
# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## THE EFFECT OF DIFFERENT THICKNESS MATERIAL STACKING FOR FOUR LAYER SPOT WELDING

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Maintenance Technology)(Hons.)

by

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# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **The Effect of Different Thickness Material Stacking for Four Layer Spot Welding**

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I hereby, declared this report entitled "The Effect of Different Thickness Material Stacking for Four Layer Spot Welding" is the results of my own research except as cited in references.

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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 Bachelor's Degree in Mechanical Engineering Technology (Maintenance Technology)(Hons.). The member of the supervisory is as follow:

……

(Mohd Harris Fadhilah Bin Zainudin)

# ABSTRAK

Projek Tahun Akhir ini menggariskan latar belakang projek "Kesan Bahan yang Berbeza Ketebalan untuk Empat Lapisan Kimpalan Titik". Proses kimpalan titik adalah salah satu proses penyambungan logam yang penting terutamanya di industri automotif. Kimpalan rintangan titik empat lapisan kepingan logam umumnya lebih mencabar daripada tiga lapisan disebabkan oleh beberapa gangguan. Kekuatan struktur bahan kenderaan kebanyakannya bergantung kepada struktur kimpalan. Oleh itu, laporan ini bertujuan untuk menyelidik sifat mekanik empat lapisan yang telah dikimpal titik daripada ketebalan yang berbeza. Metodolgi kajian dalam projek ini telah dikaji dan dikenal pasti. Proses uji kaji yang telah dilakukan ialah ujian tegangan dengan menggunakan INSTRON Mesin Ujian Universal (model 5969). Dalam kajian ini, kekuatan pada tegangan ricih ujian sendi pusingan dalam kimpalan titik pada keluli tinggi kekuatan berketebalan 2.80mm, 3.50mm dan 4.40mm ketebalan empat lapisan yang dikimpal telah telah dikaji. Semua keputusan kemudiannya dibandingkan dengan tiga lapisan kimpalan titik yang berketebalan 2.80mm. Tiga lapisan yang berketebalan 2.80mm dikimpal titik dijadikan sebagaiu penanda aras dalam kajian ini. Dari perbincangan didapati bahawa empat lapisan kimpalan titik mempunya kekuatan tegangan yang lebih tinggi berbanding dengan tiga lapisan kimpalan titik. Kajian ini diharapkan akan membantu pengeluar kereta dalam menghasilkan produk yang lebih baik dalam industri automobil.

# ABSTRACT

This Final Year Project outlines the background of the project "The Effect of Different Thickness Material Stacking for Four Layer Spot Welding". Spot welding is one of the metal joining processes that mainly use in the automotive industries. Resistance spot welding of four layer metal sheet generally more challenging than three layers of spot welded sheet due to the several interfaces. The strength of vehicle structure mostly depends on the weld structure. Thus this report intended to research the mechanical properties of four layer welded sheets from different thickness. The research methodology on this project has been studied and identified. The experimental process that had been done is tensile test by using INSTRON Universal Testing Machine. In this research, the strength on the tensile shear-test of lap joint in spot welding of 2.80mm, 3.50mm and 4.40mm thickness of four layer welded sheet was investigated. All the results were then compared with three layer of welded sheet with thickness 2.80mm. Three layer of 2.80mm thickness welded sheet function as a benchmark in this study. From the discussion, it was discovered that four layer of spot welded sheet have higher tensile strength compared to three layer of welded sheet. The study is hopefully will help automobile manufacturer in producing a better product for the automobile industry.

# DEDICATION

Highest Special Thankful Wishes to Both My Lovely Father and Mother

Madi Bin Teh

&

Mek Eshah Binti Jusoh

Also

Beloved Brothers and Sisters

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Firstly, millions of thankful wishes to ALLAH S.W.T because with His permissions, I am able to complete my Final Year Project report.

In preparing this paper, I have engaged with many people in helping me completing this project. First, I wish to express my sincere appreciation to my main thesis supervisor Mr Mohd Harris Fadhilah Bin Zainudin, for encouragement, guidance, advices and motivation.

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# LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

| | | |
|---|---|---|
| AC | - | Alternate Current |
| DC | - | Direct Current |
| RSW | - | Resistance Spot Welding |
| ST | - | Squeeze Time |
| UTM | - | Universal Testing Machine |
| WT | - | Weld Time |

# CHAPTER 1
# INTRODUCTION

## 1.1 Background of The Project

Resistance spot welding (RSW) process is one of the oldest in the electrical welding processes that are mostly used in the modern manufacturing technology such as bridges, shipbuilding, home appliance and more. It also constantly used in the industry of conveyance manufacturing especially in automotive industry. In automotive industry, spot welding has been used to combine two or more plates in producing a car. Proton and Perodua are examples of local automotive industries using spot welding to fabricate their cars. For example, there are 3000-6000 spot welds in car (Luo Yi et al., 2009). Spot welding is a key technology in automotive assembly production due to fast process and can easily weld many different material combinations which are difficult or even impossible to join by other welding techniques.

