THE CORRELATION OF MICROSTRUCTURE – SURFACE ROUGHNESS EFFECT ON FRICTION STIR WELDING LAP JOINT USING AA6061 ALUMINIUM ALLOY

INDAH SITI SHOUFEA BINTI NAHARANUAR
B071710301

BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PROCESS AND TECHNOLOGY) WITH HONOURS

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Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
in fulfillment of the requirements for the degree of
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2022

DECLARATION

I declare that this Choose an item. entitled " THE CORRECLATION OF MICROSTRUCTURE – SURFACE ROUGHNESS EFFECT ON FRICTION STIR WELDING LAP JOINT USING AA6061 ALUMINIUM ALLOY" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : *Indah Siti Shoufea binti Naharanuar*

Date : 18 January 2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours.

Signature :

Supervisor Name : *Ts. Mohd Hairizal Bin Osman*

Date : 18 January 2022

DEDICATION

This research is dedicated to almighty God to Giving me strenght thru this journey. A special appreciation, I dedicated this thesis to my beloved husband and my parents, Mohammad Syafiq bin Mohd Sarif, Naharanuar bin Ayob and Azimah binti Ariffin. As well to my superior Ts. Mohd Hairizal Bin Osman, a lot of thanks for guidance and advices in completing this thesis.

ABSTRACT

Friction Stir Welding (FSW) is advance method in joining two parts by heat that been produced from friction between the stir head and the base metal. Generally, FSW rarely used in industry because of this is new technology and a lot of limitation into apply this technology in industries. Because of that, this study has been conducted to find solution for the limitation to gain new knowledge about FSW. Purpose of this study is to find out The Correlation of Microstructure versus Surface Roughness Effects on Friction Stir Welding for Lap Joint Using Aluminum Alloy 6061. Studies will be conducted in three phases which is it start with journal review, design the tool, followed by fabricate the tool. Second phase, run the friction stir welding using conventional milling machine with 9 differences parameter and surface roughness testing. Last but not list, phase three consist of cutting the part to get specimen that will be used for microstructure testing. At the end of this studies, should be able to determine the microstructure of the specimen either in Dry Friction Stir Welding or Underwater Friction Stir Welding.

ABSTRAK

Friction Stir Welding (FSW) adalah kaedah terkini dalam menyambung 2 bahan melalui haba yang dihasilkan daripada geseran antara pusingan mataalat dan logam asas. Secara amnya, FSW jarang digunakan dalam industri kerana ini adalah teknologi baharu dan banyak halangan untuk menggunakan teknologi ini dalam industri. Oleh sebab itu, kajian ini telah dijalankan untuk mencari penyelesaian bagi halangan yang ada untuk mendapatkan pengetahuan baharu tentang FSW. Tujuan kajian ini adalah untuk mengetahui Korelasi Struktur Mikro berbanding Kesan Kekasaran Permukaan terhadap Pusingan Geseran Kimpalan untuk Sambungan Lap Menggunakan Aloi Aluminium 6061. Kajian akan dijalankan dalam tiga fasa iaitu bermula dengan pembacaan jurnal, reka bentuk mataalat, diikuti dengan pembuatan mataalat. Fasa kedua, menjalankan FSW menggunakan mesin pengilingan konvensional dengan 9 perbezaan parameter dan ujian kekasaran permukaan. Bagi fasa ketiga, terdiri daripada memotong bahagian yang dikimpal untuk mendapatkan spesimen yang akan digunakan untuk ujian mikrostruktur. Di akhir kajian ini, keputusan yang dia harapkan adalah dapat menentukan struktur mikro spesimen sama ada dalam FSW keadaan kering, atau FSW keadaan dalam air.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful,

First and foremost, I would like to thank and praise to Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to Universiti Teknikal Malaysia Melaka (UTeM) in providing the research platform.

My utmost appreciation goes to my supervisor, Ts. Mohd Hairizal bin Osman for all his supports, advice, and inspirations. He consistently patience for guidance and providing priceless insights will forever be remembered.

Last but not list, from the bottom of my heart a gratitude to my beloved husband, Mohammad Syafiq bin Mohd Sarif, for his encouragements and who have been the pillar of strength in all my endeavors. My eternal love also to my son, Haris Nawfal bin Mohammad Syafiq, for their patience and understanding. I would also like to thank to my beloved parents Naharanuar bin Ayob and Azimah bin Ariffin for their endless supports, loves and prayers. Finally, thank you to all the individual who had provided me the assistances, supports and inspirations to embark on my study.

