A STUDY OF THE SPOT WELDING TIME ON JOINING STRENGTH OF THE MILD STEEL PLATES

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This report submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Mechanical Engineering

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NOVEMBER 2008
SUPERVISOR’S DECLARATION

“I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the Bachelor Degree in Mechanical Engineering”

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I declare that this thesis entitled “A Study of The Spot Welding Time On Joining Strength of The Mild Steel Plates” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Name : MOHD RAFA’AT BIN MOHD IBRAHIM

Date : 10 NOVEMBER 2008
I humbly dedicate this thesis to

my lovely mom and father, Lazimah Bt Ali and Mohd Ibrahim Bin Hj Yunos
my dearest brother, Mohd Raof and Mohd Razi
my dearest sister, Nur Mazwa and Nurshahida
my friends, Hakimi, Rafiuddin, Raja Salleh, Alexson, Syafiq and Anis
Praise to Allah! May Allah peace and blessing upon Prophet Muhammad, his family and companions, and those who follow their guidance.

I would like to thank to my supervisor, Mr Mohamed Reza Zalani Bin Mohamed Suffian for his guidance through out the period of this project. I would like to express my appreciations and gratitude to him who give attention and support on my progress and development every time. I also would like to thank Mr Rizal Bin Mat Ali for his guidance, support and helpful tips to complete the experiment and answering my question regarding the spot welding machine.

A special acknowledgement goes to my parents for their great moral and motivation support along the way to accomplish this project. Not forget, the Mechanical Engineering lab assistants and all my friends who involve in this project.
ABSTRACT

In this study, the effect of welding time on the tensile-shear strength and tensile-peel strength of the welding joints in electrical resistance spot welding of mild steel plates having 1.0 mm thicknesses were investigated. The plates are welded by electrical resistance spot welding by fixing electrode form, materials type and electrode force while changing welding current and time (second). The welding current was fixed at 4 kA. The electrode pressure was fixed at 6 kN while the welding time were changing at 2, 4, 6, 8, and 10 sec. The welding joints were exposed to tensile-shear and tensile-peel test and the effect of the welding time on tensile test were being investigated using related period diagram. The optimum welding times for tensile-shear test obtained at 4 sec and for the tensile-peel test also obtained at 4 sec.
ABSTRAK

Kajian ini adalah mengenai kesan masa terhadap dua jenis ujian tarikan untuk menguji kekuatan kimpalan dengan menggunakan mesin kimpalan elektrik untuk mengimpal kepingan besi lembut berketebalan 1 mm. Semasa proses kimpalan kepingan besi dilakukan dengan menggunakan mesin kimpalan elektrik, elektrod yang digunakan, jenis kepingan besi dan daya yang dikenakan oleh elektrod adalah sama untuk semua proses kimpalan dan hanya mengubah masa kimpalan sahaja. Kekuatan arus elektrik yang digunakan adalah sama iaitu sebanyak 4 kA. Daya tekanan yang dikenakan oleh elektrod juga sama iaitu sabanyak 6 kN dan hanya mangubah masa kimpalan iaitu 2, 4, 6, 8, dan 10 saat. Kepingan yang telah dikimpal diuji dengan menggunakan ujian tarikan. Data yang diperolehi dikaji dengan menggunakan graf hubungan masa. Dari kajian ini didapati kekuatan maksimum untuk ujian tarikan ’mengoyak’ adalah pada 4 saat dan kekuatan maksimum bagi ujian tarikan ’mengupas’ juga ialah pada 4 saat.
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CHAPTER 1

INTRODUCTION

1.1 Background

Spot welding is one form of resistance welding, which is a method of welding two or more metal sheets together without using any filler material by applying pressure and heat to the area to be welded. The process is used for joining sheet materials and uses shaped copper alloy electrodes to apply pressure and convey the electrical current through the work pieces. In all forms of resistance welding, the parts are locally heated. The material between the electrodes yields and is squeezed together. It then melts, destroying the interface between the parts. The current is switched off and the "nugget" of molten materials solidifies forming the joint.

Resistance spot welding depends on the resistance of the base metal and the amount of current flowing to produce the heat necessary to make the spot weld. One of the important factor is time. In most cases several thousands of amperes are used in making the spot weld. Such amperage values, flowing through a relatively high resistance, will create a lot of heat in a short time. To make good resistance spot weld, it is necessary to have close control of the time the current is flowing. Actually, time is the only controllable variable in most single impulse resistance spot welding application. Current is very often economically impractical to control. It is also unpredictable in many cases.
Most resistance spot weld are made in very short time periods. Since alternating current is normally used for the welding process, procedures may be based on a 60 cycle time (sixty cycle = 1 second).

