EXPERIMENTAL STUDY OF SHEAR STRENGTH OF SHEET METALS

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A report submitted

In fulfilment of the requirements for the degree of

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DECLARATION

I declare that this project report entitled "Experimental Study of Shear Strength of Sheet Metals" is the result of my own work except as cited in the references

Signature	:	………………………
Name	:	MOHD FIRDAUS BIN SAMSUDIN
Date	:	27 JUNE 2016

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Materials).

Signature	:	………………………
Name	:	PROF. MADYA ABD SALAM BIN MD. TAHIR
Date	:	27 JUNE 2016

DEDICATION

To my precious and beloved father and mother,

Samsudin bin Ahmad and Rozanah binti Hussin.

ABSTRACT

Sheet metals forming have been widely used in various applications such as in automotive, aerospace and manufacturing industries either through cold or hot work to deform it. This depends on its mechanical properties and desirable stress-strain behaviour of sheet metals when subjecting to deforming load. The main purpose of this project is to design a special method to determine the shear strength of sheet metals by conducting a shear test. There are many types of shear tests had been done to determine the shear yield strength and plastic deformation of the selected sheet metal. It can be done by using Marciniak in-plane torsion test, Miyauchi shear test and also based on ASTM B831-14 method. Hence in this study, a group of shear test specimen was prepared as well as a special fixture was designed and fabricated to grip the shear test specimen during the test. The shear test specimens were fabricated from an automotive hood and door parts to determine its tensile and shear strengths by using a universal testing machine. The shear yield strength test results obtained from the developed method are approximately half of its tensile yield strength test results for the hood specimens but for the door specimens, the shear yield strength test results are quite high than the expected result. In addition, low percentage of difference of shear yield strength was obtained between the experimental results and the theoretical results calculated by using the Tresca and von Mises Criterion for the hood specimens. Meanwhile, high percentage of difference of shear yield strength is obtained for the door specimens and this is greatly influenced by several factors. The analysis of the factors which influenced the shear test results is done for a future study.

ABSTRAK

Pembentukan kepingan logam telah banyak digunakan dalam pelbagai aplikasi seperti di dalam industri automotif, aeroangkasa dan juga rekabentuk melalui kerja sejuk atau panas untuk membentuknya. Ini bergantung kepada ciri-ciri mekanikal dan perlakuan tegasan-terikan kepingan logam apabila dikenakan suatu daya pembentukan. Projek ini adalah untuk menghasilkan suatu cara untuk mengetahui ciri-ciri tegangan ricih kepingan logam dengan menjalankan ujian ricih. Terdapat banyak cara ujian ricih yang telah dijalankan untuk mengetahui kekuatan alah ricih dan deformasi plastik sesuatu kepingan logam. Ujian in juga boleh dijalankan dengan menggunakan teknik ujian putaran Marciniak, Ujian Ricih Miyauchi dan mengikut piawai ASTM B831-14. Oleh itu, dalam kajian ini pemilihan spesimen untuk ujian ricih perlu disediakan dan jig perlu direkabentuk untuk memegang spesimen semasa ujian dijalankan. Spesimen- spesimen untuk ujian ricih telah dihasilkan daripada hud dan pintu kereta untuk mengetahui daya tegangan dan ricih dengan menggunakan mesin ujian umum. Keputusan ujian ricih yang diperoleh berdasarkan teknik yang digunakan menunjukkan anggaran keputusan ujian ricih adalah separuh daripada kekuatan tegangan untuk spesimen-spesimen hud tetapi untuk spesimen-spesimen pintu, keputusan ujian ricih agak tinggi berbanding keputusan yang dijangka. Tambahan pula, kadar peratusan perbezaan yang rendah untuk daya ricih telah diperoleh antara keputusan ujian ricih eksperimen dan keputusan ujian ricih teori yang dihitung melalui Kriteria Tresca dan von Mises untuk spesimen-spesimen hud. Manakala, kadar peratusan yang tinggi untuk daya ricih telah diperoleh untuk spesimen-spesimen pintu and ini mungkin disebabkan oleh beberapa factor. Analisis perihal faktor yang mempengaruhi keputusan ujian ricih dilakukan untuk pembelajaran akan datang.

