UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF DIFFERENT WELDING PARAMETERS TO THE MECHANICAL PROPERTIES OF SPOT WELD

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

by

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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honors. The member of the supervisory is as follow:

…….

(Mr. Mohd Harris Fadhilah Bin Zainudin)

ABSTRAK

Kimpalan tempat rintangan adalah proses kimpalan di mana pemasangan bahagian kerja dihasilkan oleh tekanan elektrod dan mendapatkan haba daripada rintangan dengan aliran arus elektrik. Bentuk dan saiz kimpalan yang terbentuk bergantung kepada bentuk dan saiz elektrod. Kekuatan struktur kenderaan kebanyakannya bergantung pada struktur kimpal. Oleh itu, projek ini bertujuan untuk mengkaji kesan parameter kimpalan yang berbeza kepada sifat-sifat mekanik pengimpalan tempat. Parameter kimpalan tempat rintangan seperti semasa kimpalan, daya kimpalan, dan masa kimpalan telah diubah mengikut parameter yang ditetapkan. Dalam projek ini, kekuatan tegangan dan ujian kekerasan pada sambungan bersama di kimpalan tempat untuk ketebalan 2.12 mm dua helaian dikimpal lapisan diselidiki. Proses ujian yang telah dilakukan adalah uji ricih tegangan dengan menggunakan Mesin Ujian Universal, ujian kekerasan dengan menggunakan Mesin Penguji Vickers Microhardness, dan mikrostruktur permukaan oleh Mikroskopi Pengimbasan Elektron. Oleh hasil yang diperolehi dalam projek ini, parameter empat nampaknya menjadi parameter yang paling baik berbanding yang lain. Yang paling kurang kecemerlangan ialah parameter yang mempunyai nilai tegangan dan kekerasan yang terendah. Hasil kajian ini mendapati, parameter empat sesuai untuk proses kimpalan tempat kerana ia mempunyai kualiti yang tinggi dari segi kekuatan, kekerasan dan mikrostruktur.

ABSTRACT

Resistance spot welding is a welding process where the assembly of work part is produced by electrode pressure and heat obtain from resistance with the flow of electric current. The shape and size of weld formed are depends on the shape and size of the electrodes. The strength of vehicle structure mostly depends on the weld structure. Thus, this project purposed to study the effect of different welding parameters to mechanical properties of spot weld. The parameter of resistance spot welding such as welding current, welding force, and welding time were changed follow by the parameters designated. In this project, the tensile strength and hardness test of lap joint in spot welding for 2.12 mm thickness of two layer welded sheet was investigated. The testing process that had been done is tensile shear-test by using Universal Testing Machine, hardness test by using Vickers Microhardness Testing machine, and surface microstructure by Scanning Electron Microscopy. By the results obtained in this project, parameter four seems to be the most excellence parameter compare from the others. The most less excellence is parameter one that has tensile and hardness value lowest. The results of this study found, parameter four suitable for spot welding process because it has high quality in terms of strength, hardness and microstructure.

DEDICATION

Most Elevated Exceptional Grateful To Both My Beloved Father and Mother

Mazlan Bin Kamis

&

Normah Binti Ibrahim

Also

Beloved Brothers and Sisters

Besides, I am very grateful to be given a Supervisor who was very helpful in this study

Mr. Mohd Harris Fadhilah Bin Zainudin

&

Mr. Mohd Falihan Bin Bahari

Lastly, to my panel for giving constructive comments

Mr. Mohd Afdhal bin Shamsudin

Thank you a lot.

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LIST OF ABBREVIATIONS & SYMBOLS

AHSS	-	Advanced High Strength Steel
BM	-	Base Metal
FZ	-	Fusion Zone
HAZ	-	Heat Affected Zone
Hz	-	Hertz
kA	-	kiloAmpere
kN	-	kiloNewton
mm	-	milimeter
RSW	-	Resistance Spot Welding
SEM	-	Scanning Electron Microscopy
SPCC	-	Cold Rolled Steel
TTT	-	Time Temperature Transformation
UTM	-	Universal Testing Machine

CHAPTER 1
INTRODUCTION

1.0 Introduction

This chapter explain briefly about importance of Resistance Spot Welding (RSW) including on how it works and effect in automotive industry. In addition, objective and project scope also had been done in this chapter.

1.1 Background of Project

Resistance spot welding (RSW) is a popular welding process due to its high speed and low cost combination. It also provides excellent reproducibility. In electronics, biomedical and automotive industries, RSW is one of the metal joining techniques for high volume production (Singh & Suman, 2013). It is one of the efficient and cleanest welding for fabrication sheet metal.

