DESIGN ANALYSIS OF SHEET METAL WELDED JOINT BASED ON TRANSIENT THERMAL CONDITION

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This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Design) (Hons.)

by

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TAJUK: **Design Analysis of Sheet Metal Welded Joint Based on Transient Thermal Condition**

SESI PENGAJIAN: **2013/14 Semester 2**

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design) (Hons.). The member of the supervisory is as follow:

ABSTRAK

“Resistance spot welding” adalah satu proses yang cepat, mudah diautomasikan dan mudah dikekalkan tetapi mempunyai produktiviti yang tinggi. Disebabkan oleh kelebihan ini, penggunaan “resistance spot welding” dalam automotif industri adalah sangat tinggi. Hampir 90% daripada pemasangan bahagian-bahagian automotif logam menggunakan proses penyambungan ini. Projek ini telah dijalankan untuk menyelidik parameter reka bentuk kepingan logam kimpalan berdasarkan kepada keadaan haba sementara. Selain itu, keadaan haba fana kepingan logam yang dianalisis dan faktor keselamatan dicadangkan pada akhir projek. Parameter reka bentuk termasuk beberapa kimpalan tempat , dimensi , bahan dan ketebalan kepingan logam. Keadaan mantap dan fana terma analisis dijalankan ke atas aloi aluminium 5182 kepingan logam dengan dimensi 120mm × 60mm, ketebalan 1mm hingga 6mm dan tempat kimpalan dua hingga lime. Gabungan ketebalan kepingan logam dengan bilangan tempat kimpalan yang sesuai akan dicadangkan selepas simulasi dan analisis. CAD model dan analisis kepingan logam telah dijalankan dengan menggunakan perisian ANSYS. Keputusan analisis haba adalah fluks haba, tindak balas siasatan dan faktor keselamatan. Pemarkahan dilakukan untuk menentukan bilangan kimpalan yang sesuai bagi setiap ketebalan kepingan logam. Ia didapati bahawa dua tempat kimpalan sesuai untuk ketebalan 1mm, 2mm, 4mm, dan 6mm bagi dimensi tersebut di atas. Bagi lembaran logam dengan 3mm dan 5mm ketebalan , lima dan dua tempat kimpalan sesuai masing-masing.

ABSTRACT

Resistance spot welding is a fast, easily automated and easily maintained process with high productivity. These advantages result in the highly usage of resistance spot welding in automotive industrial. Almost 90% of the assembly of automotive parts are using this joining process. This project was performed to investigate the design parameters of sheet metal welded joint based on transient thermal condition. Also, the transient thermal condition of the sheet metal is analysed and the factor of safety is proposed at the end of the project. The design parameters included are number of spot welding, dimension, material and thickness of sheet metal. Steady state and transient thermal analysis were conducted on aluminium alloy 5182 sheet metal with dimension 120mm×60mm, thickness 1mm to 6mm and number of spot weld two to five. Suitable combination of thickness of sheet metal with number of spot weld is proposed after the simulation and analysis. The CAD model and analysis of sheet metal was performed by using ANSYS software. The results of both the thermal analysis were heat flux, reaction probe and factor of safety. Scoring is done to determine the number of spot weld for each thickness of the sheet metal. It is found that two number of spot weld is suitable for thickness of 1mm, 2mm, 4mm, and 6mm for the dimension mentioned above. As for sheet metal with thickness 3mm and 5mm, five and two spot weld is suitable respectively.

DEDICATION

To my beloved parents, siblings, and friends for their love and support.

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I would like to express my sincere thanks of appreciation to my co-supervisor, Dr. Taufik for his guidance and encouragement for completing this report. I am so grateful for his patient and tolerance of my naive mistakes.

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$\dot{Q}_{cond}$	-	Rate of Conduction Heat Transfer (W)
$\dot{Q}_{conv}$	-	Rate of Convection Heat Transfer (W)
A_s	-	Surface Area
T_{Cold}	-	Temperature of Colder Object
T_{Hot}	-	Temperature of Hotter Object
T_f	-	Fluid Bulk Temperature
T_s	-	Surface Temperature
Δx	-	Thickness of Heat Transfer
A	-	Heat Transfer Area
Al	-	Aluminium
Cu	-	Copper
Fe	-	Iron
g	-	Gravitational Acceleration (m/s^2)
h	-	Convection Heat Transfer Coefficient ($W/m^2.K$)
I	-	Electric Current (Ampere)
k	-	Thermal Conductivity of Material (W/m.K)
L_c	-	Characteristic Length
Mg	-	Magnesium
Mn	-	Manganese
N_u	-	Nusselt Number
Pr	-	Prandtl number
Q	-	Total Energy (Joule)
R	-	Resistance (Ohm)
R_{aL}	-	Rayleigh Number
Si	-	Silicon
t	-	Time (Second)
v	-	Kinematic Viscosity of fFuid (m^2/s)
Zn	-	Zinc

CHAPTER 1

INTRODUCTION

This chapter discussed the general idea of thermal transient condition for resistance spot welding of sheet metal. Others elements that included in this chapter are problem statement, objective, scope, and report organization.

