DESIGN OF PEEL TEST FIXTURE FOR ADHESIVELY BONDED JOINTS

WONG YEW SHENG

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OF PEEL TEST FIXTURE FOR ADHESIVELY BONDED JOINT

WONG YEW SHENG

A report submitted
in fulfillment of the requirements for the Bachelor of Mechanical Engineering with Honours

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I hereby, declared this report entitled “Design Of Peel Test Fixture For Adhesively Bonded Joints” is the results of my own research except as cited in references.

Signature : ……..
Author’s Name : WONG YEW SHENG
Date : 15 MAY 2018

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Mechanical Engineering with Honours.

Signature :…….....
Supervisor Name :…….....
Date :…….....

ABSTRACT

The purpose of this project is to design a suitable jig to carry out peel test on a Universal Tester Machine (UTM). Adhesive joint is widely used in today industry. Peel test is the test carried out to test the strength of an adhesive joint. Therefore, peel test is one of the important tests run for the advancement in adhesive technologies. In this project, the jig designed is focuses on 90 degree peel test to test the adhesive strength of adhesive tape on different type of materials. The peel test standard follows the standard of ASTM D3330/D3330M, 2010. Engineering design process is used in order to design a suitable jig for this project. The jig is designed and analyzed through CATIA software where the conceptual design is selected using the Pugh's selection method. After final selection, the functional prototype of the jig is manufactured using rapid prototyping process. Manufactured jig is tested on UTM machine and the sample result is recorded. Different material can be attached to the specimen plate of the jig to carry out peel test with different specimen. The jig designed in this project can be improved and modified in future similar studies for better peel test jig for UTM.

ABSTRAK

Objektif utama projek ini adalah untuk mereka bentuk sebuah jig yang sesuai untuk menjalankan ujian kupas atas Universal Tester Machine (UTM). Bahan pelekat merupakan suatu bahan yang selalu digunakan untuk mencantumkan bahagian mekanikal dalam industri hari ini.. Ujian kupas pula merupakan suatu ujian untuk mengkaji kekuatan bahan pelekat. Ujian ini sangan penting untuk perkembangan dan kemajuan dalam teknologi pelekat. Dalam projek ini, jig yang direka adalah bagi tujuan membantu UTM untuk menjalankan ujian kupas 90 darjah ke atas permukaan bahan yang berlainan. Ujian kupas ini mengikut standard ASTM D3330/D3330M. Proses reka bentuk kejuruteraan telah digunakan dalam proses mereka jig ini bagi tujuan menghasilkan satu jig yang sesuai untuk digunakan. Perisian CATIA telah digunakan untuk menghasilkan lukisan CAD jig dan menganalisa struktur jig yang telah dilukis. Kaedah Pemilihan Pugh pula digunakan untuk memilih konsep yang telah direka. Selepas pemilihan akhir dibuat, prototaip yang berfungsi dalam projek ini telah dibuat menggunakan kaedah 'rapid prototyping'. Jig yang telah siap dibuat telah dicuba-guna atas UTM dan hasil ujian telah dicatatkan. Permukaan yang berlainan boleh dilampirkan ke atas plat spesimen untuk menjalankan ujian kupas yang berkaitan. Walaubagaimanapun, jig yang direka dalam projek ini masih boleh ditambahbaik pada masa akan datang dengan memperbaiki atau megubahsuai reka bentuk jig.

DEDICATION

To my beloved family,

Mrs Chiang Lan Heong

Ms Serrine Chiang Mee Heong

Mr Cheong Mee Khuan

My Supervisor,

Dr. Mizah Bt Ramli

My friends especially to Mr. Tan Chee Teck

All lab assistant that had guided me throughout my time in the lab

ACKNOWLEDGEMENT

First of all, I am very grateful that I am able to complete my final year project in time. There are a lot of help in term of guidance and advice that had come to me when I needed them. I would like to take this opportunity to extend my gratitude to all the parties that had involve in this project.

Firstly, I would like to thank University Teknikal Malaysia Melaka (UTeM), for providing me this chance to gain my knowledge and experience through this final year project. I did learn a lot and gain a lot of knowledge while completing this project. Next I would like to sincerely thank my Supervisor, Dr Mizah Bt Ramli for her guidance and patience throughout my final year project. My design will never be able to complete without her guidance. I also would like to thanks my panels who corrected my mistake and taught me things that I never learn.

Not forget to mention my friends and lab assistants who also provided help when I needed. Last but not least, I want to thank my single-parent mother, Mrs Chiang Lan Heong and others relatives for their moral and financial support not just in this project, but also throughout my life in university. Their inspirational and courageous talk had walked me through the hard time completing the final year project.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLE

CHAPTER 1

INTRODUCTION

1.1 Background

Adhesive technology is an application that has been widely used worldwide. It can mechanically assemble parts without altering the structure and mechanical properties of the parts. Adhesive peel test is the mechanical test to test the strength of adhesive on chosen specimen.

