IMPACT OF TOOL FEATURES ON THE QUALITY OF WELD IN BFSW PROCESS

Submitted in accordance with the requirement of the University Teknikal Malaysia Melaka (UTeM) for the bachelor's degree of Manufacturing Engineering (Hons)

by

FARIS AFIQ BIN AHMAD

B051510256

961226-14-6401

FACULTY OF MANUFACTURING ENGINEERING

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DECLARATION

I hereby, declared this report entitled "IMPACT OF TOOL FEATURES ON THE QUALITY OF THE WELD IN BFSW PROCESS "is the results of my own research except as cited in reference.

Signature :…….

Author's Name:……

Date :……...

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirement for the degree of Bachelor of Manufacturing Engineering (Hons). The member of the supervisor is as follow:

……

(Dr. Mohammad Kamil Bin Sued)

ABSTRAK

Alat pengacau dengan jenis pin dan bahu yang berlainan digunakan pada kimpalan kacau gesekan bobbin pada bahan AA 1100. Dimensi pada AA1100 akan menjadi 140mm x 140mm x 6mm dan akan siap dengan plat berkondisi rata. Terdapat empat jenis ciri alat dalam eksperimen ini, pin berulir dengan bahu skrol, eksentrik pin berulir dengan bahu skrol, 4 pin Flat dengan bahu rata dan pin silinder dengan bahu rata. Semuajenis pin alat yang berbeza akan memberikan kesan yang berbeza terhadap kualiti kimpalan dan menghasilkan sifat mekanikal yang berbeza. Eksperimen akan dijalankan pada ujian mekanikal pada mesin tegangan. Semua empat alat yang berbeza akan menghasilkan kekuatan tegangan, getaran dan analisis suhu yang berbeza pada bahan yang dikimpal. Parameter pengelasan telah dipilih dari mengoptimumkan parameter oleh penyelidik terdahulu. Oleh itu, alat yang mempunyai kekuatan tegangan tinggi, getaran yang baik dan tindak balas suhu akan dipilih kerana menghasilkan kimpalan yang berkualiti.

ABSTRACT

Stir tools with different type of pin and shoulder were applied to the bobbin friction stir welding on AA 1100 material. The dimension on AA1100 will be 140mm x 140mm x 6mm and will completing with butt joint. There are four types of tools features in this experiment, threaded pin with scroll shoulder, eccentricity of threaded pin with scroll shoulder, 4 Flats pin with flat shoulder and cylinder pin with flat shoulder. Those different type of tool pin will give different effect on quality of weld and different mechanical properties produce. The experiment will conduct on mechanical testing on ultimate tensile machine. All four different tools will be produced different tensile strength, vibration and temperature analysis on welded material. The welding parameter has been selected from optimize parameter by previous researcher. Hence, the tools with high tensile strength, good vibration and temperature responds will be selective due to produced good sound weld.

DEDICATION

TO MY BELOVED PARENTS,

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TO MY BELOVED GRANDPARENTS,

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TO MY HONOURED SUPERVISOR

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For his advices, support, motivation and patience during completion of this project

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LIST OF ABBREVIATIONS

DOE	-	Design of Experiment
HAZ	-	Heat Affected Zone
NWZ	-	Nugget Welded Zone
CFSW	-	Conventional Friction Stir Welding
BFSW	-	Bobbin Friction Stir Welding
TWI	-	The Welding Institute
BM	-	Base Material
SEM	-	Scanning Electron Microscope
TEM	-	Tunnelling Electron Microscope
XRD	-	X-ray Diffraction
DSC	-	Differential Scanning Calorimetry
AS	-	Advancing Side
RS	-	Retreating Side
TMAZ	-	Thermal Mechanical Affected Zone
SZ	-	Stir Zone
PAZ	-	Pin Affected Zone
RFZ	-	Rotational Flow Zone
SAZ	-	Shoulder Affected Zone
KB	-	Kissing Bond
NZ	-	Nugget Zone
RPM	-	Revolution per minute
ASTM	-	American Standard Testing of Material
UTM	-	Ultimate Tensile Machine
ANOVA	-	Analysis of Variance