In the spot welding process, two or more overlapped or stacked stamped components are welded together by applying an electric current through two contact points. The interface of the parts creates current resistance which produces heat. The application of pressure on the two metal will form a shape type that is called a "button". The welds will be of the approximate size of the contact points and the filler metal consist of the base materials only. This process can be done by the work piece as they are held together under pressure between two electrode. This process may be performed by robotic, manually or by dedicated spot welding machine. Spot welding process

take only few seconds. In the Figure 1.1 below, a complete secondary resistance spot welding circuit is illustrated. For clarify, the various arts of the RSW machine are stated.

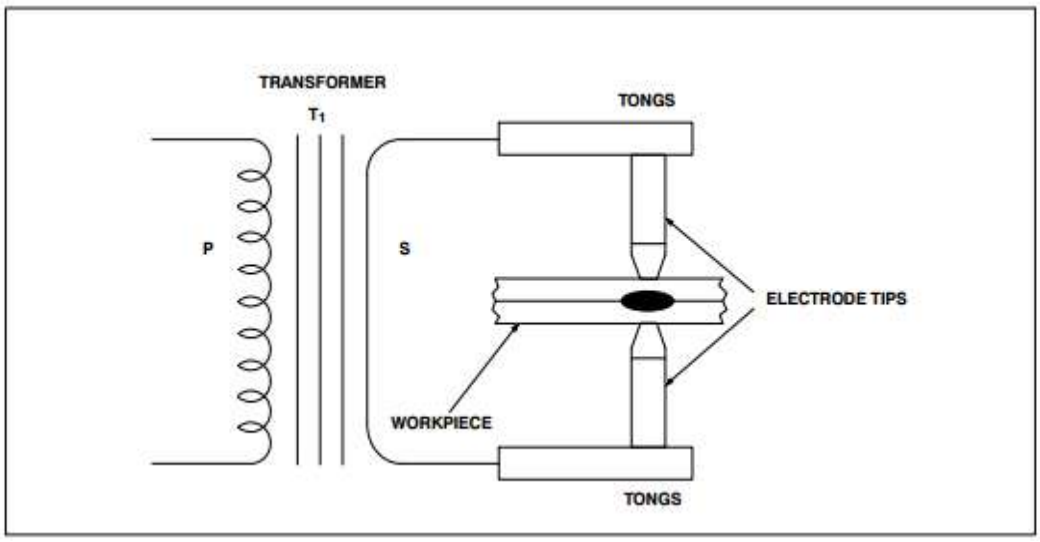


Figure 1.1: Resistance Spot Welding Machine with Workpiece. (Luo Yi et al., 2009).

Spot welds are discrete weld locations that look like small circles on the assembled component due to weld that was done by spot welding process. This weld process is linear welds and they are not continuous. The weld process are usually done manually for the components in low volume while for the components in high volumes, they are usually done by using robots or dedicated weld equipment. In spot welding, there are various variable involve in the process such as current, pressure, time, human element, welders condition, surfaces condition of materials, and surface condition of electrode tips. However, some of the weld variables are difficult to manage and may cause weld problems except others such as the current, time and electrode pressure which is easy to control. Good quality of spot welding can be achieve by a good process design that minimizes the parameter during welding process.

The automotive industry has introduced the four-layer weld configuration, which represent new challenges compared to normal two-sheet and three-sheet lap welds. Nielsen C. V. et al., (2011) stated that the process is more complicated by

introducing various combinations of different material and different thickness. The development of new, four-sheet weld sheet for use in the automotive industry represents new challenges to the industry. Joining four-sheet by spot welding can be a new trend in automotive assembly. The strength of resistant spot welded joints is important for improving auto body rigidity. By understanding the scenario of the current needed, this project was focused on investigating the mechanical properties of four-sheet resistance spot welded from different material combination.

## 1.2 Problem Statements

In the modern society, traffic accidents are one of the top causes of mortality (Teng et al., 2008). Based on the inspection of vehicles involved in real world crashes where at least one occupant was either hospitalized or killed **(** Fildes et al., 1994). Fildes et al., (1994) state that the most common source of injury to both front and rear occupants was the door panel and frame. Decreasing the severity of the injuries sustained by a vehicle occupant in the event of a collision involves improving the design of automobiles and their protective features and device. Thus, manufactures now working together to produce of safety devices and features into their vehicles such as airbags, energy-absorbing steering columns, side door beams, and so on.

