UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY OF RESISTANCE SPOT WELDING FOR AUTOMOTIVE APPLICATION

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

by

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DECLARATION

I hereby, declared this report entitled “Study of Resistance Spot Welding for Automotive Application” 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 degree of Bachelor in Manufacturing Engineering Technology (Process & Technology) (Hons.). The member of the supervisory committee is as follow:

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(Project Supervisor)

ABSTRACT

Resistance spot welding is commonly used in the automotive industry, because it has the advantage which is high speed, high-production assembly lines and suitability for automation. The welded joints are exposed to the variables of load and pressure, these conditions made the welded joint to rupture. The objective of this project is to study different properties of the welded joint of the SPCC & SPHC sheets metal by using the different electrode tip. Four test is used in this project which is tensile test method to analyze the maximum load that can be applied before the specimen is rupture or tears apart, liquid dye penetrant to check porosity, visual test using caliper to measure the nugget diameter (mm) of the specimen and testing using microscope to get the microstructure of welding fusion of the specimen. By doing the analysis, the suitable welding tip can be determined. The materials used in this study are SPCC and SPHC and the selected welding tip used dome nose and flat nose because it is varied in the industrial applications.

ABSTRAK

Kimpalan rintangan bintik kebiasaannya digunakan di industri automotif, hal ini di sebabkan kerana kelebihannya dari segi kelajuan yang tinggi, hasil pemasangan yang tinggi dan sesuai dalam automasi. Sambungan hasil kimpal kebiasaanya terdedah dengan pelbagai beban dan tekanan, keadaan seperti itu menyebabkan sambungan itu retak. Objektif projek ini adalah untuk mengkaji sifat yang berbeza pada sambungan SPCC & SPHC lembaran logam dengan sambungan menggunakan saiz radius elektrod tip yang berbeza. Empat ujian digunakan di dalam projek ini iaitu kaedah ketegangan untuk menganalisa beban maksimum yang boleh dikenakan sebelum specimen itu terpisah dua atau retak, cecair pewarna penusuk untuk melihat keliangan, ujian pandangan menggunakan caliper untuk mengukur diameter nugget (mm) pada specimen dan ujian menggunakan miscroskop untuk mendapatkan struktur mikro kimpalan kelakuran pada specimen. Dengan melakukan analisis, saiz elektrod tip yang sesuai dapat ditentukan. Bahan yang digunakan dalam kajian ini adalah SPCC dan SPHC dan tip kimpalan yang dipilih utk digunakan adalah elektrod kubah hidung dan elektrod hidung rata kerana ia digunakan dalam pelbagai industry.

DEDICATION

Special feeling of gratitude's to my loving family who have supported me throughout the process of completing this report. This project report is dedicated to my father, Abdul Razi bin Abdul Latiff, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, Roslinda binti Zainal Abidin, who taught me that even the largest task can be accomplished if it is done one step at a time.

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I would also like to take this opportunity to convey an appreciation to all the academics, administrative and staffs for their various contributions and assistance, directly or indirectly, in the running of this project. Thank to the Faculty of Engineering Technology, UTeM, for giving me the opportunity, space, facilities and time to work on this project.

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LIST OF ABBREVIATIONS

RSW	=	Resistance Spot Welding
SPCC	=	Cold-rolled sheet metal
SPHC	=	Hot-rolled sheet metal
NDT	=	Non-destructive testing
NDE	=	Non-destructive examination
IF	=	Interfacial failure
PF	=	Pullout failure
CF	=	SPCC material is joint using flat nose welding tip
HF	=	SPHC material is joint using flat nose welding tip
CB	=	SPCC material is joint using dome nose welding tip
HB	=	SPHC material is joint using dome nose welding tip
GF	=	Grain boundary ferrite
PF	=	Polygonal ferrite
AF	=	Acicular ferrite
AC	=	Ferrite with aligned M-A-C
FC	=	Ferrite carbide aggregate
M	=	Martensite

CHAPTER 1
INTRODUCTION

This chapter explains the background of this study, problem statements, objectives, scope, project significance and conclusion for this chapter one as well as the limitations in completing this research. The structure of the report of the study is briefly explained as well to ensure a better visualization of the sequence of the entire study.

1.0 Introduction of resistance spot welding (RSW)

Resistance spot welding (RSW) is a process in which metal surfaces arejoined in one or more spots by resistance to the flow of electric current through workpieces that are held together under force by electrodes (Han Z, Indacochea, Chen &Bhat. 1993). The weld is made by acombination of heat, pressure, and time. The process is used for joining sheetmaterials and uses shaped copper alloy electrodes to apply pressure and convey theelectrical current through the work piece. Heat is developed mainly at the interfacebetween two sheets, eventually causing the material being welded to melt, forming amolten pool, the weld nugget. The molten pool is contained by the pressure appliedby the electrode tip and the surrounding solid metal. The resistance spot welding hasthe advantage which is high speed and suitability for automation.