LIST OF SYMBOLS

°C	-	Degree Celsius
MPa	-	Mega Pascal
mm/min	-	millimetre per minute
%	-	percent
HB	-	Hardness Brinell
HV	-	Hardness Vickers
Hz	-	Hertz
µm	-	micrometre
kN	-	kilo Newton
VRms	-	Voltage Root Mean Square

CHAPTER 1
INTRODUCTION

The introduction of this project means to elaborate the main idea of the project by introducing its title, background of project, problem statement, objective, the significant of project and the scope that are going to be covered in this project.

1.1 Background

Friction Stir Welding (FSW) was invented at the The Welding Institute (TWI), United Kingdom in 1991. It was an alternative joining technique for fusion welding. This technique is categorized as solid-state welding which material between two plate are joined together at below temperature of melting point. The process of FSW occur when tool shoulder contact with the workpiece to be weld. FSW process occurs when shoulder and pin of tool features is contact with the workpiece to be weld. The most heat generates on shoulder part of the tool features. Vijay and Murugan (2010) claimed that the joining process occurred when frictional heat produced by the FSW tool when in contact with the area need to be weld combining with the surrounding temperature causing the stirred material to be softened and mixed. Theoretically, the grains contact with each other between plate were transferred and rearranged at same time and produced the strong join. The advantages of this FSW are minimum observing during process run, low energy consumption, good weld strength almost same characteristics of the material to be weld and minimum requirement for secondary process which finishing process. Other welding technique such as Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW) and Shielded Metal Arc Welding

(SMAW) are under fusion welding which those technique used filler material and gas to ignite the process. Those process are not greenly environment. The process produces hazardous gas such as oxyacetylene and argon.

According to, as solid-state welding eliminates many of the defects that usually occurred in fusion state welding such as shrinkage, solidification, cracking and porosity. Other that, FSW also produce uniquely bond of original material, good strength, bending and fatigue properties. FSW is the one new method that permanently joining the metal in greener way.

Impact of tool features on the quality of welded part plays an important role in the conventional friction stir welding (CFSW) to verify whether the welded part in good or not in its mechanical properties. This is because the better design for tool features can make the product more durability. Tool features gives slightly effect on material flow on the quality of weld in CFSW. The main mechanic involved in FSW are the thermal flow, flow dynamics and the metallurgy. Flow occurring under the tool contains two types which are pin-driven flow and shoulder-driven flow. Both tools are affecting the material plastic flow and deformation on the microstructures of the plate. Besides, the design of the tool is likewise known to influence the shape, size and area unfilled weld (defects). Thus, to achieve good quality on weld in FSW, the role and effect of the tool design need to be understood. Each design of the tool features has its own pros and cons effect on the weld quality. For instance, the one pros of the tool feature design are producing low energy consumption while high heat friction process generates on the plate and produce good in mechanical properties. Meanwhile for the cons of the tool contains distortion, penetration and weak weld strength during process of friction stir welding occur.

1.1.1 Conventional Friction Stir Welding (CFSW)

Tool design for CFSW has been dynamic zone of research for single shoulder type CFSW tools. There are three sorts to consider be quality factor of weld which are (1) Pin, (2) Shoulder, (3) Tool measurements. Those known practical results of each are recognized as pursues.

Pin features: vertical movement can be presented with cylindrical thread pin feature, while flutes and flat faced features impact horizontal movement which helps in mixing of material through the procedure. A most extreme of four flutes/faces is favoured similarly as with extra flutes/faces give little differences effect. Also, a tapered pin decreases the torque and bending moment as a result of decreased cleared volume on mixing.

