UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PINLESS FRICTION STIR WELDING FOR WELD THE THIN PLATE SPCC

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

by

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance) With Honours. The member of the supervisory is follow:

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ABSTRAK

Geseran Kacau Kimpalan Tanpa Pin (GKKTP) menyediakan pelbagai kelebihan pada reka bentuk alat dibandingkan dengan geseran kacau kimpalan tradisional dimana ianya boleh mengelakkan alat menjadi haus dan tiada lubang kunci pada fabrikasi. Sebagai salah satu kimpalan keadaan pepejal yang baru, GKKTP boleh digunakan untuk menggabungkan kepingan nipis SPCC (1 mm tebal). Kajian ini bertujuan untuk menyiasat kesan parameter yang berbeza (putaran kelajuan alat dan kelajuan kimpalan) dengan menjalankan satu ujian kekuatan tegangan dan kekerasan selepas menyiapkan kimpalan bersama. Sejarah haba pada plat SPCC dibawah parameter yang berbeza dan sifat kimpalan telah disiasat. Dalam kajian ini, geseran kacau kimpalan tanpa pin (GKKTP) telah dilaksanakan menggunakan mesin CNC pengilangan menegak dengan dua kelajuan putaran berbeza (900 dan 1050 rpm) dan dua kelajuan kimpalan yang berbeza (45 dan 75 mm/min). Alat yang diperbuat daripada keluli (H13) telah digunakan untuk membuat konfigurasi sendi butt. Pemerhatian ujikaji menunjukkan bahawa sifat-sifat mekanik GKKTP (kekuatan tegangan dan kekerasan) berkurangan dengan peningkatan kelajuan putaran dan mengurangkan kelajuan kimpalan. Walau bagaimanapun, kelajuan putaran dan kelajuan kimpalan memainkan peranan lebih penting dalam proses yang dapat juga dibuktikan dengan data haba diuji dan direkodkan dengan meletakkan K-jenis termokouple. Penyiasatan penggunaan current motor gelendong telah dijalankan untuk mengukur permintaan current semasa proses kimpalan.

ABSTRACT

Pinless friction stir welding (PFSW) provides various advantages on tool design compare to the traditional FSW where it can avoid the wear of the tool and no retained keyholes of fabrication. As a new solid-state welding, pinless friction stir welding (PFSW) can be used to join thin (1 mm thick) SPCC sheet. The aim of this study was to investigate the effect of different parameters (tool rotational speed and welding speed) by conducting a tensile strength test and hardness test after completing the weld joint. The heat history of the SPCC plate under different parameters and the weld properties have been investigated. In this study, PFSW was performed using a CNC vertical milling machine with two different rotational speed (900 and 1050 rpm) and two different welding speed (45 and 75 mm/min). A tool made from steel (H13) was used to make a butt joint configuration. The experimental observations showed that the mechanical properties of PFSW (tensile strength and hardness) decrease with the increasing of rotational speed and the decreasing of the welding speed. However, the rotational speed and welding speed played a more important role in the process which could also be proved by the thermal data tested and recorded by placing K-type thermocouples. The investigation of spindle motor current consumption has been carried out in order to measure the current demand during the welding process.

DEDICATION

To my beloved father (Mohd Abd Wahab Bin Hussin), mother (Kalthom Binti Kassim) and siblings. A special thanks to all of my lecturers and friends that had given me multiple guidelines and support in completing my studies in UTeM.

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LIST OF SYMBOLS

P	-	Power
Ω	-	Spindle Speed
M	-	Torque

LIST OF ABBREVIATIONS

3D	Three dimensional
AS	Advancing Side
ASTM	American Society for Testing and Materials
BFSW	Bobbin Friction Stir Welding
BM	Base Material
CFSW	Conventional Friction Stir Welding
FSW	Friction Stir Welding
GMAW	Gas Metal Arc Welding
HAZ	Heat Affected Zone
HV	Hardness (Vickers)
ISO	International Organization for Standardization
JIS	Japanese Industrial Standard
NZ	Nugget Zone
PFSW	Pinless Friction Stir Welding
RS	Retreating Side
TMAZ	Thermos-Mechanically Affected Zone
TWB	Tailor Welded Blank
TWI	The Welding Instituted

CHAPTER 1

INTRODUCTION

1.0 Background of Study

Welding is a permanent process to join two or more parts at their touching surfaces by a suitable application of pressure and heat. Metal and alloy parts are primarily material utilized in the welding process. During the welding process, the parts of the material to be joined are melted at the joining edge interface. Typically, a filler metal is added to fill a space of molten material that become harden to bolster the joint.