However, improving the peel tester for the adhesive will directly contributes to the advancement of adhesive technologies.

Therefore, jig is components of machine tool installations, specially designed in each case to position the work piece, hold it firmly in place, and guide the motion of the power tool(Hamad Mohammed Abouhenidi, 2014). Jig plays a vital role to the efficiency and

accuracy of a peel tester. Installing a suitable jig design on adhesive peel tester can significantly enhance its performance.

Design of jigs and fixture must satisfy the following conditions which are reduction of idle time, provision of coolant, hardened surface, safety, fool proof and indexing type of jigs. (Lakshmi Kumari, G.Prsasnna Kumar, 2015)

The fixture and jig is to be designed for peel test for adhesively bonded joint. The fixture is to be installed onto a universal testing machine (UTM) and 90 degree peel test is conducted on the machine with the aid of the fixture. The adhesively bonded specimen to be tested on the machine is metal. The standard of this peel test on metal follows the standard of ASTM-B571-97.

The test is of the standard DIN EN 50461 and ASTM D3330M. However, test with other standard is also possible to be used with the universal testing machine.

1.2 Problem Statement

The problems emerged from the peel tester used to test adhesive today are weak specimen gripping and bad positioning of specimen on the peel tester during the test. Universal Testing Machine is used in order to carry out the 90 degree peel test of adhesively bonded joint.

The accuracy of the adhesive peel test tested on the UTM is not precise because the specimen is not static while the adhesively bonded joint is peeled. The bonded joint peels irregularly and hence decrease the accuracy of the result of peel test. When the specimen is not static, the specimen also tends to move around which also indirectly decreases the result of the peel test.

1.3 Objective

The objectives of the project are as follows:

1. To understand the method and steps of peel test on adhesively bonded joint using Universal Testing Machine.
2. To design a suitable jig or fixture to be added onto the Universal Testing Machine using mechanical designing software.
3. To design jig that can carry out 90-Degree Peel Test.
4. To fabricate and install the designed jig or fixture to the Universal Testing Machine and do an analysis onto the efficiency and accuracy of the peel test.
5. Design of jig that fulfills the design requirement.
6. Design a functional jig at minimal cost.

1.4 General Methodology

Below are engineering design method involved to carry out the objectives of the project :

1. Literature review

   Studying journals, researches, articles and others peel test and jigs related material

2. Studying peel test and the capabilities of Universal Testing Machine

   Observe and understanding the mechanism of the UTM machine and hands-on to learn doing peel test using UTM machine. Measure the size of jig or fixture required

3. Design Requirement

   Determine the requirement of the jig design.

4. Conceptual Design

   Generate ideas by morphological chart.

5. Concept Selection

   Selection of best design using appropriate method.

6. Detailed Design

   Create a CAD drawing of the designed jig.

7. Fabrication of jig

   Fabricate the designed jig using 3D printer.

8. Analysis of peel test performance of UTM machine with jig designed.

   Test the jig or fixture fabricated to achieve the objective of the project.

9. Report writing

   Prepare post-project report at the end of the project.