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A	Cross sectional area
A_{shear}	Shear area
D	Direction
L	Longitudinal
T	Transverse
kN	Kilo Newton
M	Torque
MPa	Mega Pascal
P_{all}	Allowable load
P_{max}	Maximum load
P_y	Yield Load
t_o	Initial thickness
σ_y	Yield tensile stress
σ_{ult}	Ultimate tensile stress
τ_y	Yield shear stress
τ_{ult}	Ultimate shear stress

CHAPTER 1

INTRODUCTION

1.1 Background

Shear stress is widely used for material characterization especially for sheet metals to achieve large deformations without plastic instability or to achieve plastic deformation without rupture like blanking or punching a sheet metal under shearing load or stress. Shear stress is a mechanical property which the stress applied on the metal or specimen causes shearing and tearing along a plane where it is parallel or tangential to the exerted shearing force. In other words, shear strength determines the amount of shear force that tends to produce a sliding failure (or tearing for the out-of-plane case) on a material along a plane that is parallel to the direction of the force.

There are many examples of shear stress phenomena such as cutting a raw meat, cutting a paper with a scissor, a blanking or punching method to shape a vehicle parts and using a fastener like rivet and bolt to join plates or support a beam. Therefore, understanding of shear application is important so that catastrophic failure can be avoided. As an example, the choosing of bolt material in structural component where the shear stress applied is within the expected load to avoid deformation or failure to the component.

Shear strength of a material may exhibit different value for an anisotropic material such as composites, woods, and cold worked and rolled-sheet metals used for the body parts of the vehicles. Meanwhile for an isotropic and homogeneous material, the shear strength is assumed the same in all directions. Hence for sheet metal, there is a need to apply a special method and specially designed specimen to conduct a shear test and determine the shear properties.

Thus, there are many methods have been established to find the shear properties of metal especially for sheet metals. For instance, a method has been developed that allows measurement of stress-strain curves for a thin strip of AA5182 metal being deformed in multiaxial tension by using a modification of Marciniak in-plane biaxial stretching test (Iadicola et. al(2007). Similar finding is found by Iadicola & Gnaeupel-Herold (2008) had proposed a method of measuring biaxial stress-strain by using Marciniak Test on aluminium alloy (AA 5754-O).

Another example of finding the shear property of sheet metals by Flores et. al (n.d) by using a Miyauchi simple shear test device. The test is used to identify the material properties by performing plane strain and simple shear test. Apart from that, Zillman et. al (2011) proposed the same technique by using a Miyauchi setup for a simple shear test to test the AA6016 aluminum alloy sheet.

Apart from that, there is another simple method to find the shear properties for sheet metals by using American Society for Testing and Materials standard ASTM B831-14 (2014). This shear test setup based on this standard is very easy to be carried out because the shear test specimen is a simple geometry and simple estimation of the shear stress and strain (Yin et. al, 2014). To perform this shear test method, it needs a special built-in fixture to grip the shear test specimen. In addition, the shear test based on ASTM B831-14 can be tested by using a universal testing machine like INSTRON 8802 just like Marciniak and Miyauchi methods.

Therefore, the main purpose of this work is to prepare the shear test specimens based on ASTM B831-14 shear test standard and design a shear test fixture in order to grips the shear test specimen. After that, shear test is conducted by using a universal testing machine INSTRON 8802 to determine their shear strength.

1.2 Objective

The main objective of this work is to design a shear test fixture and determine the shear strength of sheet metals for various type of metals as available locally and used particularly in an automotive industry by performing a shear test.

1.3 Problem Statement

To conduct the shear test experiment, a special design fixture is needed to grip the sheet metal based on various shear test standards. The fixture is mounted on universal testing machine and gripped the shear test specimen during the test. Therefore, a study and research about various shear test standard in order to obtain the mechanical properties of sheet metals and to design a shear test fixture are needed. After that, a suitable material is selected for the fabrication of shear test fixture for the purpose of safety factor as well as avoiding failure.