Control of time is important. If the time element is too long, the base metal in the joint may be exceed the melting (and possible the boiling) point of material. This could cause faulty welds due to gas porosity. This is also the possibility of expulsion of molten metal from the weld joint, which could decrease the cross section of the joint weakening the weld. Shorter weld time also decrease the possibility of excessive heat transfer in the base metal. Distortion of the welded parts is minimized, and the heat affected zone around the weld nugget is substantially smaller.

![Figure 1.1](image.png)

*Figure 1.1* Resistance spot welding machines with work
1.2 Problem Statement

In this study, the effect of welding time on the tensile-peel strength and tensile-shear strength of welding joints in electrical resistance spot welding of mild steel sheet metals were investigated. It has to developed experiment to carry out the time effect in welding mild steel sheet metals by resistance spot welding machine. While doing the experiment, it has to select welding current periods and adjust the welding time during the welding process. The electrode pressure is fixed. After doing the experiment is one of the important success strategies to analyze the data of the mild steel sheet metals, which were produce suitable time effect of the spot welding. So that using tensile test is really take part in this project. Also using chart and variety of table can prove the result.

1.3 Objective

i. To study about the effect of welding time on welding sheet metal by using resistance spot welding machine and developed experiment to carry out welding time effect in welding mild steel sheet metals by resistance spot welding machine.

ii. To analyze the result of the experiment and gain suitable time of welding by using tensile test.
1.4 Scope of Study

The scope of project covered study and analysis about the effect of welding time on welding mild steel sheet metals by using resistance spot welding machine. This will be done by using experiment and the result would be analyzed by using tensile test. Mild steel sheet metals will be selected and being welded by electrical resistance spot welding machine. The electrode forms, material type, cooling water flow rate and electrode force were fixed. The only variable is the welding current and time. The welded mild steel sheet metals will expose to tensile-shear and tensile-peel test in order to determine the joint strength. The tensile speed was remained constant during the test.

1.5 Importance of Research

Resistance spot welding is widely used joining process for fabricating sheet metal assemblies such as automobiles, truck cabins and home applications due to its advantages in welding efficiency. For example, a modern auto-body needs 7000 to 12000 spots of welding according to the size of the car. Each spot welding is not performed on the same condition because of the alignment of sheet metals and electrodes as well as surface condition. So that each spot welding process needs the optimum process condition that could afford allowance in parametric value for good quality of welding. The displacement of the electrodes is an important feature during the resistance spot welding process due to its performance in the control of the quality of welding. When it is weld long, the amount of molten metal increase and fused metal spurts out. In addition heat affected zone (HAZ) extends and the contact surface become dark. So that to find the suitable time for welding aluminum sheet metals with certain electrode pressure is the important and main objective of this research.
CHAPTER 2

LITERATURE REVIEW

2.1 Background of the Resistance Spot Welding

Resistance spot welding is one of the oldest of the electric welding processes in use by industry today. The weld is made by a combination of heat, pressure, and time. As the name resistance welding implies, it is the resistance of the material to be welded to current flow that causes a localized heating in the part. The pressure exerted by the tongs and electrode tips, through which the current flows, holds the parts to be welded in intimate contact before, during, and after the welding current time cycle. The required amount of time current flows in the joint is determined by material thickness and type, the amount of current flowing, and the cross-sectional area of the welding tip contact surface.

Figure 2.1 Spot welding [2]
2.2 The Principles of the Electrical Resistance Spot Welding

In the spot welding process, two or three overlapped or stacked stamped components are welded together as a result of the heat created by electrical resistance. This is provided by the work pieces as they are weld together under pressure between two electrodes. Spot welding may be performed manually, robotically or by a dedicated spot welding machine. The similar spot welds having same property can be obtained in high production speeds by controlling welding current, electrode force and weld time automatically (Fig. 2.2) [1].

![Diagram showing resistances occurred in electrical resistance spot welding](image)

**Figure 2.2** The resistances occurred in electrical resistance spot welding [2]

Fe = Electrode Force  
R1 = Upper Specimen Resistance  
R2 = Upper Specimen – Upper Electrode contact Resistance  
R3 = Upper Specimen – Bottom Specimen contact Resistance  
R4 = Bottom Specimen Resistance  
R5 = Bottom Specimen – Bottom Electrode contact Resistance  
R6 = Upper Electrode Resistance  
R7 = Bottom Electrode Resistance
The required low voltage (5–20 V) and high current intensity (2000–15,000 A) for welding process is obtained from transformers and the pressure is obtained from hydraulic, mechanic and pneumatic devices (Fig. 2.3) [1].

