimental usually can develop performance and optimize welding parameter of Friction Stir Welding. Generally a suitable welding parameter has the potential to increase a tensile shear strength of the joint. In this studies, the parameter that be highlighted is spindle speed, weld rate. and weld length. Figure 2.1 shows the resistance of Friction Stir Welding (FSW).

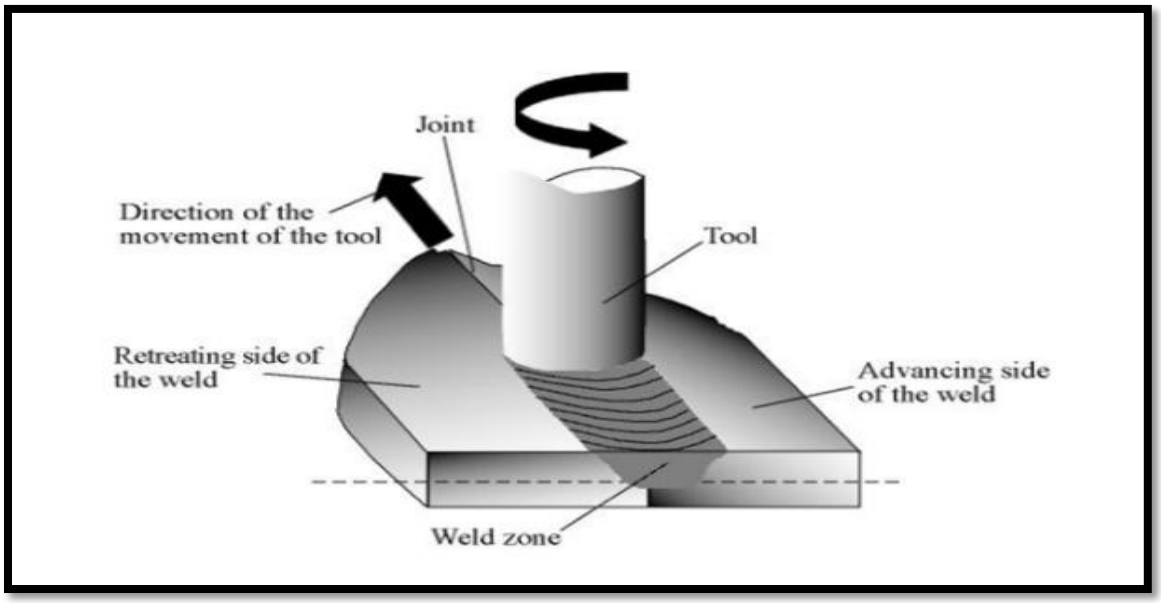


**Figure 2. 1: Resistance Friction Stir Welding**

Research has been done about, the study Friction Stir Welding (FSW) of welding Al 5052 with Al 6061. In this study, about the Friction Stir Welding of two aluminium alloys is AA5052 and AA6061 was carried out at various combinations of tool rotation speeds and tool traverse speeds. The traverse cross-section of the weld was used for optical as well as electron microscopy observations. Then, the microstructural studies were used to get indication of the extent of material mixing both at the macro and microscales. It was observed that, at the interface region both a material exhibited similar texture despite the non-rigorous mixing of mixing of the materials in the nugget (N.T.Kumbhar.2012) .Based on previous research, about the effect of tool rotation speed and tool traverse speed on the stirring action and friction heat during Friction Stir Welding (FSW) experiments on dissimilar Al alloys AA5052-O and AA6061-T6 ( J.C.Park and S.J.Kim,2010).