1.4 Scope

1) Carry out a preliminary study and review past research on the scope of study which is shearing test based on various standards.

2) Obtained any materials as available locally and used in automotive industry as a test specimen.
3) Proposed a test fixture design and specimens and conduct a shear test by using Instron's Universal Testing Machine.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are many methods or standards available as found in the literature to conduct a shear test such as proposed by Marciniak (1961), Miyauchi (1984) and based on ASTM standard B831-14 (ASTM, 2014). In general, Marciniak method used a round specimen to conduct the test, while Miyauchi (1984) used a specimen with a double shear zone and ASTM B831-14 used a single shear zone. All techniques have the advantages and disadvantages which are important for the test selection in this project. The yield criteria for ductile material are discussed in order to obtain the theoretical value of shear yield stress of the shear test specimens.

2.1.1 Marciniak In-Plane Torsion Test

Marciniak (1961) had proposed in-plane torsion test or also called twin bridge shear test. In this test, the round specimen as shown in Figure 2.1 is clamped at the inner and the outer of the round specimen by using a design fixture which containing the outer and inner fixture (Yin et. al, 2014). Marciniak twin bridge shear test used moment as a loading instead of using force couple.

When moment is applied to the specimen, the specimen rotated and shear deformation occurred at the shear bridges. Note that there are two bridges in twin bridge specimen which mean that Marciniak in-plane torsion test has two sheared zone. The geometry and dimensions of twin bridge specimen is shown in Figure 2.2 and Table 2.1.

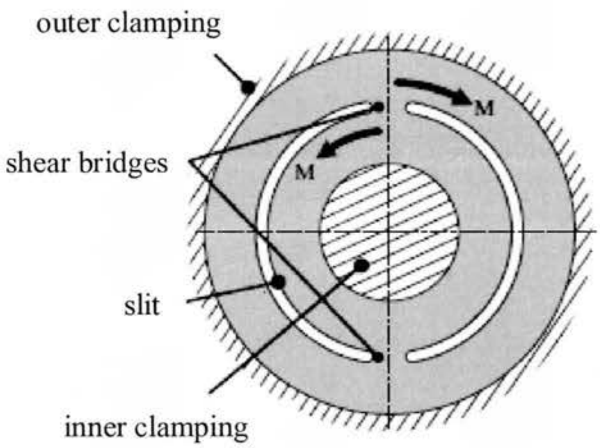

Figure 2.1: Marciniak twin bridge specimen

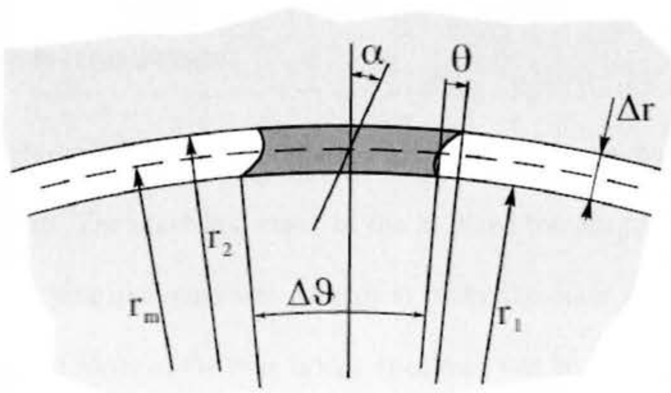

Figure 2.2: The geometry of shear area for twin bridge specimen

Table 2.1: The dimension of twin bridge specimen (Yin et. al, 2014)

Specimen radius	40.0 mm
Inner clamping radius, r_i	15.0 mm
Outer clamping radius, r_o	30.0 mm
Arc length, $\Delta\vartheta$	20°
Radius, r_m	21.5 mm
Height, Δr	1.0 mm
R_1	21.0 mm
R_2	22.0 mm
Notch radius, r_s	0.5 mm

The shear stress, τ in this test can be calculated as,

$$\tau = \frac{M}{t_o . \Delta\vartheta . \mathrm{r}_\mathrm{m}^2} \qquad \text{.................................. (2.1)}$$

where M is the applied torque, t_o is the initial thickness of the specimen, $\Delta\vartheta$ is the arc length and r_m is the radius. Meanwhile, the strain of the shear areas can be determined by using an optical strain measurement.

