STUDY ON MECHANICAL BEHAVIOUR OF RESISTANCE SPOT-WELDING TECHNOLOGY

SANMUGETHAN A/L KUPPUSAMY

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

"I admit that I have read this report
and I found that it is suffice from the aspect of
scope and quality for the award of the degree of
Bachelor of Mechanical Engineering (Structure & Material)"

Signature : _____

Supervisor : MOHD RIZAL BIN ALKAHARI

Date : _____

STUDY ON MECHANICAL BEHAVIOUR OF RESISTANCE SPOT-WELDING TECHNOLOGY

SANMUGETHAN A/L KUPPUSAMY

A project report is submitted to the Faculty of Mechanical Engineering in partial fulfillment of the requirements for the award of the degree of
Bachelor of Mechanical Engineering
(Structure & Material)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

MAY 2009

"I admit this report is done all by myself except statement that I have already stated on each one of them"

Signaturre : _____

Author : SANMUGETHAN A/L KUPPUSAMY

Date : _____

To all my family especially my beloved parent, Mr. KUPPUSAMY A/L RAMASAMY and Madam KALIAMMAH A/P PALANISAMY, to my supervisor MOHD RIZAL B. ALKAHARI, all my lectures and all my friends.

Thank you for the motivation and full support

ACKNOWLEDGEMENT

It gives me the greatest pleasure to express my sincere gratitude to my supervisor, Mohd Rizal B.Alkahari of which we had an excellent working relationship, and who offered tremendous help and encouragement throughout the course of my graduate studies and completion of this project.

In addition, I would also like to express thanks to all my lecturers and technician teams from the Faculty of Mechanical Engineering for their critics, guidance, opinion, advice and ideas during the final year project period.

Thanks also to Universiti Teknikal Malaysia Melaka for giving me the opportunity to complete my degree program successfully and providing help financially to buy the materials required to complete the project.

I would also like to take this opportunity to thank my family members who inspired and supported me throughout the completion of my project.

Last but not least, thanks to all my lecturers, friends and relevant personnel who helped in one way or another for me to successfully complete this project.

ABSTRACT

This report described about a project titled "**Study on Mechanical Behaviour of Resistance Spot-Welding Technology".** Resistance spot welding is widely used in automotive body assembly compared to other joining technology. Resistance spot weld produce less heat affected zone in workpiece and have greater joining strength. The strength of the spot weld is influenced by many factors such as physical, chemical and mechanical properties of the base metal. An optimized condition of parameters can give good and quality weld joints. The influence of the primary parameters which are welding current and weld time on the tensile shear force and microstructure of the spot weld joint between mild steel and galvanized steel has been investigated in this study. The experiment is conducted to study the effect of the resistance spot welding joining strength by varying the sheet material, sheet metal thickness, weld time and welding current. From the observation two types of fracture mode was found which are separation and tearing types. It was found from the study, increasing current, welding time and material thickness increases the tensile shear strength and hardness value. The presents of porosity did not directly affect the strength of the weld since no initiation of crack in the weld nugget when tensile test are carried out.

.

ABSTRAK

Laporan ini menerangkan tentang projek "**Study on Mechanical Behaviour of Resistance Spot-Welding Technology**". "Resistance spot welding" luas digunakan dalam bidang membuat struktur badan kereta berbanding dengan teknologi penyambungan logam lain. Ketahanan penyambungan menggunakan "Resistance Spot Welding" dipengaruhi banyak factor contohnya sifat fizikal, sifat kimia dan sifat mekanikal. Pengaruh faktor utama iaitu arus elektrik kimpalan dan masa kimpalan terhadap ketahanan kelenturan dan microstruktur penyambungan diantara logam mild steel and galvanized steel dikaji dalam projek ini. Experimen dijalankan untuk menganalisis kesan terhadap kekuatan penyambungan logam menggunakan "Resistance Spot Welding" dengan menggunakan logam yang berlainan saiz, logam berlainan jenis, masa kimpalan dan arus elektrik kimpalan. Dua jenis pematahan didapati daripada eksperimen ini iaitu perpisahan dan koyakakn di sekitar tempat penyambungan logam. Daripada kajian yang dibuat, didapati bahawa semakin tinggi nilai arus elektrik kimpalan and masa kimpalan semakin tinggi kekuatan penyambungan logam dan kekerasanya. Kehadiran "porosity" tidak mempengaruhi ketahanan kelenturan disebabkan tidak ada kehadiran retakan semasa menjalani ujian ketahanan kelenturan.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF SYMBOL

H	=	Heat
I2	=	Current Squared
R	=	Resistance
T	=	Time
K	=	Heat Losses
t	=	Thickness of the steel sheet

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION TO JOINING TECHNOLOGIES

1.1 Introduction

The history of joining metals goes back several millennia, with the earliest examples of welding from the Bronze Age and the Iron Age in Europe and the Middle East Joining is the act or process of putting or bringing things together to make them continuous or to form a unit. Sheet metal joining methods have shown many advantages in numerous applications. The ability to join allows products and structures to be created with sizes and shapes, and overcomes the limitations of primary fabrication processes (like casting, molding, forging, powder processing, and composite lay-up) and single material properties.