Spot weld joints are widely used in a car that normally have an average of 3000-4000. It doesn't change the weight of the car thus widely used compared to arc welding (Aravinthan Arumugam, 2011). It has many advantages like the simple case of operation, process with high speed and automation adaptability in production joining sheet metal. (Sahota, Singh, Sharma, & Singh, 2013).

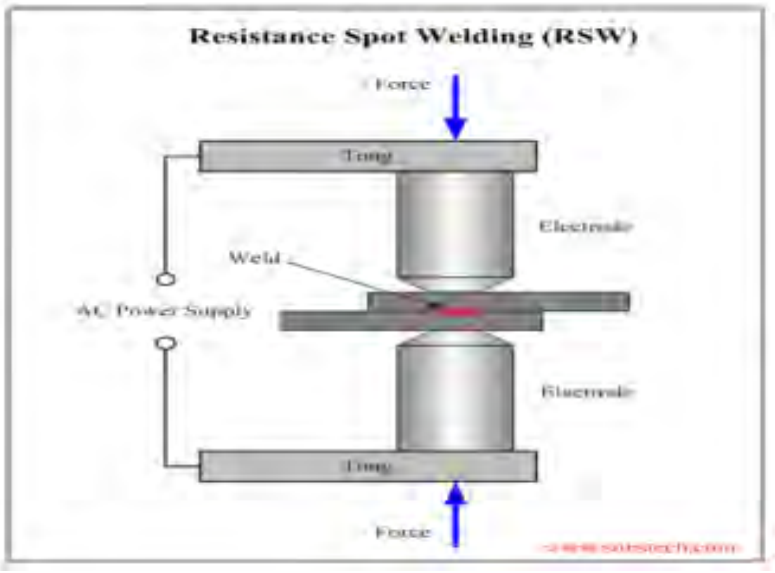

Figure 1.1 : Simple Drawing of RSW (Sahota et al., 2013)

Resistance spot welding is a welding process where the assembly of work part is produced by electrode pressure and heat obtain from resistance with the flow of electric current. The shape and size of weld formed are depends on the shape and size of the electrodes (Sahota et al., 2013).

RSW is widely used in automotive industry because of its ability to join any material with great precision and accuracy without having much problem. Figure 1 above shows simple drawing of RSW process. This machine can operate manually and automatically depend on usage and situation. It also can adjust with different parameters such as welding time, welding force and welding current.

1.2 Problem Statement

To meet the challenges in the today's automobile requirements, such as durability and reliability. Resistance spot welding been widely used automotive, aerospace and other industrial area and it is also is an important branch of the welding subject (Chen, Sun, Jiang, Qi, & Zeng, 2016). Recently, it is used largely and gain attention from variety industries such as the automotive industry due to many advantages on it such as low cost, small deformation and high efficiency.

Material play an important role in an automotive body in white. It has been observed as a result of increasing requirements of passenger safety, vehicle performance and fuel economy. The response of steel industry to the new challenges is a rapid development of higher strength steels, named Advanced High Strength Steels (AHSS). (Kuziak, Kawalla, & Waengler, 2008)

AHSS offer the excellent properties of potential in improving the vehicle crash performance without extraweight increase. To date, for different structural parts of a vehicle, 85% of AHSS approximately have been used and it could lead up to a weight reduction to 25% compared with a previous model (Liu, Zheng, He, Wang, & Wei, 2016). AHSS is applied in the automotive industry because of its strength safety and lightweight compared to another steel. Due to lightweight itself, the consumption of fuel is automatically reduced

In addition, reliability of resistance spot weld is important due to impact safety standards. When designing vehicle structures, their 'deep collapse' behaviour, where displacements may exceed the wall thickness by several orders of magnitude is very important aspect. Not only the maximum strength and initial instability is necessary. For the same time these structures must meet other criteria like production, functional, time-to-market, and cost criteria, which lay additional constraints on the manufacturing and development process. (Structures, 1998)

Since resistance spot welding largely used in various industries, basic quality requirements for strength and durability of spot weld must be concerned for creating perfect nugget diameter and surface appearance. These quality depends on perfect parameters of resistance spot weld machine.