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LIST OF SYMBOLS AND ABBREVIATIONS

FSW	-	Friction Stir Welding
etc	-	And the other things
Kg	-	kilogram
FRW	-	Friction Welding
PP	-	Polypropylene
g	-	gram
°	-	Degree
Rpm	-	Rotation per minute
HAZ	-	Heat Affected Zone
HRB/HRC0	-	Value hardness in Rockwell
Kw	-	Kilowatt
Kg/mm3	-	Kilogram per cubic milimeter
UV	-	Ultraviolet
Mm	-	Milimeter
V	-	Voltage
AC	-	Altenative current
DC	-	Direct Current
HP	-	Host Power
AA6061	-	Aluminium Alloy 6061
Mm/min	-	Milimeter per minute

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

In the machinery industry, joining two or more materials has become one of the most important procedures. These methods of combining materials have been used for centuries and decades to make a better and more flexible shape for easier use. One material can be joined with another that is comparable or distinct and suitable. The most basic instrument for combining materials is the nail and hammer, but it has a variety of drawbacks, including material hardness, accuracy, the number of products that may be made, and product durability.

The process of connecting two metals is known as metal fabrication. The diagram below displays the classification of joint processes, from permanent and nonpermanent categories to subcategories at a deeper level. One of the most often used processes in industry is solid state.

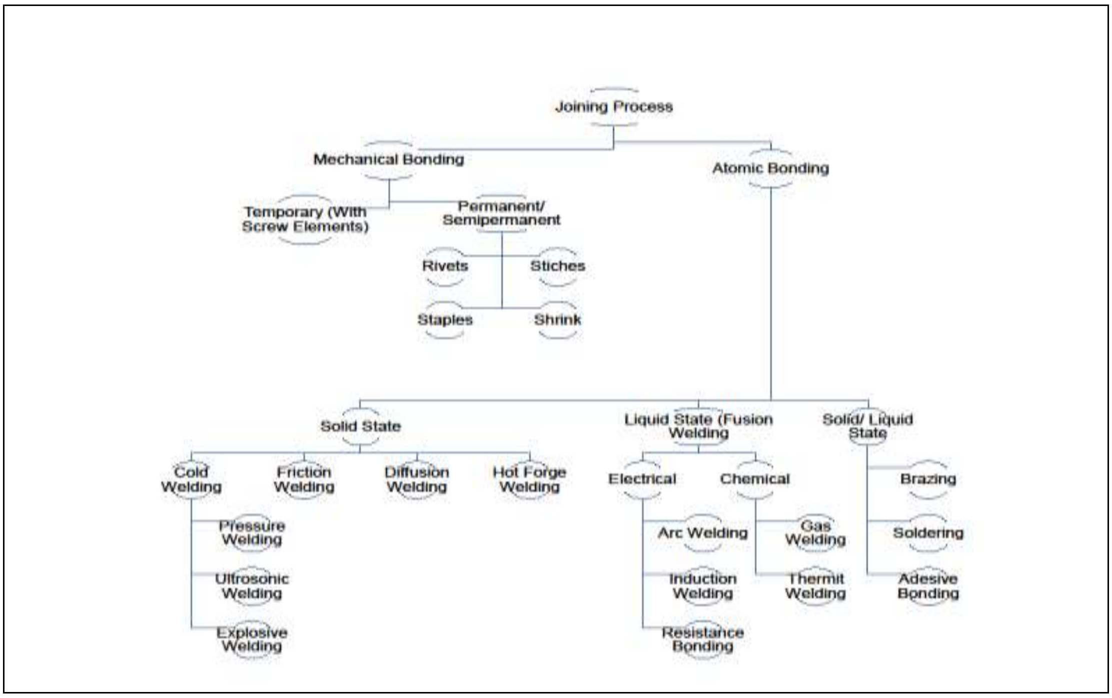

Figure 1.1 Chart Tree Joining Process

Welding is a technique for joining two or more materials. Welding is a fabrication or sculptural technique that uses coalescence to join materials, most commonly metals or thermoplastics. This is frequently accomplished by melting the workpieces and adding a filler material to form a pool of molten material (the weld pool) that cools to form a strong joint, with pressure being used in conjunction with heat or alone to achieve the weld. The welding process is descended from several processes, each with its own set of characteristics. Friction welding, for example, melts the filler material using the heat generated by friction.