In this modern world now, there is a presence of many joining technology and invention for new joining technology in progress. Joining technology are playing very important role in most manufacturing and construction industries. Joining methods can be classified into three fundamental forces. There are:

- **Mechanical Joining : Using Mechanical Forces**

Mechanical forces arise from interlocking and resulting interference between parts, without use any chemical or physical (electromagnetic) interaction. Mechanical fastening and integral mechanical attachment are the two ways in which mechanical forces can be used to join structures and materials. Common examples of mechanical fasteners are nails, bolts (with or without nuts), rivets, pins, and screws. Less popular mechanical fasteners are paper clips, zippers, buttons, and snaps. Common examples of designed-in integral mechanical attachments are dovetails and grooves, tongues-and grooves, and flanges, while common examples of processed-in attachments are crimps, hems, and punch marks or ‘‘stakes.’’

- **Adhesive Bonding : Using Chemical Forces**

In adhesive bonding, materials and the structures are joined one to the other with the aid of a substance capable of holding those materials together by surface attraction forces arising principally from chemical origins. The bonding agent, called an ‘‘adhesive,’’ must be chemically compatible with and chemically bondable to each substrate of what are called ‘‘adherents.’’ Metals, ceramics, glasses, polymers, and composites of virtually all types, as well as dissimilar combinations of these, can be successfully adhesive-bonded.

- **Welding: Using Physical Forces**

Welding is a most natural of all joining processes. In practice, welding is the process of uniting two or more materials through the application of heat or pressure or both to allow the aforementioned bonding to occur. Example of type of welding is Metal Inert Gas Welding (MIG), Tungsten inert gas (TIG), Shielded Metal Arc Welding (SMAW), Resistance Spot Welding (RSW) and etc. There are two sub-classifications of welding in which the base materials are heated but not melted, a

filler material is added and melted, and little or no pressure is applied; the molten filler spreads to fill the joint by capillary attraction forces. These two methods are known as brazing and soldering.

At the moment, many industries are finding for fast, economical and good strength joining methods. Especially, automotive industry trying to reduced the automobile weight in order to improve the fuel efficiency. High strength steel and aluminum can be used instead of mild steel to produce automobile parts and reduce the weight. In this study, major focus will be given towards the joining methods applicable in sheet metal production and how efficiently the different joining methods can be utilized in the sheet metal production. Sheet metal production has numerous applications and the production depends completely on the joining methods. Therefore, study on mechanical behavior of sheet metal joining technologies will be very helpful to determine its strength. For study purposes of sheet metal joining technologies, Spot welding and Self-Pierce rivet was chosen because it is widely used in automotive industry.

1.2 Problem Statement

This project can be defined as a study on mechanical behavior of resistance spot welding technology. The resistance spot welding is affected by parameters such as weld time and welding current. These parameters influenced the strength of the resistance spot weld joints and the microstructure of the weld. Using unsuitable parameter may cause poor resistance spot welded joint quality in terms of its appearance and strength. Therefore an optimized condition of parameters is necessary to produce good and quality weld. These selected joining technologies will be studied in terms of joining strength and microstructure by varying parameters such as material, material thickness, weld current and weld time.

1.3 Objective

The objective of this project is to analyze and compare the mechanical strength and quality of resistance spot welding process when subjected to different process parameters.

1.4 The Scope of This Research Includes:

1. Literature review on different sheet metal joining technologies.
2. Study on the effects of different process parameters on the strength of resistance spot welding.
3. Study on how the porosity affects the strength of spot-welded joint.

CHAPTER II

LITERATURE REVIEW

A literature search was performed to study and analysis the resistance spot welding and self pierce riveting process. It also includes the investigation of what others have done in this area.