1.1 Background

Sheet metal working are normally undergoes cold condition compared to formed under hot condition. This is because sheet metal has a lower resistance to deformation when heated (Boljanovic, 2004). The sheet metal forming processes included roll forming, stretch forming, drawing, stamping, rubble-pad forming, spinning, superplastic forming, poem forming, explosive forming and magnetic-pulse forming (Kalpakjian and Schmid, 2009).

Many methods have been used in joining materials together which are adhesive bonding, mechanical joining, fusion welding, solid state bonding welding, friction welding, electromagnetic welding, brazing and roll bonding (Imaizumi, 1996).

Resistance spot welding is one of the welding processes that have been used broadly in sheet metal joining (Cho and Cho, 1989). It is also the most commonly method that used in joining car body steel component (Kowieski et al., 2012). Some of the advantages of this welding process are high speed, suitability for automation industry and high productive assembly lines (Cho and Cho, 1989).

When a structure or part is produced by welding process, a non-uniform temperature distribution is created in the structure or part. A rapid thermal expansion and contraction in weld and the surrounding areas during welding process results in this temperature distribution. Thus, inhomogenous plastic deformation and residual stresses in the weldment is formed when the structure is cold (Armentani and et. al., 2006).

1.2 Problem Statement

Resistance spot welding process include the combination of thermal, electrical, mechanical and metallurgical phenomena. It is a complicated welding process (Nied, 1983). The complexity of this welding process had led to some difficulties in understanding the thermal behavior in the weldment (Cho and Cho, 1989).

After resistance spot welding process, the residual stress and strain will remain in the weldment due to the deformation during the welding process. Upon electrode force and heating, stress and strain will be created and changed. A numbers of researches of the mechanical features for resistance spot welding process are being done. As a conclusion from the researches, the factors that might lead to the failure of resistance spot welding are residual stress, welding schedule, nugget size, welding parameters, thickness, material properties and gap (Wang et al., 2009).

Due to the complexity of resistance spot welding, the actual setting of resistance spot welding such as current and welding time is determined by trial and error most of the time (Saleem and et. al.). At the same time, the number of spot welds needed for a particular dimension is also a factor that leads to failure (Ertas and Sonmez, 2008).
During resistance spot welding, sheet metal experienced change of temperature. Different amount of spot weld generated produced different amount of heat energy. It cannot be denied that thermal condition is one of the factors that need to be considered in resistance spot welding. Thus, there is a need to analyse a sheet metal

welded joint within the factor of safety based on transient thermal condition where the number of spot welds need to be determine.

1.3 Objectives

The objectives of this project are:

a. To investigate the design parameter of sheet metal welded joint.
b. To analyze the transient thermal condition.
c. To propose the factor of safety of sheet metal welded joint.

1.4 Scope

In this project, the sheet metal welded joint is created by using resistance spot welding. The design parameters that investigated are material, dimension and thickness of sheet metal that used in this project. The material of the sheet metal is aluminium alloy 5182 with thickness between 1mm-6mm. The dimension of the sheet metal in this project is 120mm x 60mm. The numbers of spot welds are vary from two spot welds to five spot welds.

This project study the thermal condition of the sheet metal after spot welding joint is formed. The transient thermal condition was analyzed using software ANSYS. Steady state and transient thermal analysis were conducted in order to obtain total heat flux, reaction probe and factor of safety. These results were used in determine the number of spot welds that are suitable for each thickness with the dimension mentioned above.

1.5 Report Organization

This report consists of three chapters where Chapter 1 of this report is introduction. This chapter included the general idea of transient thermal condition of resistance spot welding and the part included. This chapter also discussed the problem statement, objectives, scope, report organization and project schedule.

Chapter 2 is literature review where the review of previous studies that done by other researchers were included in this chapter. This chapter discussed the parameter of spot welding, thickness and materials of sheet metal. Also, this chapter included the design and analysis software that been used to carry out this project.