Figure 2.3 shows the experimental setup for in-plane torsion testing used to test the twin bridge specimen. The inner and outer of the in-plane torsion test are mounted to the universal testing machine and used servo motor to rotate the outer fixture. During the test, the torque and rotation angle of the twin bridge specimen can be measured by using sensor. Meanwhile, the strain can be measured by using Digital Image Correlation, DIC.

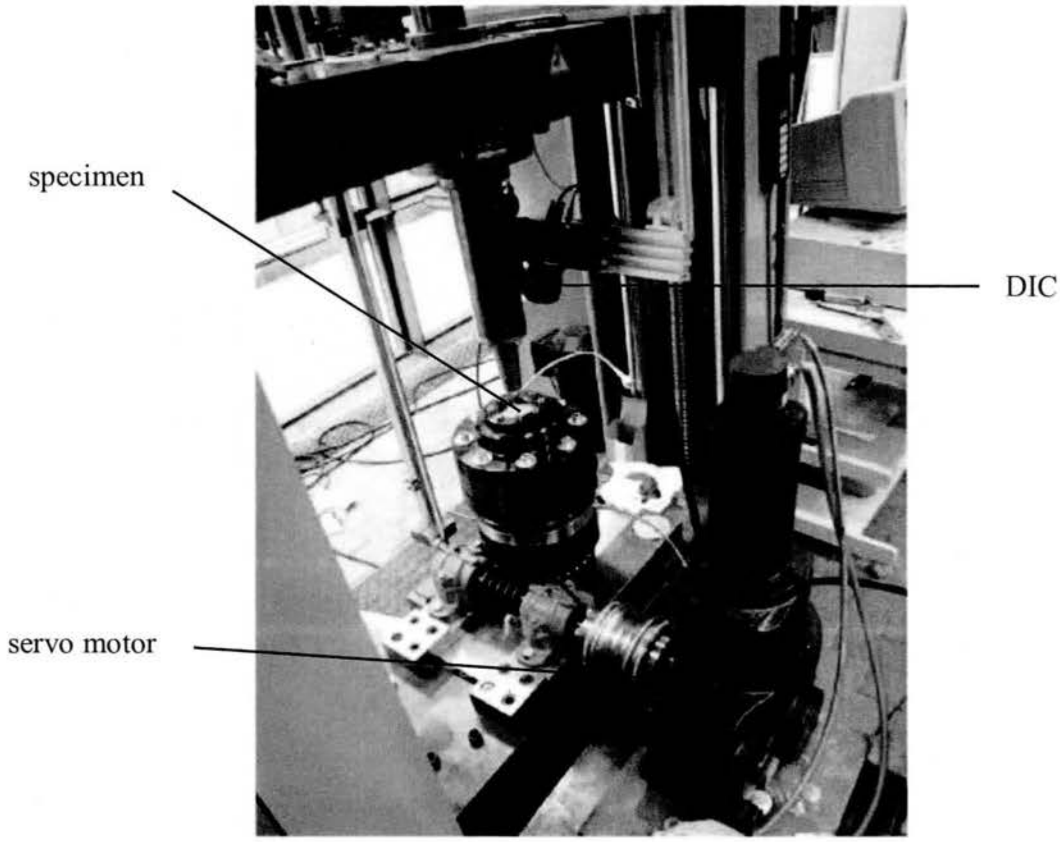

Figure 2.3: Experimental setup for in-plane torsion testing used for the twin bridge specimen

2.1.2 Miyauchi Shear Test

Miyauchi (1984) had proposed a simple shear test with double shear areas. The specimen has three bars where connected by two sheared zone. Two areas of simple shear are generated in the sheet of shear test specimen. After that, the middle bar will be exerted with tensile load and the shear areas will deform by shear deformation. The principle of Miyauchi method is illustrated in Figure 2.4.