The welded joints are exposed to the variables of load and pressure, these conditions made the welded joint to rupture. Mechanical testing is an important aspect of weld ability study. Such testing iseither for revealing important welds characteristics, such as weld nugget diameter orweld button size, or for obtaining and evaluating the quantitative measures of weld’sstrength (Han Z, et al. 1993). Mechanical testing of a weldment can be static or dynamic test andamong the static test, tensile shear testing is commonly used indetermining weld strength or the tensile strength of the welded joints because it iseasy to conduct the test and the specimens for the test is simple in fabrication. Other than that, lack of fusion is also important defect need to be given more attention, using microscope to check the fusion. The critical nugget diameter also will be measured using vernier calliper as a visual test. It is also easy to conduct. Last but not least, liquid penetrant is important in determine internal crack of the welded joint.

1.1 Problem statement

Resistance spot welding are widely used in automotive industry and also well known with their excellent joining process to their strength of joint and rapidly process. Nevertheless, properties of the joint using different welding tips are still questionable. Failure of the joint is possible to occur to the joint of the material. Testing the properties on the joint that using different welding tip is the technique to determine and compare between the joint. Therefore, this project will focus on study the effect of welding tip radius for resistance spot welded joints. Two different electrodes are use which is dome nose electrode and flat nose electrode tip on the cold rolled sheets metal (SPCC) and on the hot rolled sheets metal (SPHC). The specimens will go through four standard testing. They are tensile test, liquid penetrant (NDT), visual test using calliper and microscope to get microstructure fusion of the weld.

1.2 Objective

1. To study properties of the welded joint SPCC and SPHC sheets metal using different electrode tip radius.

1.3 Scope of project

In order to obtain the objectives of this research, the scope of the study has performed as shown in Figure 1.1. The scope of this project is to study the properties of sample after undergo joining using resistance spot welding by using different welding tip. Sheets metal of SPCC and SPHC is used as a sample in this project. The sample will be cut into ASTM standard size 30mm x 100mm with thickness 1mm for testing.

In general, this work study is focused on the characterization and measurement of the sample after the joining process. The evaluation of this research is from fourstandard testing which are tensile strength of the welded joint of sheets metal being evaluated in terms of the maximum load (N) and the displacement of the welded specimens (mm) by using tensile test machine, liquid penetrant testing (NDT) is used to detect the internal flaws by using dye penetrant solvent removable aerosol cans, visual test using calliper to measure the nugget diameter (mm) of the specimen. Last but not least, microscopicexamination to get the microstructure for welding fusion of the specimen. Three specimens are involved in each testing, 24 specimens before weld size 30mm x 100mm will be provided for SPCC and 24specimens' before weld size 30mm x 100mm will be provided for SPHC.

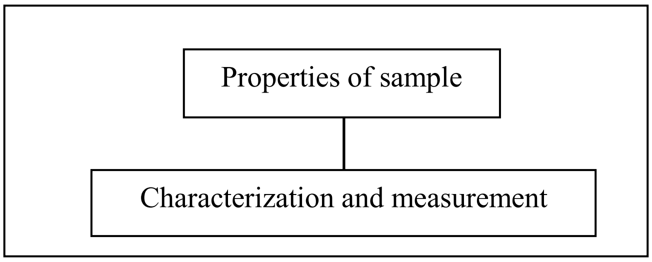

Figure 1.1: Project Work scope

1.4 Conclusion

This chapter describes the research background, goals, purpose and limitations of the dissertation of this research. In addition, it shows the details about problems or aims to be investigated, how the research will be conducted and the contribution of different welding tip for many potential applications as automotive product. The next chapter will provide an overview of the resistance spot welding in details.

CHAPTER 2

LITERATURE RIVIEW

2.0 Introduction

This chapter discussed literatures of the resistance spot welding, their background, principle, parameter and welding tip. Other than that, material SPCC and SPHC are also being discussed.

2.1 Resistance spot welding

Resistance spot welding is one of the oldest electric welding processes in use by industry today, especially in the automotive industry. It is a joining process in which coalescence of the metal sheets is produced at the faying surface by the heat generated at the joint by the resistance of the work to the flow of electric current (Han Z, et al. 1993).

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 surfaces (Miller, 2012).