Chapter 3 methodology described the method that used to achieve the objectives. A flow chart is presented to illustrate the steps and overall process flow of this project. The steps in carried out the analysis using ANSYS were discussed in this chapter too.

Chapter 4 included the results and discussion for this project. The results obtained from the analysis were tabulated and discussed. The suitable numbers of spot welds were suggested at the end of this chapter.

Chapter 5 summarize the whole report and recommend for future work that can be done regarding to this project.

1.6 Project Schedule

Table 1.1 shows the project schedule of Final Year Project 1.

Table 1.1: Project Schedule for Final Year Project I.

Task	Academic Week of Semester I (2013/2014)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Title Selection														
Form Filling														
Identify Objectives and Scope of Project														
Review of Problem Statement														
Sheet Metal Identification														
Welding Parameters Identifications														
Extract Information from Journal, Reference Book and others Conferences														
Implement Introduction and Literature Review														
Prepare Methodology Flow Chart														
Implement Methodology														
Complete Report														
Review Report														
Report Repair and Modify														
Report Submission														
Presentation														

Table 1.2: Project Schedule for Final Year Project II.

Task	Academic Week of Semester II (2013/2014)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Create 3D Model														
Determine Analysis Setting														
Update Methodology														
Analysis Simulation														
Extract Data from Analysis Result														
Analyse Data														
Scoring														
Determination of Number of Spot Weld														
Prepare Results and Discussion														
Review Objective														
Report Preparation														
Review Report														
Report Repair and Modify														
Report Submission														
Presentation														

CHAPTER 2

LITERATURE REVIEW

This chapter is discussed the concepts and theory of sheet metal forming and joining process and welding metallurgy. This chapter also discussed the transient thermal condition of resistance spot welding. Also, other researches that had been done by other researchers are included in this chapter too.

2.1 Sheet Metal

According to The Aluminium Association, aluminium sheet is a product that is rectangular in cross-sectional and form, with thickness more than 0.20mm and less than 6.30mm. A sheet is known as plate if the thickness exceed or more than 6.30mm (The Aluminium Association, 2007).

2.1.1 Sheet Metal Forming

The methods that are most often being used for sheet metal forming are shearing, punching and blanking, deep drawing, bending and other processes (Boljanovic, 2004). Among the methods, shearing, punching and blanking are cutting process.

A shearing process is used to cut off sheet metal material with the usage of punch, die and blank holder (Ishiguro et al., 2009). Figure 2.1 shows the schematic of shearing process. The sheet metal experienced shearing process or being cut by the punch and die where force is added. This process is usually used to produce various opening in a sheet metal (Kalpakjian and Schmid, 2009).

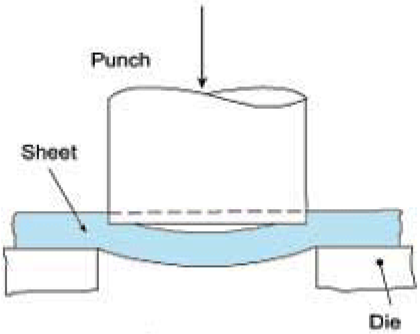

Figure 2.1: Schematic of Shearing Process (Stuart, 2002-2013)

Blanking and punching (also known as piercing) are both shearing process. The main difference of these two processes is the scrap. Figure 2.2 shows the difference between punching and blanking operations. Punching operation is whereby the scrap the part that had been cut out. The workpiece of blanking is called a blank. This is the part which cut off during the process (Totre et al., 2013).

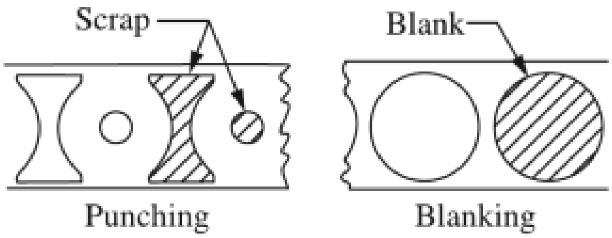

Figure 2.2: Punching and Blanking (Khan and Haque, 2011)

Deep drawing is process where the sheet metal is forced to flow between the surfaces of punch and die by adding force through the punch. This process is a compression-tension forming process (Kaonga, 2009). Figure 2.3 shows the schematic of deep drawing. Through deep drawing process, a flat sheet metal is formed into cylindrical, conic, or boxed-shape.