One of the quality requirement of spot weld is the nugget diameter. It is important due to strength requirements of the resistance spot welded joints, and associated car body structural integrity. It was reported forming of nugget on the workpiece plays a crucial role in structure joining (Y. Luo, Rui, Xie, & Zhu, 2016). Weld nugget formation is a balance between heat generation and heat dissipation. It has been experimentally observed that in the case of two thickness resistance spot welds, initial heat generation and weld nugget formation occurs where the resistance to the flow of current was the greatest (M Pouranvari & Marashi, 2012).

Parameters of resistance spot weld make this type of welding special. The formation of weld is mainly influenced by controlling parameters of spot welding. It consists of weld time, weld current and weld pressure. The good parameters of spot weld will make the joining of metal tougher. All of this things strongly affect the mechanical behaviour of spot welds. The geometrical parameters of weld assemblies are known to directly influence their mechanical response (Huin, Dancette, Fabrègue, & Dupuy, 2016a).

1.3 Objective

The main objectives of this project are: -

1. To compare the mechanical properties of 2-layer spot welding using different welding parameters
2. To investigate the quality of spot weld in different welding parameters

1.4 Project Scope

This research is subjected to the following scope: -

1. Comparing welding hardness using Microhardness Testing Machine
2. Comparing the tensile strength of different welding parameters using Universal Testing Machine (UTM)
3. Analyzing microstructure of welding between Advance High Strength Steel (AHSS) and cold roll steel (SPCC) using Scanning Electron Microscopy (SEM)
4. Investigating the quality of spot weld from different sizes of nugget formation by pull out test

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter explain about resistance welding machine, resistance spot weld machine, parameters of spot weld machine, nugget formation, failure modes, microstructures and types of material use.

2.1 Resistance Welding Machine

Resistance welding is a technology that used in various industries for joining metal sheets together. Resistance welding is a thermo-electric process in which heat is generated at the interface of the parts to be joined by passing an electrical current through the parts for a precisely controlled time and under a controlled force (Amada Miyachi America, 2013). The weld is made by generating heat through current at the metal sheets. The formation of the welding that's called 'nugget' is using electrode with right amount of force, current and time. Resistance welding machine can be classified into several type according to its shape of work pieces and form of electrodes: -

i. **Resistance Projection Welding**

ii. **Resistance Seam Welding**

iii. **Resistance Butt Welding**

iv. **Resistance Spot Welding**

2.1.1. Resistance Projection Welding

Resistance projection welding is resistance welding process in joining two sheets metal by embossing the projection on the surface by specially design electrode to fit the shapes of work pieces. Heat is produced by both electrodes at the same time. High generation of heat and current are localized at the electrodes that have contacts with work pieces. The electrodes are designed flat and big and usually made from copper based alloys. Figure 2.1 below shows how the process of this welding happen.

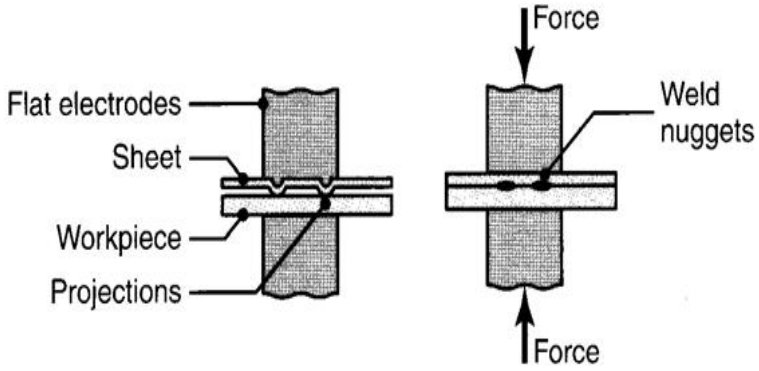

Figure 2.1: Projection Welding Process
(Source: <http://www.mechscience.com/projection-welding-projection-welding-machine-resistance-projection-welding-rpw/> 24/09/15**)**

Resistance spot weld equipment can be used for this type of welding by changing the electrodes. Nuts and bolts can be welded to sheets and plates by this process. Figure 2.2 below shows how projection welding happen in nuts and bolts. Projection welding widely used in construction industries, electric and electronic.