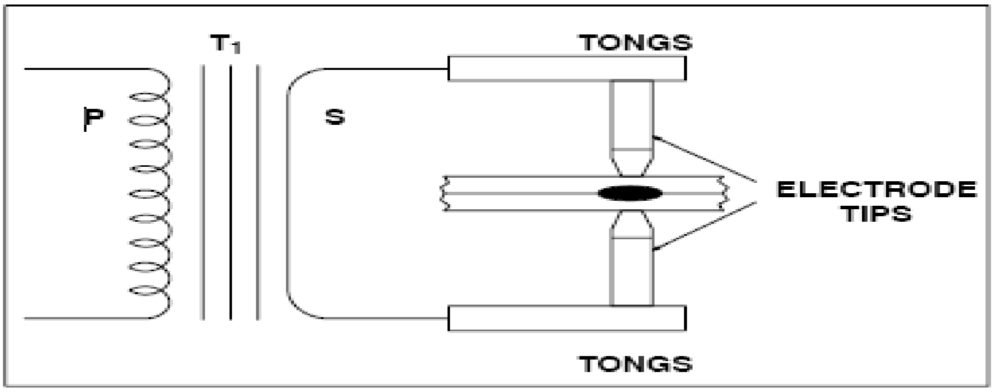

Figure 2.1: Resistance spot welding machine with work

The size and shape of the individually formed welds are limited primarily by the size and contour of the electrode faces. The weld nugget forms at the laying surfaces, as shown in Figure 2.1, but does not extend completely to the outer surfaces. In section, the nugget in a properly formed spot weld is round or oval in shape. Spacing between adjacent spot welds or rows of spot welds must be enough to prevent shunting or to limit it to an acceptable amount (Miller, 2012).

2.2 Principle of the resistance spot welding

Resistance Spot Welding is done when current is caused to flow through electrode tips and the separate pieces of metal to be joined. The operation of spot welding involves a coordinated application of current of the proper magnitude for the correct length of time. This current must pass through a closed circuit. The resistance of the base metal to electrical current flow causes localized heating in the joint, and the weld is made.

The resistance spot weld nugget is formed when the interface of the weld joint is heated due to the resistance of the joint surfaces to electrical current flow. In all cases, of course, the current must flow so the weld can be made. The pressure of the electrode tips on the work piece holds the part in close and intimate contact during the making of the weld (Miller, 2012).

2.3 Spot welds parameter

2.3.1 Electrode Force

The electrode force is required to squeeze the metal sheets to be weld and joint together. This requires a large electrode force because the weld quality would not be good enough. However, the force must not be too large as it might cause other problems. When the electrode force is increased the heat energy will decrease. So, the higher electrode force needed a higher weld current. When weld current becomes too high, spatter will occur between electrodes and sheets. This will cause the electrodes to get stuck to the sheet.

2.3.2 Squeeze Time

Squeeze Time is the time interval between the initial application of the electrode force on the work and the first application of current. Squeeze time is necessary to delay the weld current until the electrode force has attained the desired level (Entron, 2014).

2.3.3 Weld or Heat Time

Weld time is the time during which welding current is applied to the metal sheets. The weld time is measured and adjusted in cycles of line voltage as with all timing functions. As the weld time is, more or less, related to what is required for the weld spot, it is difficult to give an exact value of the optimum weld time. For instance:

- Weld time should be as short as possible.
- The weld parameters should be chosen to give as little wearing of the electrodes as possible. (Short welded time.).
- The weld time shall cause the nugget diameter to be big when welding thick sheets.

- The weld time might have to be adjusted to fit the welding equipment in case it does not fulfil the requirements for the weld current and the electrode force. (A longer weld time might be needed.).
- The weld time shall cause the indentation due to the electrode to be as small as possible. (A short welded time.).
- The weld time shall be adjusted to welding with automatic tip-dressing, where the size of the electrode contact surface can be kept at a constant value. (A shorter welded time.) (Entron, 2014).

2.3.4 Hold Time (cooling-time)

Hold time is the time, after the welding and occurred when the electrodes are still applied to the sheet to chill the weld (time that pressure is maintained after weld is made.). Hold time is necessary to allow the weld nugget to solidify before releasing the welded parts, but it must not be to long as this may cause the heat in the weld spot to spread to the electrode and heat it. The electrode will then get more exposed to wear. Further, if the hold time is too long and the carbon content of the material is high (more than 0.1%), there is a risk the weld will become brittle (Entron, 2014).

2.3.5 Weld Current

The weld current is used during welding is being made. The amount of weld current is controlled by two things; first, the setting of the transformer tap switch determines the maximum amount of weld current available; second the percentage of current control determines the percentage of the available current to be used for making the weld. Low percentage of current settings is not normally recommended because it might affect the quality of the weld. Proper welding current can be obtained with the percentage current set between seventy and ninety percent by adjust the tap switch.

