UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE INVESTIGATION OF MECHANICAL PROPERTIES OF FOUR LAYER SPOT WELDING

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

by

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I hereby, declared this report entitled THE INVESTIGATION OF MECHANICAL PROPERTIES OF FOUR LAYER SPOT WELDING is the results of my own research except as cited in references.

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Author : MUHAMMAD ASYHRAF BIN NADZRI

Date:

APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours. The member of the supervisory is as follow:

Signature: …….

Supervisor : Mr. HARRIS FADHILAH BIN ZAINUDIN

ABSTRAK

Projek Tahun Akhir ini menggariskan latar belakang projek "Penyiasatan Sifat Mekanik Empat Lapisan Kimpalan".Kimpalan rintangan adalah proses penjanaan haba yang agak mudah: laluan semasa melalui rintangan menjana haba. Ini adalah prinsip yang sama digunakan dalam operasi gegelung pemanasan. Di samping rintangan pukal, rintangan hubungan juga memainkan peranan utama. Rintangan hubungan dipengaruhi oleh keadaan permukaan. Kimpalan rintangan empat titik adalah suatu usaha yang lebih mencabar daripada kimpalan rintangan tiga titik. Ini disebabkan oleh faktor beberapa gangguan. Kekuatan sesuatu struktur sesebuah kereta bergantung kepada sifat mekanik dan struktur suatu kimpalan. Oleh itu, laporan ini bertujuan untuk menyelidik sifat mekanik lapisan telah dikimpal empat titik dibandingkan dengan sifat mekanik kimpalan titik tiga. Projek ini mengandungi metodologi yang telah dikaji dan dikenalpasti. Dalam kajian ini, kekuatan pada tegangan ricih ujian sendi pusingan dalam kimpalan titik pada keluli tinggi kekuatan berketebalan 0.7mm ketebalan empat lapisan yang dikimpal telah telah dikaji. Semua keputusan kemudiannya dibandingkan dengan tiga lapisan kimpalan titik yang berketebalan 0.7mm .Tiga lapisan yang berketebalan 0.7mm dikimpal titik dijadikan sebagaiu penanda aras dalam kajian ini.

ABSTRACT

This Final Year Project outlines the background of the "Fourth Welding Layer Mechanical Properties project". Resistance spot welding is a relatively simple heat generation process: the current passage through heat-generating resistance. This is the same principle used in the operation of coil heating. In addition to bulk barriers, relationship barriers also play a major role. Relationship resistance is influenced by surface conditions. Four-point resistance welding is a more challenging endeavour than three-point resistance welding. This is due to several interference factors. The strength of a car's structure depends on the mechanical properties and structure of a weld. Therefore, this report aims to investigate the mechanical properties of the welded welds of four points compared to the mechanical properties of the three-point welding. This project contains the methodology that has been studied and identified. In this study, the strength of the joint test shear tensile strength of the round joints in the welding point on the high steel strength of 0.7mm thickness welded four layers has been studied. All results are then compared to three layers of 0.7mm welds. Three layers of 0.7mm welded joints are used as a benchmark for this study.

DEDICATION

I dedicate this final year project to my family members and friends for their full support in my studies. Thank you for giving me the opportunity to improve and prove myself throughout my life. Anything great that has gone to my life is cause of your love, example and guidance.

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Q	-	Heat generation
I	-	Current
R	-	Resistance of the conductor
t	-	Time
S(u)	-	Ultimate Tensile Strength
P(max)	-	Maximum Load
Ao	-	Cross Sectional Area

LIST OF ABBREVIATIONS

AC	Alternating Current
DC	Direct Current
RSW	Resistance Spot Welding
UTM	Universal Testing Machine
HSLA	High Strength Low Alloy Steel
DP	Dual Phase
TRIP	Transformation Induced Plasticity Steel
TWIP	Twin Induced Plasticity Steel
GS	Hot-dip Galvanized Steel
SPCC	Cold Rolled Steel
HV	Hardness Vickers