![Figure 2.3 The schematic illustration of electrical resistance spot welding Machine [2]](image)

1 – Circuit Connection
2 – Current Amplificator
3 – Transformator
4 – Secondary Circuit
5 – Force Transformation System
6 – Process Control Devices

The welding current must pass from the electrodes through the work. Its continuity is assured by forces applied to the electrodes. The sequence of operation must first develop sufficient heat to raise a confined volume of metal to the molten state. This metal is then allowed to cool while under pressure until it has adequate strength to hold the parts together. The current density and pressure must be such that a nugget is formed, but not so high that molten metal is expelled from the weld zone. The duration of weld current must be sufficiently short to prevent excessive heating of the electrode faces.
The heat required for these resistance welding processes is produced by the resistance of the workpieces to an electric current passing through the material. Because of the short electric current path in the work and limited weld time, relatively high welding currents are required to develop the necessary welding heat. The amount of heat generated depends upon three factors: (1) The amperage, (2) The resistance of the conductor and (3) The duration of current. These three factors affect the heat generated as expressed in the formula

\[
Q = I^2 Rt
\]

Where \( Q \) = heat generated, joules; \( I \) = current, amperes; \( R \) = resistance of the work, ohms; \( t \) = duration of current, seconds.

The resistance is influenced by welding pressure through its effect on contact resistance at the interface between the workpieces. Pieces to be spot welded must be clamped tightly together at the weld location to enable the passage of the current. Everything else being equal, as the electrode force or welding pressure is increased, the amperage will also increase up to some limiting value.

Spot welds are discrete weld locations that look like small circles on the assembled components. They are not continuous, linear welds. Low volume components are usually done manually, whereas high volumes can be achieved best by using robots or dedicated weld equipment. Electrodes play a vital role in these devices. They must have adequate strength and hardness, because weld quality will deteriorate as tip deformation proceeds. In addition, a momentary reduction in electrode force permits the internal metal pressure to rupture unfused metal in weld zone. Internal voids or excessive electrode indentation may result. The welding process is generally performed in less than one second. This time is called as period.
2.3 Test Specimens

2.3.1 Suitability of Mild Steel for Spot Welding

Steel is derived from iron. Iron ore requires great thermal energy (around 1,500°C) to reduce to its metallic form of iron. The iron is then alloyed with carbon and metals such as nickel or tungsten to produce steel. Steels are described as mild, medium- or high-carbon steels, according to the percentage of carbon they contain. Mild steel is an iron alloy that contains less than 0.25% carbon. Mild steel is very reactive and will readily revert back to iron oxide (rust) in the presence of water, oxygen and ions. The readiness of steel to oxidize on exterior exposure means that it must be adequately protected from the elements in order to meet and exceed its design life [3].

The suitability of mild steel for spot welding depends mainly on 3 factors:-
(a) Surface condition
(b) Chemical composition
(c) Metallurgical condition

2.4 The Tensile Test

The tensile test can be applied to a bar or some other specimen. From Hooke’s observations, that at small stresses and hence small strains can have a linear relationship [5].

\[ \sigma = E \varepsilon \]  \hfill (2)

In fact, if the load is increased, other systematic behaviors can found once it beyond the elastic limit. If a test was carried out on a round bar up to the point when the bar eventually snapped, a stress / strain curve can be found as in Fig. 2.4
The behaviors can be summarized in terms of three regions on the curve in Fig. 2.4. Region I from the origin to the point at $\sigma_y$ when the behaviors in the linear. Region II is from the point at $\sigma_y$ to the point at $\sigma_u$ which is the maximum stress on the curve. Region III is from $\sigma_u$ to $\sigma_f$ is the point of failure (fracture).

### 2.4.1 Tensile Shear-Strength and Peel-Strength of the Welding Joint

Tensile shear strength (tensile strength in shear direction: TSS) and cross tension strength (tensile strength in peel direction: CTS) are one of the important parameters to show reliability of spot-welded joints. Fig. 2.5 shows the effect of nugget diameter on tensile shear strength of joints. Tensile shear strength increases in proportion to nugget diameter and also increases with sheet thickness. This is the same as cross tension strength [4].
Up to now, in case of mild steel sheets and peel test were always conducted for the purpose of checking joint strength because this relation between nugget diameter and tensile shear strength, cross tension strength was recognized. Fracture mode changes from shear type that fracture is occurred inside the nugget to plug type that fracture is occurred around the nugget (HAZ, base steel or sometimes partly inside the nugget). Nugget diameter that fracture mode changes from shear type to plug type increase with increase of base steel strength and sheet thickness as mentioned after. Generally, plug type is desire from the viewpoint of product liability (PL) law [4].
CHAPTER 3

METHODOLOGY

3.1 Methodology Flow Chart

To achieve the objective of the project, a methodology flow chart has been developed as shown in figure 3.1. The methodology flow chart is used as a guideline and direction to execute the project work successfully. Following is the summary of the methodology flow chart.
3.2 Define Problem Statement

In this project, Squeeze time is the time interval between the initial application of the electrode force on the work and the first application of current. It is necessary to delay the weld current until the electrode force has attained the desired level. After that, the weld time is measured and adjusted in cycles of line voltage as are all timing functions.