The weld current should be kept as low as possible. When determining the current to be used, the current is gradually increased until weld spatter occurs between the metal sheets. This indicates that the correct weld current has been reached. Weld current also influences the value of nugget diameter. Different value of current, it will produce different dimension of the nugget diameter (Entron, 2014).

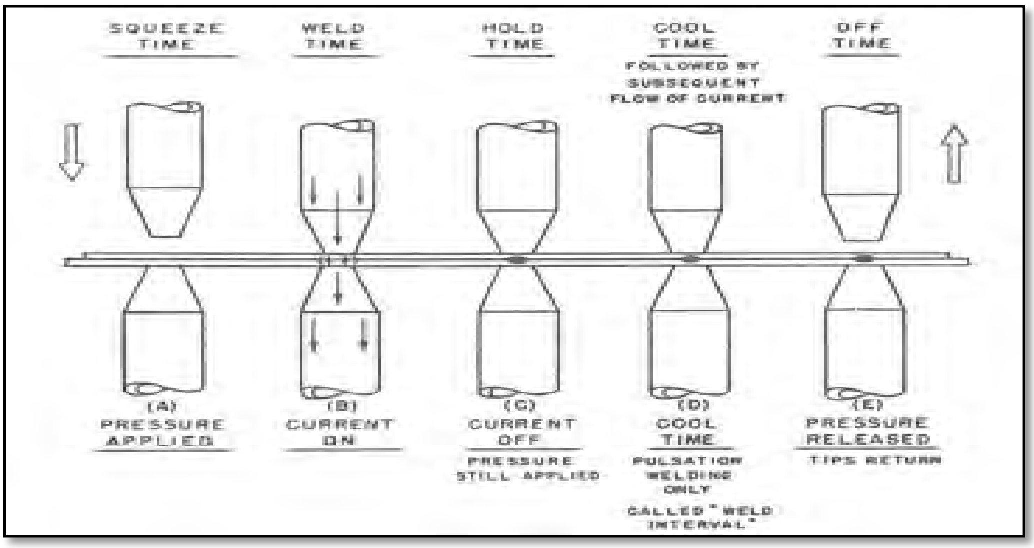

Figure 2.2: Welding Cycle

The welding processes in resistance spot welding have 5 cycle process as shown in the Figure 2.2. The first cycle is the squeeze time, where pressure from the electrode force is applied to the workpiece. The second cycle is weld time, this process where the current is on and the welding current is applied in the metal sheets to melt the sheet metal for the welding process. Then, post heat time, the current delay at the low level. The fourth cycle is cool time. This cycle allow the melt nugget diameter to solidify before the releasing the welded parts and lastly the off time cycle, the electrode force applied on the sheets metal is released the welding process is done.

2.4 Electrode tip

Copper is the base metal normally used for resistance spot welding tongs and tips. The purpose of the electrode tips is to conduct the welding current to the workpiece, to be the focal point of the pressure applied to the weld joint, and to conduct heat from the work surface. The tips must to maintain their integrity of shape and characteristics of thermal and electrical conductivity under working conditions (Miller, 2012).

Electrode tips are made of copper alloys and other materials. The Resistance Welders Manufacturing Association (RWMA) has classified electrode tips into two groups:

Group A − Copper based alloys

Group B − Refractory metal tips

The groups are further classified by number. Group A, Class I, II, III, IV, and V are made of copper alloys. Group B, Class 10, 11, 12, 13, and 14 are the refractory alloys. Group A, Class I electrode tips are the closest in composition to pure copper. As the Class Number goes higher, the hardness and annealing temperature values increase, while the thermal and electrical conductivity decreases (Miller, 2012).

Group B compositions are sintered mixtures of copper and tungsten, etc., designed for wear resistance and compressive strength at high temperatures. Group B, Class 10 alloys have about 40 percent the conductivity of copper with conductivity decreasing as the number value increases. Group B electrode tips are not normally used for applications in which resistance spot welding machines would be employed (Miller, 2012).

About the size of welding tip, when you consider that it is through the electrode that the welding current is permitted to flow into the workpiece, it is logical that the size of the electrode tip point controls the size of the resistance spot weld. Actually, the weld nugget diameter should be slightly less than the diameter of the electrode tip point. If the electrode tip diameter is too small for the application, the weld nugget will be small and weak. However, the electrode tip diameter is too large; there is danger of overheating the base metal and developing voids and gas pockets. In either instance, the appearance and quality of the finished weld would not be acceptable. Determining electrode tip diameter requires some decisions on the part of the weldment designer (Miller, 2012).