CHAPTER 1

INTRODUCTION

1.1 Background of Project

Resistance spot welding process was invented in 1877 Professor Elihu Thomson and has been widely used since then in manufacturing industry, especially in the automobile and air craft industries(Saleem,2012). Resistance spot welding process is so complex and massively non-linear that it becomes so difficult to be modeled cause of the presence of electric, thermal and mechanical phenomenon in it. Usually, the automotive industries tend to combine two or more plates together using spot welding. Automotive industries use spot welding in manufacturing the body of a car especially on the side structure. Concluding the statements, the spot welding has its own speciality which it can undergo the process of welding in a short period of time, can weld different combinations of material together and it even surpass many of the welding techniques to join difficult or even impossible combinations of sheet metal plates.

Resistance Spot welding process is started with the overlapping of two or more sheets stack of material components. Two contact points which is above and below the overlapped sheets are welded by flowing electric current through it. The interaction of two points then create current resistance in it which then continued to produce heat. The pressure that been applied to the contact points will then form a round irregular-shaped weld joint. The process of applying pressure at two points on the workpieces by using two electrodes can be done manually, using mechatronic spot welding robotic machine, or using dedicated spot welding machine. Spot welding is a very fast process. Usually,

spot welding process will take the time about few seconds to be completed. Figure 1.1 shows the schematic circuit of resistance spot welding.

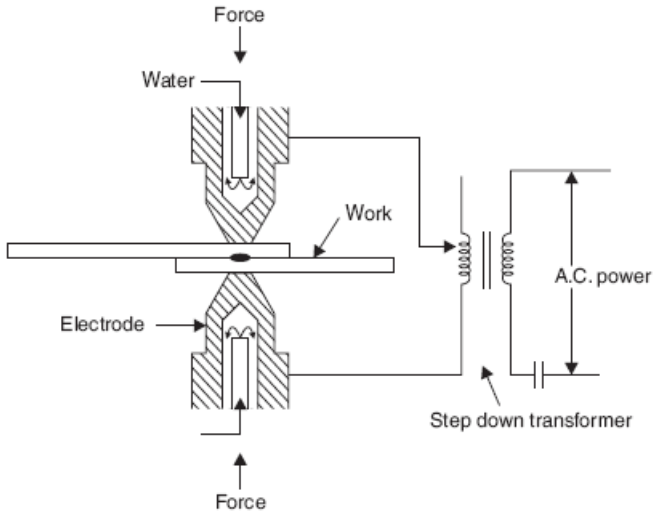

Figure 1.1: Schematic of Circuit for Resistance Spot Welding Process

The resistance spot welding is a liner process and it is not continuous. There are some instances where spot welding process is done manually or using the robotic spot-welding machine and prepared spot-welding machine. For low volume of weld process, the resistance spot welding will be done manually and vice versa which it will be done using the robotic spot-welding machine or dedicated spot-welding machine if the volume of weld process is high. In resistance spot welding process, there are many types of variable that can be analysed. There are welding current, welding time, welders condition, surface condition of materials and condition of the electrode tips. Although there are many variables that can be analysed, some of it were hard to handle and it may deteriorate the whole weld process. The variables that can be analysed and easily controlled are welding current, welding time, and electrode force. By minimizing the

parameter of spot-welding process, there is a high chance of getting a good spot weld process.

Today, automotive industries have widened the resistance spot welding process by advancing it to four-layer spot welding process. The process is more complicated by introducing various combinations of different material and different thickness. C.V Nielsen et. Al (2011). The development of this type of spot welding enhances the challenges that need to be coped by the industries. The most important part of each spot welding process is the strength of the welded part. Investigation of the scenario of strength of four-layer spot welding process is the main part of this project.

1.2 Problem Statement

Nowadays, death cases involving traffic accident has been the one of the top-notch situations in Malaysia. More than 1.2 million of people die annually in highway-related crashes and as many as 50 million are injured (F.L. Mannering,2014). One of the death related cases is of course from car collisions. Improvement of design engineering is needed in current automobiles manufacturing system so that it can decrease the severity of the collision by providing more protective designs and materials. The improvement of the design, build quality and material on automobile manufacturing will ensure that each car can sustain each collision damage much better and hence reducing the number of deaths involving car collisions.