Crash testing is a commonly employed technique for evaluating the crashworthiness of a particular vehicle due to satisfy the various industrial and governmental safety regulations and address consumers valid concerns for safety. Side impacts and front impact is one of the crash testing. Vehicle crashworthiness, which is defined as the capability of car structure to provide adequate protection to its passengers against injuries in the event of a crash, largely depends on the spot weld structural mechanical behaviour. There are several ways of reducing side impact which is increasing the layer of door structure. Basically, automotive industry often use two or three layer of metal sheet in spot welding process. With increased competition in the automobile market, automotive industry are competing to produce multi-material structure of auto body in order to satisfy request at the same time improving car strength and safety (Kleiner, M et al.,2003). Ambroziak & Korzeniowski, (2010)

describe that over 90 % of spot welds are performed by automotive industry at all over the world. It was estimated, that each body car components contains over 50 hundred spot welds. Pouranvari et al., (2013) pointed out that the failure that happen in spot welds cause the spot welds can have less strength and can lead into total destruction of manufacturing parts of car bodies. Therefore, the failure characteristics and performance of the spot welds significantly affect the durability and safety design of the vehicles. (Marashi & Pouranvari, 2012)

According to Marcus, Morgan et al., (1983), lateral impacts cause a big proportion of all serious and death injuries as much as 27 percentage to 30 percentage. Side impacts account for 12 percentage of total „harm‟ (Malliaris et al., 1982). Otte (1993) showed the range of directions of impact in two-car side collision as shown in Figure 1.2.

Based on the previous study on the result of side impact countermeasures, door plays the important role in side impact injuries for both near and far side impacted occupants ( Fildes et al., 1994). Thus, by improving structure of side door will help in reduce of injuries cause by side impact collision. Some manufactures have experimented with different combinations of materials and pading structure on vehicle in order to optimise injury reductions. It has been claimed that thoracic and pelvic injuries can be reduced by up to 10 percent by improving side door structure.

Joining four-sheets by resistance spot welding will become a new trend in automotive assembly. However it is more challenging because of extra interface introduced (Nielsan et al., 2011). Besides that, in production management, it was recommended that four layer sheet spot welding should be avoided whenever it could be replaced by spot welds of three sheets. Hence, this research will help by making research on mechanical properties of four-sheets of different material stacking by using spot welding process. Thus, this research will promote improvement in the automotive industry.

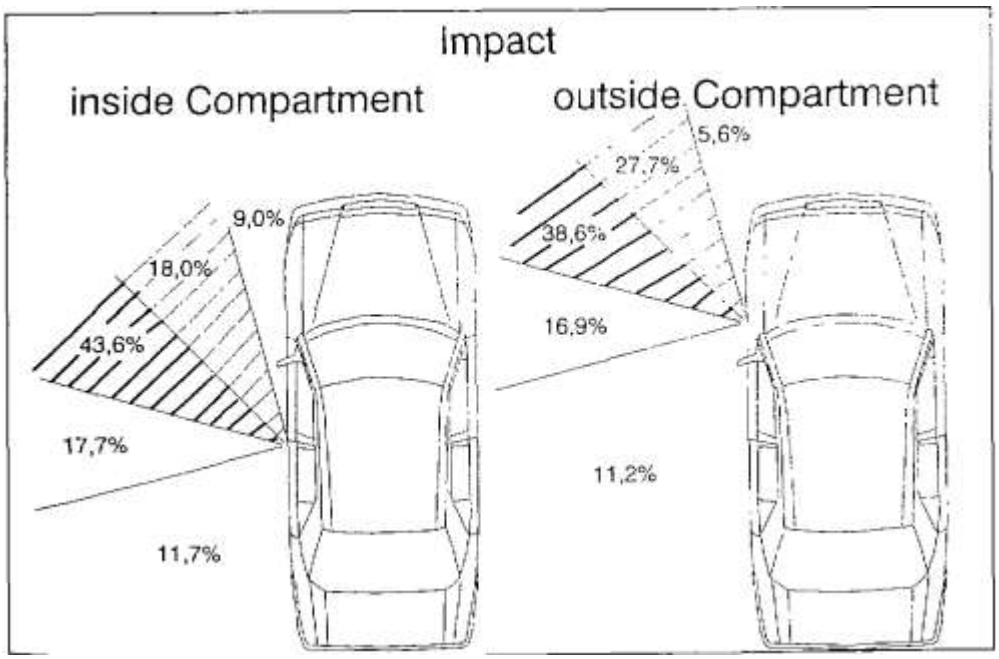


Figure 1.2: Distribution of impact angle (direction of impact of the impacting car) in a range of real-world side collisions (from otte 1993)