2.1 An Overview of Joining Technology In Automotive Body Structures

Sheet metal joining methods have shown many advantages in numerous applications especially in automotive body structures. The advantages are mainly based on different joining methods, which give precise products with the help of different joining processes. Joining methods are usually implemented for different types of metals and different types of products. The joining material can be of different composition from the parent material, or it may be a similar type of material employed in diverse conditions. Some of common joining methods of body structures are explained below:

2.1.1 Inert Gas arc welding

Arc welding is still required in automotive body assembly to achieve structural stability. In stead of general arc welding, MIG arc welding systems are used. The system comprises of a current source, push-push wire feeder, a hose bundle, torch head and torch cleaning unit. The system is supplemented with various sensors to achieve consistent quality. Different shielding gases are used for specific materials being joined. Recent advances in MIG welding are concerned with power source design for better accuracy and ease of tuning the welding equipment, and process techniques for improving the operating characteristics and reducing cost. Trend is towards electronic power sources based on thyristor, transistor, and AC line rectifier. Specific advantages of electronic power sources in MIG welding are:

i. more precisely controlled welding parameters through a feed back system
ii. accurate tuning of the welding parameters through continually variable voltage setting
iii. control system can be readily interfaced with mechanical or automatic equipment
iv. micro computer for storage of welding parameters for different program

2.1.2 Seam Welding

Seam welding is still used for a number of parts and/or subassemblies such as gas tank. Seam welding of coated sheets- such as galvanized/Terne, is drastically different from that of uncoated steels. During weld cycles, the metal coating tends to build up on electrode wheels. The build-up produces a high resistance path creating an undesirable heating effect in the welding zone that results in inconsistent weld quality (voids, leakage points). A new system uses copper wire as an intermediate electrode

running over the welding wheels at normal welding speeds; the copper wire picks up and carries off all melted coating materials as the workpiece passes through the electrode welding wheels. The process ensures consistent high weld quality.

2.1.3 Laser Welding- the new technology

A typical vehicle body can have a few hundred of laser welding. Laser welding provides an advantage to weld onto a very mall area. This joining technology is suitable particularly for welding deep and narrow joints. Laser welding were employed in body structure joins because it produces welds of good quality with minimum shrinkage and distortion. Laser welds have good strength and generally are ductile and free of porosity. Figure 2.1 below illustrates the possible area of laser welding application in joining the body structure.

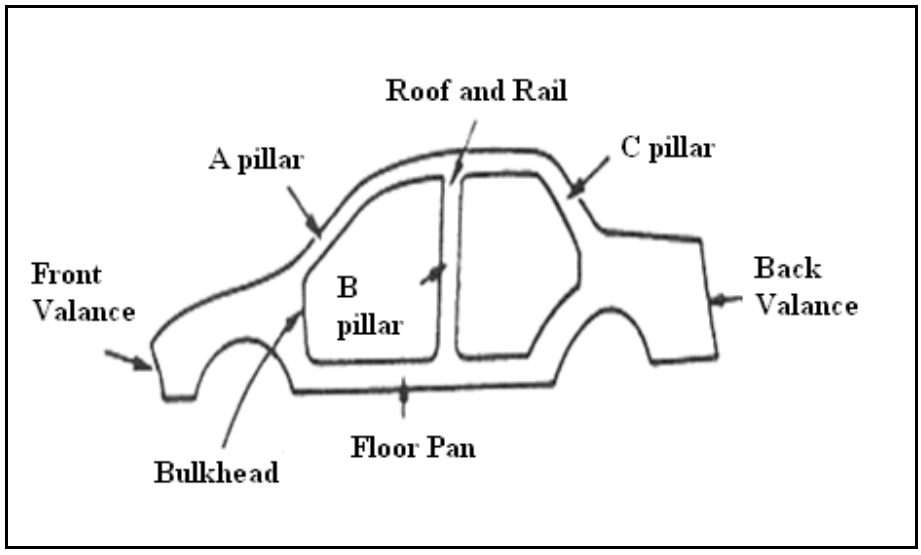

Figure 2.1: Possible Laser Welding Areas of Autobody

(Source: Google image)

2.1.4 Resistance Welding

Spot welding can be classified into resistance spot welding, resistance seam welding and resistance projection welding. The principle of these three methods is similar, which use electrical resistance heating to form the weld join. Resistance spot welding is a simplest and most widely used joining technology to produce body structures. In addition RSW gives fast and economical means of joining overlapped materials.

2.1.5 Mechanical Joining: A re-emerging joining technology

Panels of coated sheet material are being increasingly used to meet product functionality requirements such as reduced weight, service life and recyclability. The self piercing riveting has potential as a replacement for spot resistance welding (Abe *et al.* 2006). Resistance spot welding can't be used because of its limitations. Some self-piercing riveting technologies are emerging fast as a key mechanical joining method for automotive bodies compared to other mechanical joining methods such as clinching. Rivet material and its geometry along with die geometry will be critical to this joining process.

2.1.6 Self-Pierce Rivet

Self-pierce rivet was invented about 50 years ago; it is only in the last 20 years the technology of the SPR starts growing (He *et al.* 2008). The reason for the development of SPR is because of the automotive industry which looking for energy efficient vehicles. In order to produce energy efficient vehicle, the design of lightweight structures is major issue. Problems arise in joining lightweight material because this