A test done by the analyst to measure if a car is capable of sustaining the damage of each collision and it is called crash test. Crash test is a method of destructive test which is to satisfy safe design standards applied by the government and requested

by mass of automobile industries in crashworthiness and crash compatibility for different transportation and related system and components. There are many types of test in crash test and two of them are most related to car collision nowadays which are frontal-impact test and side-impact test. The vehicle crashworthiness is one of the factors pinpointed in crash test which it examines the capability of a car structures to provide enough protection for the passengers against injuries and even imminent death. This protection of a car massively depends on the spot weld structural mechanical behaviour. It is believed that the side structure of a car is important in a crash test. According to (G.Dong et al. 2007), global accidents statistics show that side impacts accounts for approximately 30% of all impacts and 35% of all fatalities. Increasing the layer of spot-welding process is the solution to reduce the side impact of a collision of a car. Basically, automotive industries tends to produce two-layer spot welding and three-layer spot welding. The race of automobile industries has become a real vision for them to provide the best build for satisfying the request for clients as well as improving the strength and safety.

The automotive industry has introduced the three-layer weld configuration, which represents new challenges compared to normal two-sheet lap welds. The process is further complicated by introducing high-strength steels in the joint. (C.V.Nielsen et al. 2014) managed to complete a resistance spot welding of three layer metal sheets. Investigation in his research was about weldability of thin, low-carbon steel to two thicker, high-strength steels of high-strength low-alloy (HSLA) 340, DP600, or TRIP700.The introduction of extra interface in the three-layer resistance spot welding makes it massively more complicated. The complication in this three sheets resistance spot welding is added by different material combinations and different material

thickness. M.Pouranvari et.al (2013) has also done a three-layer resistance spot welding which he investigates the weld nugget formation and mechanical properties of three-sheet resistance spot welded low carbon steel. It was found that the weld nugget diameter increase as the thickness of the specimen increase.

Resistance spot welding of four-layer steel sheets are rarely found in automotive industries. However, it is more challenging than those of two-layer and three-layer steel sheet spot welding process. This is because of the introduction of the extra interface underneath the combination. It is recommended by the producer to avoid the four-layer spot welding if the three-layer spot welding can be done. In conclusion, this research will help by finding the mechanical properties and the type of failure of four layer spot welding process. This research also provide a promotion for the automotive industries.

1.3 Objective

- To investigate the mechanical properties of four-layer resistance spot welding process.
- To investigate the type of failure of four-layer resistance spot welding process.

1.4 Scope

- To compare the tensile strength of four-layer with three-layer spot welding process.
- To compare the nugget diameter of four-layer spot welding with three-layer spot welding process.
- To compare the hardness value between four-layer with three-layer resistance spot welding process

CHAPTER 2

LITERATURE REVIEW

2.1 Resistance Welding

Resistance welding is a thermo-electric process where electrical current is flowed through the weld part which resulted in production of heat at the interface of the part to be joined under a accurately controlled time and also under controlled pressure which also known as force. The process begins with the generation of currents through the electrode which then when it reaches necessary amount of heat, the metal sheet will eventually start to melt and as a result there will be a formation of welding nugget which then will make a strong bond joining the metal sheets together regardless of how many metal it joins.Although it may seems easy to say there are several parameters that need to be taken into account when doing this resistance welding in order to ensure a quality welding product. The parameters are welding current, welding time,electrode force, type of material and material of the electrode.(H.Zhang et al.2012) investigated that governed by the principle of Joule Heating, the general expression of heat generated in an electric circuit can be expressed as

$Q = I^2R\tau$ *I= Current R=Resistance t=time*

He undergone an investigation of the effect of welding current over time to the failure mode of dissimilar thickness resistance spot welded joints in dual-phase steels.The result of test of various values of welding currents, he determined that when the welding currents increase, the failure modes change in the order of IF, P-IF and