UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION OF FRICTION STIR WELDING PARAMETER ON ALUMINIUM 5052 ALLOY BY USING TAGUCHI METHOD

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

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(MR. MOHD HAIRIZAL BIN OSMAN)

ABSTRAK

Dalam pembelajaran ini, kepingan Aluminium aloi 5052 dicantumkan dengan menggunakan kaedah tekanan geseran oleh mesin kimpalan geseran dan proses parameter yang terbaik adalah dengan memggunakan kaedah reka bentuk Taguchi (L_9) yang mengandungi 9 percubaan. Dua parameter faktor yang digunakan dalam pembelajaran ini adalah kelajuan putaran pengumpar dan kelajuan kimpalan mesin. Nisbah Signal-to-Noise (S/N) dan Analisis Varians (ANOVA) telah digunakan untuk mengenalpasti kesan ketara parameter yang lebih tinggi untuk melakukan kekuatan tegangan dalam proses pencantuman Aluminium aloi 5052. Dua faktor serta tiga tahap yang berbeza ortogon dilakukan dengan menggunakan program komputer yang diberi nama Minitab. Jumlah keseluruhan sembilan percubaan kajian (L_9) dijalankan untuk mendapatkan parameter yang dapat mencapai kekuatan yang paling tinggi dalam proses pencantuman. Karakter kualiti untuk kekuatan tegangan adalah "lebih besar, lebih baik". Keputusan ramalan dan pengesahan dilakukan untuk gabungan. Nisbah Signal-to-Noise (S/N) dan Analisis Varians (ANOVA) menunjukkan pencantuman terbaik adalah pada 800 rpm kelajuan putaran pengumpar (tahap 1) dan 5mm/s kelajuan kimpalan (tahap 1) atau B1A1.

ABSTRACT

In this study, Aluminium alloy 5052 sheets were joined using Friction Stir Welding machine and the process parameter were optimized using Taguchi L_9 Orthogonal Array design of experiment. Two process parameter which are spindle speed (rpm) and welding speed (mm/s) were considered under this study. Signal-to-Noise ratio (S/N) and Analysis of Variance (ANOVA) were used to identify the significant welding parameters affecting the joint tensile strength. Two factors with three levels orthogonal array were developed by application of Minitab software. A total of nine numbers of trial run (L_9) were used to optimize the process parameters to attain the optimum joint strength in the stir welded samples. The tensile strength was considered as the quality characteristic with the objective concept of "larger is better". The predicted optimum value was confirmed by conducting the confirmation test using the optimum combined parameters. Analysis results from Signal-to-Noise ratio (S/N) and the Analysis of Variance (ANOVA) have indicate that the optimum joint tensile strength was at 8000 rpm spindle (level 1) and 5mm/s weld rate (level 1)or B1A1.

DEDICATION

This report is dedicated to my parent, Mr. Ahmad bin Buhari and Kamariah binti Amir for the knowledge and wisdom that have been taught to me for embrace myself to be better. This dedication is dedicated to my Supervisor and Co-Supervisor, Mr. Mohd Hairizal bin Osman and Mr. Salleh bin Aboo Hassan for helping me a lot in order to prepare this report. This dedication also dedicated to all my beloved friends that never stop giving me encourage and advice until the report is done.

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TWI	-	The Welding Institute
FSW	-	Friction Stir Welding
TIG	-	Tungsten Inert Gas
MIG	-	Metal Inert Gas
GTAW	-	Gas Tungsten Arc Welding
SMAW	-	Shielded Metal Arc Welding
SAW	-	Submerged Arc Welding
GMAW	-	Gas Metal Arc Welding
HAZ	-	Heat Affected Zone
H	-	Heat
I	-	Current
R	-	Resistance
T	-	Time
RMS	-	Root Mean Square
ISO	-	International Standards Organization
ASTM	-	American Standard Testing and Material
BSI	-	British Standard
IEC	-	International Electrotechnical Commission
DIN	-	German Institute for Standardization
ANSI	-	American National Standard Institute

AFNOR	-	Association Francaise de Normalisation (French International Organization for Standardization)
UNS	-	Unified Numbering System (Metals and Alloys)
DXZ	-	Dynamically Recrystallized Zone
TMAZ	-	Thermo Mechanically Affected Zone
RPM	-	Revolution per Minute
NASA	-	National Aeronautics and Space Administration
BMW	-	Bavarian Motor Works
OA	-	Orthogonal Array
ANOVA	-	Analysis of Variance
F	-	F Test (ANOVA)
P	-	Percentage of Error
SS_T	-	Sum Square Deviations Total
SS_d	-	Sum Square Deviations
DF	-	Degree of Freedom
S/N	-	Signal-to-Noise
LB	-	Larger the Better
SB	-	Smaller the Better
NB	-	Nominal the Better
DOE	-	Design of Experiment
UTS	-	Ultimate Tensile Strength
°C	-	Celcius
MPa	-	Mega Pascal
Psi	-	Pounds per Square Inch