## 1.3 Objective

The main objective of this research is to improve car safety by improve the strength of car structure by using four layer of different thickness combination. The aim can be achieve by objective below:

I. To find out the strength of four layer welded sheets from different thickness material combinations.

II. To compare the strength of four layer welded sheet with three layer welded sheets.

## 1.4 Project Scope

The research is subjected to the following scope:

I. To find out the strength of four layer welded sheets by using a Universal Testing Machine (UTM) in order to analyse the tensile shear strength of welded sheets.
II. Using four of different thickness of metal sheet as the welding material.
III. The total thickness of each sample is 2.80mm, 3.50mm, and 4.40mm.
IV. Using metal sheet (JIS G3141 SPCC-1B) , (JIS G3141 SPCC-SD) and (JIS G3141 SPCC-SB)
V. Using an Inverter AS-25 spot gun welder

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Resistance Welding

Resistance spot welding process was invented in 1877 by Professor Elihu Thomson and has been widely used since then in manufacturing industry, especially in the automobile and air craft industries **(**Saleem**,** 2012). In the spot welding process, an electric current is passed through the parts being welded together, by using highly conductive electrode. A pressure is exerted during the process so as to hold the parts to be welded. The weld is made by a combination of heat, pressure, and time. In order to make a good welding joint, sufficient heat must be produced at the surface of the metal plates which are to be joined together. Current, force and time must be properly related in order to obtain a good weld.

The resistance welding process can be classified into

- Projection welding
- Spot welding
- Seam welding
- Flash butt welding

### 2.1.1 Projection Welding

It is a type of resistance welding process in which specially designed projections, shown in Figure 2.1 exist in one part. The simultaneous welding of several projections is possible during one weld. This projection, act as a current concentrator for the welding process and these projections are the high points during the welding cycles, that make the first contact. The main advantage of the resistance projection welding is the speed and versatility to be automated (Saleem, 2012). With projection welding, several welds can be conducted simultaneously.

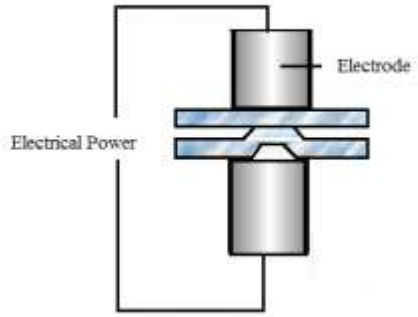


Figure 2.1: Projection Welding

### 2.1.2 Spot Welding

Text Spot welding process is a widely used process in both the automotive and other industries. The process utilizes a large amount of current within the range 1kA to 200kA. In RSW, a high welding current is passed from the welding electrodes. The metal sheets to be joined together are placed in between the welding electrodes. Due to the resistance, offered at the junction of the work pieces, heat is generated, which melts the metal at the interface thus forming a welding nugget as shown in Figure 2.2. Sufficient heat must be generated at the welding joint to raise the metal to the

desired temperature. If the heat produced is less than this temperature then the result will be a low strength weld.

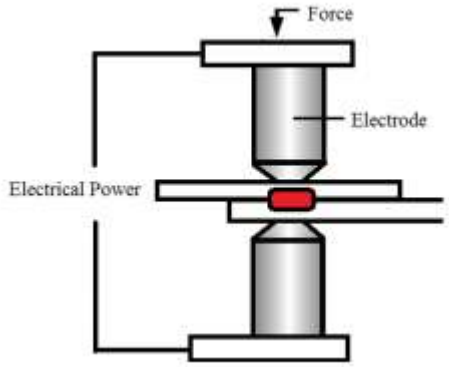


Figure 2.2: Spot Welding

### 2.1.3 Seam Welding

In seam welding the electrodes which are used for the welding, are in the form of rollers as shown in Figure 2.3. The electrical current is passed through the roller shaped electrodes, which produce heat at the interface of the sheets to be joined. A seam welding process produces a series of nuggets at the interface of the work pieces.

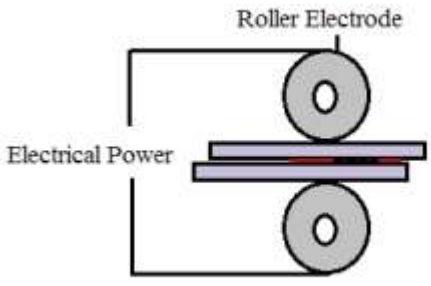


Figure 2.3: Seam Welding