Friction Stir Welding (FSW) is a solid-state welding process that uses mechanical friction to generate heat between workpieces in relative motion, as well as a lateral force called "upset" to plastically displace and fuse the materials. Friction Stir Welding is a forging technique rather than a welding procedure in the usual sense because no melt occurs. The name has gained popular due of the similarities between these procedures and classical welding. Friction Stir Welding is used in a range of aviation and automotive applications using metals and thermoplastics.

Friction Stir Welding (FSW) is a solid-state joining technology that uses frictional heat generated by a revolving tool to fuse materials (the metal is not melted). The non-consumable tool is rotated and plunged between two workpieces into the interface using a profiled probe and shoulder. It then moves along the joint axis, causing the material to heat up and soften. The shoulder is also contained in this plasticized material, which is manually mixed to make a solid phase weld.

In the last two decades, several variations of Friction Stir Welding (FSW) have gained popularity. For classical FSW, several researchers enhanced auxiliary energy sources to obtain better welding speeds and tool life at a lower cost. FSW has an edge over other welding procedures when it comes to connecting dissimilar materials like aluminum and steel. Friction stir welding (FSW) is widely used in a variety of sectors due to its high performance and long-term durability. This approach is widely used in the automotive, aerospace, shipbuilding, and railway industries.

When compared to traditional welding methods, the FSW has a significant advantage in that it reduces the number of process factors that must be managed. Travel speed, rotation speed, and pressure are the only three process parameters that must be monitored in FSW. This complicates the welding process even more, potentially increasing manufacturing costs. Furthermore, welds made with FSW have shown to have good mechanical qualities and the capacity to weld materials that were previously thought to be "un-weldable."

1.2 Problem Statement

Friction Stir Welding rarely used in industry because of it is new technology. Several studies have been done to understand and improve the process in this technology. Geometrical parameters of the tool bit play very important roles because it is resulting on metal flow and heat generation. Both factors also might cause defects during welding operations. By studying the effects of different geometry of the tool bit types on microstructure, good tool can be designed, and the process can be improved.

1.3 Research Objective

The objectives of this project shown as below:

a) To design and fabricate tool for Friction Stir Welding.
b) To study the weldability of Aluminium Alloy 6061.
c) To study effects on different geometry of tool bit types on surface roughness and microstucture of Friction Stir Welding Plate.

1.4 Scope of Research

The scope of this research are as follows:

1. To carry out in depth study on the friction stir welding process – step, parameters, machines, and application.
2. To fabricate several design tool types for Friction Stir Welding (FSW) by using Conventinal Lathe and CNC Milling Machine.
3. To study surface roughness value and grain boundries of the microstructure.

1.5 Thesis Outline

The structure of this thesis is based on the publications of this research and follows the thesis format of Universiti Teknikal Malaysia Melaka (UTeM). An introduction, literature review, methodology, findings and comments, and conclusions are included in each report chapter. The following are the specifics of the arrangement:

i) Chapter 1: The concerns exist from this study, and the research goals were mentioned clearly in this chapter. The importance of this study, as well as the extent of the examination, have been clearly stated.

ii) Chapter 2: This chapter provides an overview of previous research on topics such as tool, jig & fixture, parameter, and materials that are linked to friction stir welding. In addition, the research gap discovered in prior studies was explained in this chapter.

iii) Chapter 3: The research methodologies used in this study are explained in this chapter, with an emphasis on material preparation, machine equipment, and testing settings.

iv) Chapter 4: This chapter presents the result data of the hardness for nine different parameters of each condition within Rockwell Hardness Testing Machine. Besides that, the result was also discussed in this chapter and related to this study's objective.

v) Chapter 5: This chapter gives the project's conclusion based on the study and findings. Aside from that, a suggestion for this study project will be offered.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will define the scope of the literature review as it relates to prior research on friction stir welding in dry and underwater environments. Apart from that, this chapter will highlight the numerous trials and jobs successfully completed by various analysts and professionals in the field of research. Additionally, it illustrates the associated tool materials and various jig and fixture designs utilised in the manufacturing business. This chapter will help with the project's research. Additionally, this chapter was written with the goal of enhancing research and avoiding excessive duplication of the study's issue area. This chapter will describe how data is gathered. The data will be utilized to steer the research project's completion. As a primary source of information, the following were identified:

1. Book
2. Journals

2.2 Friction Stir Welding (FSW)

The Welding Institute (TWI) conducted the first FSW experiment in the United Kingdom in December 1991, with the first phase consisting entirely of laboratory work (Santosh K. Sahu., 2017). Friction Stir Welding (FSW) is a non-consumable joining process that uses an inert tool to connect two workpieces without melting the workpiece's material or adding electrical energy or heat from other workpiece sources (Padmanav Dash., 2017). The friction between the revolving tool and the workpiece material creates heat, which contributes to the softening of the region around the FSW tool (Dawood et al., 2015). The procedure includes mechanically combining the edge zones of two clamped metal species using a spinning tool. To obtain a defect-free welding region, the material structure must spin in lockstep with the tool's rotational speed and move in lockstep with the tool's travel speed (Ilangovan et al., 2015).

FSW is being developed in a variety of industries and research facilities worldwide. Numerous research has been conducted to better understand and expand the FSW process since its inception in 1991. Most of them address challenges such as temperature deformation distribution and heat transmission, mostly via the use of numerical methods such as finite element and finite difference approaches. It is a solid-state joining technology for producing high-quality aluminum alloy welds (Choudhary et al., 2019). FSW has been regarded acceptable for combining various materials such as magnesium, steel, titanium, copper, and composites since that time (Krishna et al., 2014). Friction stir welding has been identified as an ideal solution for enhancing the joining of different materials (Helal et al., 2019). According to (Malopheyev et al., 2016), to fabricate high-strength welds in 6061 Aluminum Alloys, the dissolving process must be accelerated while coarsening is minimized.

2.2.1 Dry Friction Stir Welding (FSW)

According to Narges Dialami et al (2019), Friction Stir Welding (FSW) is a solid-state welding technology that has been extensively used in shipbuilding, railways, and aerospace sectors since its inception because to its low defect and absence of melting. Because FSW is a solid-state joining method, it avoids flaws like hot cracking and porosity. It's used to join a variety of metals, including aluminum, stainless steel, and magnesium, that are difficult to fuse using traditional welding methods.

FSW is a linked thermomechanical process in which heat, and mass transfer alter weld characteristics and microstructure. Base material is heated by the frictional heat generated by the shoulder and agitated by the spinning pin as it passes along the weld line, according to previous research conducted by Hamid Reza Ghazvinloo and Nasim Shadfar in the year 2020. As a result, this method resembles extrusion. Because the temperatures are well below the melting point, problems associated with the liquid/solid phase transition are avoided in this procedure. Figure 2.1 shows a schematic representation of the Friction Stir Welding (FSW) technique, which will be used in this final year project.

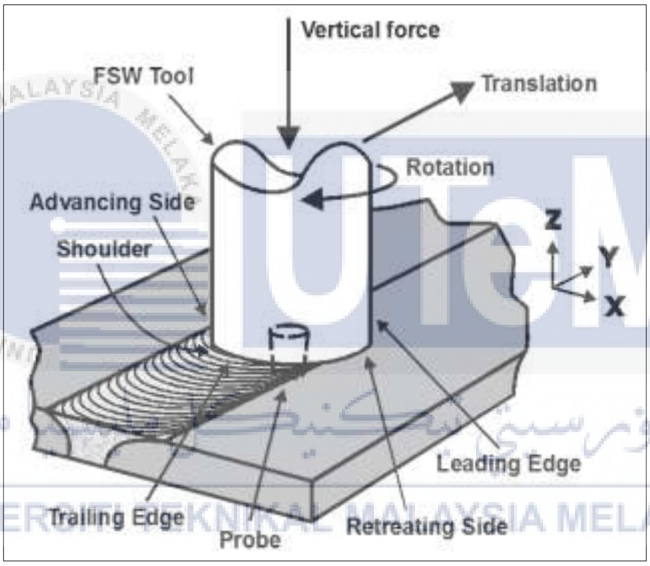

Figure 2.1 The Dry Friction Stir Welding (FSW) Process is illustrated schematically

FSW has several advantages over traditional welding procedures. It creates no noxious gases or toxic fumes, uses significantly less energy, and requires no flux, filler metal, or shielding gas, making it an environmentally benign and energy efficient material joining method. Weld flaws can be extremely problematic. For example, they degrade the quality and strength of welding joints, causing them to fail prematurely. As a result, research into the incidence of weld faults in friction stir welded joints is critical.