Mn	-	Manganese
Cr	-	Chromium
Cu	-	Copper
Mg	-	Magnesium
Si	-	Sillicon
Zn	-	Zinc
Al	-	Aluminium
Fe	-	Iron

CHAPTER 1

INTRODUCTION

In this chapter, it will be explaining the overview of the experiment study of Friction Stir Welding butt joint for single passes of Aluminum alloy. This chapter contain the Background of Research, Problem Statement, Research Objective and Scope of Work that include in this research study.

1.1 Background of Research

Although joining pieces together can be traced back more than 2000 years, welding emerged as a viable manufacturing process only in the late 1800s (Messler Jr, 2004). Friction Stir Welding (FSW) was invented by The Welding Institute (TWI) in December 1991. TWI filled successfully for patents in Europe, the U.S., Japan and Australia. TWI then establish TWI Group- Sponsored Project 5651, "Development of the New Friction Stir Technique for Welding Aluminum", in 1992 to further study this technique. FSW is relatively new joining process that has been used for high production since 1996. FSW is common and widely used as a joining process technique in broad spectrum of industries including automotive, aerospace, shipbuilding or metal fabrication industries. It is specifically adopted for joining Aluminum alloy composite when fusion welding process method is not suitable and practical to be used (P.K. Arya 2015). It has emerged as an excellent joining technique for Aluminum alloy composite since solidification of micro-structure can be avoided due to the low of welding working temperature (L. Commin et. al., 2009). This welding technique promotes several advantages such as user friendly, no welding cracking or porosity, outstanding mechanical joint properties, no fumes produced low residual stress and low energy consumption. Besides, the red glowing and the noise is also quite low that obviously shows it is the simple method but produced good joint of material.

Furthermore, there is no filler material is needed during FSW. This gives further advantage that formation of unwanted phases in the weld microstructure due to the mixing of the filler metal and parent metal, which often differ to a certain extent in alloying can be avoided. It is all about rotating tool pushing through material. The process include a rotating tool inserted into butt of the work piece due to the action of the axial pressure it produces a highly plastically deformed zone through the associated stirring action (G. Elatharasan, V.S. Senthil Kumar, 2013). Before the invention of FSW, there had been some important technological developments of non-fusion welding processes, which have found some limited industrial uses. A significant process of these is FSW develop at the time just before laser was invented. During friction welding, the pieces to be welded are compressed together and are made to move relative to each other. Thus, frictional heat is generated to soften the material in the joining region. The final step is made by applying increased pressure to the softened material to yield a metallurgical joint without melting the joining material. However, the relative movement during the stage of heat generation and material softening can practically only be rotational or linear. Because melting does not occur and joining takes place below the melting temperature of the material, a high-quality weld is created.

Although, friction welding operation is simple, the welding geometry is quite restricted and thus its use is also limited. It is also known as “green welding technology” since it does not produce fumes and flux compared to conventional welding method such as TIG or MIG (Babu S, et. al., 2013). However, quality and reliability of friction stir defect-free welds and reproducibility of the process can only be obtained following acceptable friction stir practice. 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). 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. Combination of frictional heat generated by tool shoulder and stirring heat by pin probe produce highly plastically deform weld zone area (C.J. et. al., 2007). Spindle speed, welding speed and plunge depth are the most significant process factors that affected the mechanical strength of friction stir welded parts (Gerlich et. al., 2007).

However due to a probe pin height availability, the factor of plunge depth is excluded in this research. There are two stir welding parameter factors to be considered in this research study names spindle speed and welding speed. Taguchi design of experiment is selected in this study due to their simplicity. Hence Orthogonal Array (L’9) with three levels is recommended to be applied during this research study.

1.2 Problem Statement

To sustain in global manufacturing competitiveness, manufacturing companies are always continuously striving for improvement in their products quality by producing an exceptional quality products to customers. Higher mechanical strength requirement in engineering industry such as marine and aircraft industries poses the ultimate challenges for the manufacturer. One of the major problem faced is a low capacity in tensile strength. Based on previous studies had shown process parameters such as spindle speed, welding speed and plunge depth have the most significant factors that affected the mechanical strength for aluminum welded components under FSW process joining (Gerlich et. al., 2007). Driven by the necessity to continue enhancing the tensile strength of Aluminum alloy 5052 material in marine industry application these controllable factors setting names rotational speed and traverse speed should be further studied using a structure experimentation approach and expectation result of optimum process setting shall be developed and recommended for marine industry application process references.