Welding processes are classified into two major groups that are liquid-state welding and solid-state welding. Liquid-state welding known as fusion welding require base metal to melt by means of heat. In their operation, another metal such as filler metal is added to fill the space with molten to ease the process and give a strength to the joint. Types of welding process in fusion welding are arc welding, resistance welding, oxyfuel welding, and laser beam welding. Otherwise, solid-state welding is a process of joining parts by applying mechanical force until materials deform to a plastic state. During the operation, the material needs to be joined take place by application of pressure only or a combination of pressure and heat and no additional filler metal used in this process. Types of welding process in the solid-state are diffusion welding, ultrasonic welding, and friction welding.

Friction stir welding (FSW) also known as solid-state welding which is taking place below the melting temperature of the parent materials in order to connect them. It's an alternate welding technology, a technique to fusion welding because the fundamental concept used is very simple (M. K Sued et al. 2014). Without producing harmful gas emissions, radiation and consumes considerably less energy, FSW can be categorized as a green technology compared with conventional welding. FSW has many technical advantages which systematically developed in joining soft materials, such as aluminium and magnesium alloys that are very difficult to be welded using conventional fusion welding due to the presence of many defects. FSW also avoidance of radiation and dangerous fumes to the surrounding and consume less energy and leads to a decrease in material waste compared to the fusion welding processes. This weld is made in the solid phase, which does not require melting such as fusion welding. FSW has now established as the welding technique of first choice for certain applications in the aerospace, marine, transport industries, and infrastructure because of good energy efficiency, environment friendliness and making the friction stir welding as a green technology (Thomas et al. 2010). Since its invention, the process has received worldwide attention and today companies in Japan and USA are using of this kind of technology in production, particularly for joining the material in shipbuilding, rail, automotive and building industries (Rams, Pietras, & Mroczka, 2014).

Pinless friction stir welding (PFSW) is a new solid-state welding technique derived from conventional FSW, where the research this technique still scarce (Zhenlei Liu et al. 2016). There is a possibility to produce a good weld with a pinless tool is unpredictable. However, it has potential benefits such as simpler tool geometry, versatility since such a tool isn’t concentrated to a particular sheet thickness and a preferable aesthetic appearance with a shallow and no preserved keyhole. The material flow under pinless tools is unvarying and homogeneous. With frictional heat and suitable material flow, it can accelerate the dissemination to make sound joints (Binbin Kuang et al. 2015).

1.1 Problem statement

Friction stir welding has some benefits like low distortion and shrinkage even in long welds, no filler metal needed and also can weld a very small thickness of material in one pass. Besides that, it is an environment friendliness in the process, consumes less energy and least amount of material waste.

The use of pin in FSW affecting an aesthetically undesirable keyhole that's result from the poor material flow considerably influence the weld strength. Binbin Kuang et al. (2015) found that the keyhole also leaves anxiety for corrosion performance in the application. Another problem occurs in friction stir welding is difficulty in optimizing welding parameters due to the plates very thin. The limitation using thin plates is the thickness reduction in the weld, resulting from the forging effect of the shoulder which can significantly reduce the mechanical resistance of plates. Besides that, heat producing from tool also make the plate bend too fast due to the properties of plate is not rigid.

Based on a comparison of tensile strength and hardness is the best method to obtain the optimum parameters. Other than that, with the presence of the pinless tool can yield high strength of the weld. Since the absence of a pin on the tool shoulder, no keyhole produce on the weld surface. With help of a jig (backing plate or anvil) can make the thin plate cools in a matter of time where the material is made up of mild steel.

In this research project, the study was held to understand the parameters involved in the joining process of commercial cold rolled steel (SPCC) using PFSW. This study also geared toward learning the effect of tool design and process variable in quality of

PFSW of commercial cold rolled Steel (SPCC). Additionally, it is to analyze the impact of this variable on mechanical properties (tensile strength and hardness), temperature and spindle motor current demand of welding joints.

1.2 Objective

The objective of this research project are:

1. To fabricate friction stir welding using pinless tool for welding 1 mm of commercial cold rolled steel (SPCC).
2. To investigate the effect of two parameters (spindle and travel speed) on tensile strength and micro-hardness on the welding process.
3. To analyze the temperature distribution and current consumption of pinless friction stir welding.

1.3 Scopes

Based on the problem statements discussed above, this research project is a focus on the design of a simple pinless tool and to attain good weld properties. The various parameters like speed, temperature and current are taking as consideration in this research project. The approach is taken from the previous study. The PFSW machine is (CNC vertical milling 3-axis) is employed as a core platform. The material from commercial cold rolled (SPCC) was invoked as a substrate. This substrate has a size of 1mm for thickness x 174 mm (length) x 140 mm (width) were prepared by Laser Cutting Machine. For the fabrication, tool design is employing a tool H13 steel. It is manufactured in by using Conventional Lathe Machine. Butt weld configuration is utilized. The specimen is going to be tested by using Universal Testing Machine tensile shear test according to