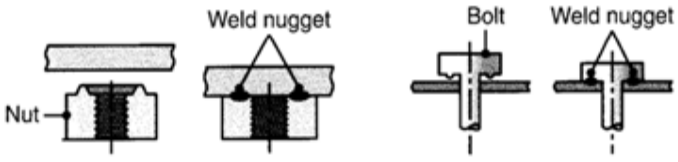

Figure 2.2: Projection Welding in Nut and Bolts
(Source: <http://www.mechscience.com/projection-welding-projection-welding-machine-resistance-projection-welding-rpw/> 24/09/15**)**

2.1.2. Resistance Seam Welding

Resistance seam welding is a welding process that joining metal sheets in continuous using two circular rotating electrode wheels. Electric current generate heat that flow through contact area and pressure to joining metal sheets by directly applying opposing force and produce a leak tight weld. A continuous overlapping nugget is formed by this process. Figure 2.3 below shows the process of seam welding.

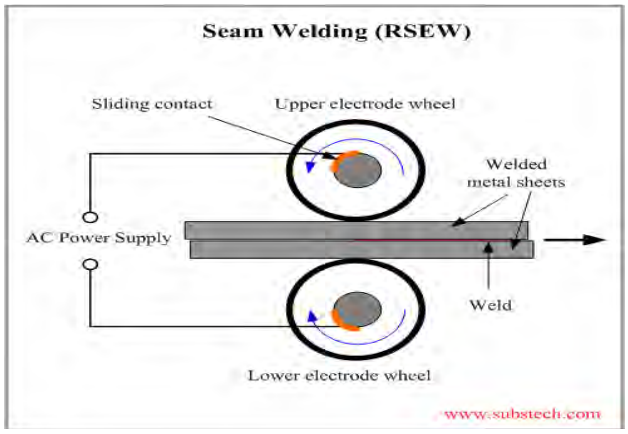

Figure 2.3: Seam Welding Process
(Source:<http://www.substech.com/dokuwiki/doku.php?id=resistance_welding_rw> 01/06/12**)**

Resistance Seam Welding is high speed and clean process. It is applying when continuous tight weld required for example like manufacturing of containers, drums, fuel tanks and radiator. Figure 2.4 below shows the example how containers was made from seam welding machine.

Figure 2.4: Seam Welding Machine Used in Making Container
(Source:<http://www.fabricated-products.com/capabilities/welding-brazing/seam-welding/> 2010**)**

2.1.3. Resistance Butt Welding

Resistance butt welding is a welding process that joining thick metal plates or bars which one bar is hold on fixed clamp and the other in moving clamp. The two bars are brought together and held simultaneously under a pressure and heated by an electric current passing through the contact area and producing a weld. After the bars was welded, the clamp will release the bar. Figure 2.5 below show how butt welding works.

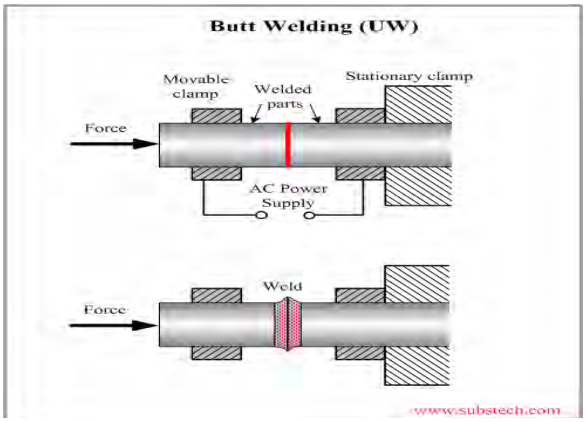

Figure 2.5: Butt Welding Process
(Source:<http://www.substech.com/dokuwiki/doku.php?id=resistance_welding_rw> 01/06/12**)**

Resistance butt welding used for welding small parts. It is very productive and clean process. This type of welding also provides joining without losing any welded material. Resistance butt welding applied in manufacturing of wheel rims, weld pipes, wire joint and railway track joint. Figure 2.6 below shows diagram on how butt welding works.

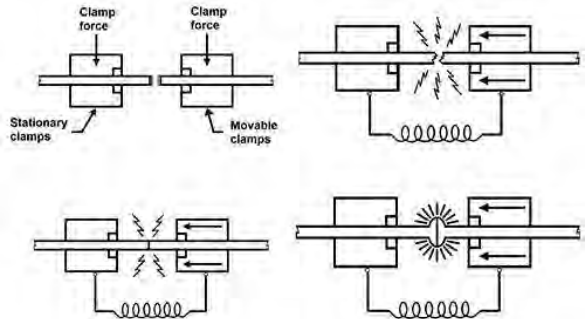

Figure 2.6: Butt Welding Diagram Process
(Source: <http://www.mmsonline.com/articles/controlled-welding-process-joins-metal-in-a-flash> 2017**)**