Shoulder features: the essential plan feature is the general shape: flat, concave or convex frame. Thus, the concave design is commonly used to ease the material flow generated by tool pin. Meanwhile, for the convex shoulder its can easily lift up from workpiece at any point position of base material. So, the convex tools give positive results that more flexibility when contact between shoulder and workpiece. Others, secondary features are likewise conceivable, the most widely recognized being a scrolled shoulder. The proposed explanation behind this feature is to move material from the outer shoulder inwards. In between, edge filet/chamfer features have likewise been utilized to reduce flash. Every one of the features can be joined in forming complex hybrid tools, a few precedents are contained inside.

Tool dimensions: there are several heuristics that have emerged. For example, it is commonly stated that the pin diameter should be equal to the thickness of the materials to be welded, and pin length should be 0.2 to 0.3 mm shorter than the thickness of the material by Vijay and Murugan (2010). For the shoulder, the diameter should be three times the plate thickness byArora, De, and DebRoy (2011).

1.1.2 Bobbin Friction Stir Welding (BFSW)

The exploration portrayed beforehand is for CFSW, the bobbin case has had significantly less research consideration. While a portion of the basic material science of CFSW is pertinent to bobbin devices, this has not been exhibited definitively. Nor is it sure that the instrument highlights and process-settings are transferable, due to the crucial contrasts in warmth age and stream attributes. The remarkable works here are J.A. Schneider1 (2018). The suggestions from Sued, Pons, Lavroff, and Wong (2014) are from these moderately little collections of literary works, are that apparatus highlights have the accompanying results

a. A cylindrical pin with threaded can create better microstructure grain size and higher bowing strength. On the other hand, three flats can be utilized.
b. A tapered tool pin with three flats results a diameter decrease in the lower shoulder which at that point contributes low torque and bending moment.
c. At the point when weld plates have high flatness variations, convex and scroll shoulder features can successfully done for the joints.

In addition, the study also will compare the weld quality effect on different type of tool design especially on shoulder and pin that has been choose in BFSW. From there, the test process must be considered to observe the quality of the weld after welded the AA1100 material. Next, the purpose is to be choose which tool design will be the best tool among it. There are a lot of pin and shoulder design that commonly use nowadays in BFSW. After the process of welded done, the testing must be run to identify whether the weld quality is in good tensile strength and good in weld responses. The machine to be testing the quality weld are Vickers hardness test, tensile testing machine, Vibration UNI-T 315, and thermocouple picolog Data Logger TC08.

1.2 Problem Statement

In this research, to creating new tools is challenging. This is because to find the best parameter suitable with tool shoulder and pin. The factor of the length of shoulder and pin need to be considered according to previous research. Besides, without choosing better tool features and parameter will produce defects such as kissing bond, tunnelling, void, roster tails and flash on the welded material. Next, there is limited previous study on bobbin friction stir welding tool design. This BFSW not same process as fusion welding that mainly focus material on AA1100 which low melting point that can easily melt. Other that, tool available not produce good sound welds which the things bring problem is the high heat generated from the welding process will affect the microstructures of the material and its mechanical properties. Every problem stated give big impacted on the quality of the weld on AA1100 such as tensile strength, hardness, durability and temperature on welded area.

1.3 Objective

The objectives of this project are:

i. To determine the weld strength of the join by different tool features.
ii. To measure weld response through measurement of vibration, and temperature by different type tools features
iii. To characterise the weld defect related based on different types of the tool features.

1.4 Scope of Research

The scope of this project is focusing about the different tool design features of shoulder and pin that effect on weld quality of the metal to be weld. The quality and features of the weld is strongly related with feed rate and rotational speed of process. Thus, the operation of BFSW are conducted on a CNC milling machine with rotational speed of 900, 950 and 1000 rpm and 120, 110 and 100 mm/min of welding speed respectively. The material to be weld has thickness 6 mm with length and width 140 mm and 140 mm respectively. At the end of the process, the weld part will be test with several type of machine that measure tensile strength (Tensile Test Machine), microhardness machine, UNI-T 315 and thermocouple picolog Data Logger TC08. respond of the weld quality. The purpose is to analyses the strength and durability of the weld part.

1.5 Significance Study

a) FSW is a new alternative way of joining a metal such as butt joint. It also can be applied to most manufacturing industry. Other that, FSW also create a great effect on the microstructure that produce similar strength and fatigue properties almost same characteristics of the material welded and minimum requirement of secondary process such as finishing process.

b) This study is important to identify the successfully of BFSW approach to weld AA1100 material. BFSW are slightly advanced welding process than conventional

FSW that consist additional shoulder. The function of the shoulder is to generate heat easily to produce friction against the material to be weld. BFSW also lead to use for the future industry 4.0 that can eliminate many disadvantages of previous welding process.

c) According to testing section, every tool features design has its own characteristics which contains it certain advantages and disadvantages. The machine used are Hardness Vickers, Tensile machine, UNI-T 315 and thermocouple picolog Data Logger TC08. This obstacle such as distortion, penetration on tool features or metal can prevent those by using some additional part or substance. The additional part is parameter variable or installation of motorized to be control for every tool design and for the substance which is coats the tool features of H13 tool with Zorn Zirconium Nitrate by using Physical Vapour Deposition (PVD).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

` Nowadays, here is industries still used fusion welding due to its material properties and aesthetics for tungsten inert gas (TIG) joint. Thus, this technique that give several negative impacts on external and internal properties of the welded product. For an example of the negative impacts are cracking formation, porosity, blow hole and shrinkage. Focusing on this field of study, Aluminium alloy (AA1100) is the one material that replacing steels which AA1100 are good in corrosion resistance and strength to weight ratio. Then, many industries such as automotive, aerospace and marine industries were used this material of aluminium alloy. In conjunction with that, this effect must be going some further attention need to focus especially in joint edge preparation, the current process needs to prepare a suitable filler rod according to thickness of the plate to be weld. Furthermore, performing long and continuous weld using fusion welding can affect easily on melting of the metal due to expose of the high temperature. Ajri (2017) stated that, the problem can be eliminated by using another alternative in order to re-shape to its original shape.

Friction Stir Welding (FSW) nowadays is well known to be one of the most suitable joining technique and specialized for aluminium alloy and other soft structured alloys. This method can be advanced used rather than conventional method as it can perform long and continuous weld while producing minimum amount of distortion. Thus, it can produce high quality welded product. In this literature review are more focus on different effect of tool features by using bobbin friction stir welding joint (BFSW).

2.2 BFSW Working Principle

Bobbin Friction Stir Welding has 3 type of main stage. First stage is the bobbin being forced through vertically downward the workpiece at the area to be joined. Second is dwell period which occur when the tool rotates at fixed place without any transverse along the workpiece. This method has been used due to build plasticize the material before the tool transverse the workpiece. Last for the welding stage is where the tool started to move transverse along the workpiece to join the two parts together from Ullegaddi, Murthy, Harsha, and Manjunatha (2017). There is additional stage by Zhang, Cao, Larose, and Wanjara (2013),which mentioned of the retracting/cooling stage. When the tool is nearly to achieve the end of the join area, the tool than levitated horizontally from the workpiece.

Basically, the principle of the friction stirs welding occurred in a solid state where the tool gives results of below melting point reading value of the material. The tool generates heat as the tool stir together between the plate as it heated by the heat pressure exerts by the tool itself. There are two categorized of the friction stir welding which are Conventional Friction Stir Welding (CFSW) and Bobbin Friction Stir Welding (BFSW). The difference between two of them are the number of shoulders it has. For CFSW only has one shoulder only while for BFSW has two shoulder only.

2.2.1 Difference Between CFSW and BFSW

W M Thomas (2017) said that the use of bobbin tool type (also known as self-reacting tool) has been proven to have more advantages compared to conventional tool (CFSW) as Figure 2.1.