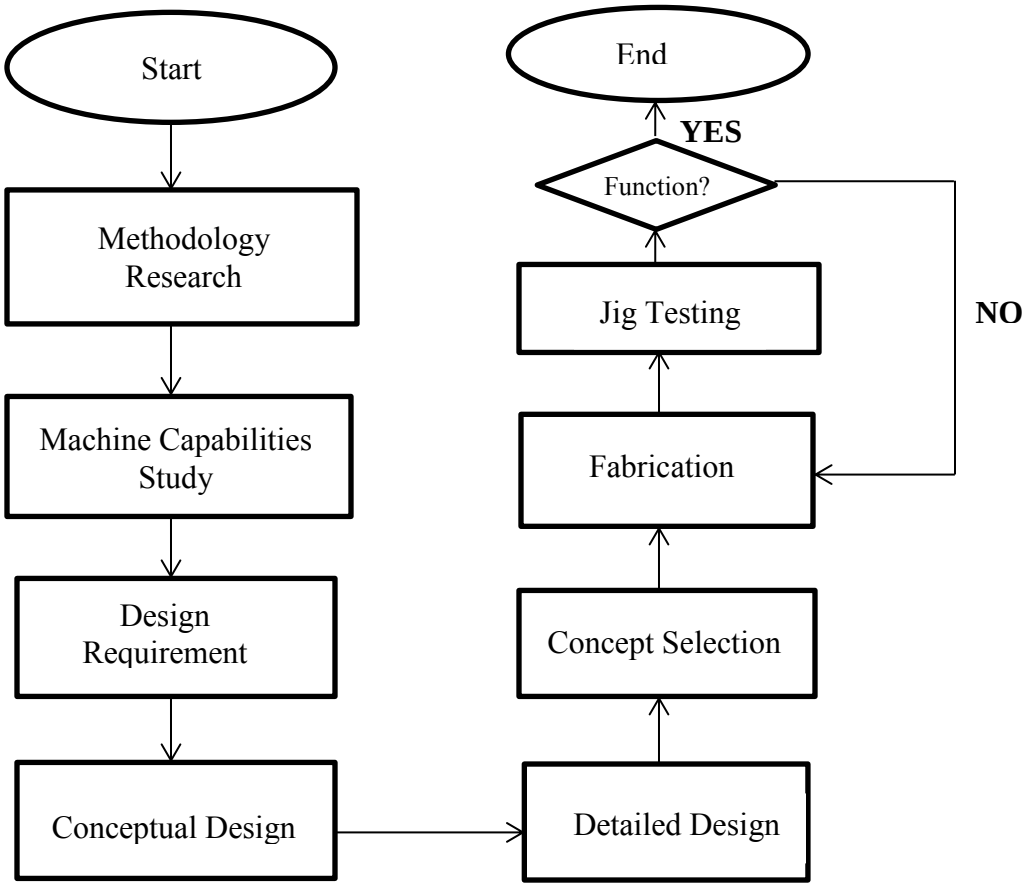

Figure 1.1 : Flow Chart of the methodology

CHAPTER 2

LITERATURE REVIEW

2.1 Adhesives Technologies

Adhesive is widely being used in mechanical field because of its ability to join parts and withstand high stress and strain. There are lots of researches done regarding to adhesive shear stress and strain. Example, Peretz experimented the shear behavior information using specially designed torsion gadget which measures the shear moment-displacement for adhesive layers.(R.D Adams, F.J Guild, F Kadioglu,2000[1]). Dolev and Ishai carried out experiment on bulk in-situ adhesives specimen with a view to characterize mechanical behavior under various load and stress.[1] Lilleheden extends his researches to investigate the mechanical properties of adhesive specimen in bulk and thin-film form to prove the reasons for above discrepancies.[1]

An adhesive must not be chosen only according to its strength but also with regards to its suitability for the environmental conditions and the loading type. In the 1990s a new generation of toughened epoxy adhesives called crash-resistant adhesives, arrived on the

market with good strength at high strain rates and large energy absorption capabilities (Adams, 2005).

In aeronautics and automobile industry, the light weight and complex structures normally used adhesive in mechanical structure bonding (Da Silva, 2011a). Use of adhesive in mentioned industry can drastically reduce the weight of vehicles (M.R.G Silva, E.A.S Marques, Lucas F.M Da Silva, 2016). On the other hand, for high strain rate application, adhesive is not recommended. Adhesives only provide high static strength.

2.2Adhesive Peel Test

Peel test is a mechanical test to measure the strength of an adhesive. It generally tests how strong can the adhesive hold a joint or object together. There are 3 common types of parameter used to measure peel test which are tensile strength, shear strength and peel force. The most frequently used result parameter of a peel test is peel force. (Yue Wang, 2014). The variables which affect the peel force are the geometry (size of specimen, thickness of adhesive), properties of the adhesive and specimen and environmental interference. (M.D. Thouless, Q.D. Yang, 2008). The general equation for peel force, P_r is stated as below depending on geometrical and material parameters based on study done by M.D. Thouless and Q.D. Yang:

$$\frac{P_f}{\Gamma_I} = f\left(\frac{\bar{E}h}{\Gamma_I}, \frac{\Gamma_{II}}{\Gamma_I}, \theta, \frac{\sigma_Y}{\bar{E}}, n, \frac{\hat{\sigma}}{\sigma_Y}, \frac{\hat{\tau}}{\sigma_Y}, \frac{\bar{E}_s}{\bar{E}}, \nu, \nu_s\right)$$

Peel test general equation (M.D. Thouless, Q.D. Yang 2018)

The analogy of a peel test can be illustrated using Dr.K. Kendall's model. The model illustrated an elastic film peeled from a rigid specimen and it explains the relationship of

elastic modulus and other variables that affect the peeling strength. Peeling adhesive layer from substrate required energy. However, this peeling process can use energy conservation law for analysis purpose. (Yue Wang, 2014). We can set up a peeling system shown in Figure 2.1 below:

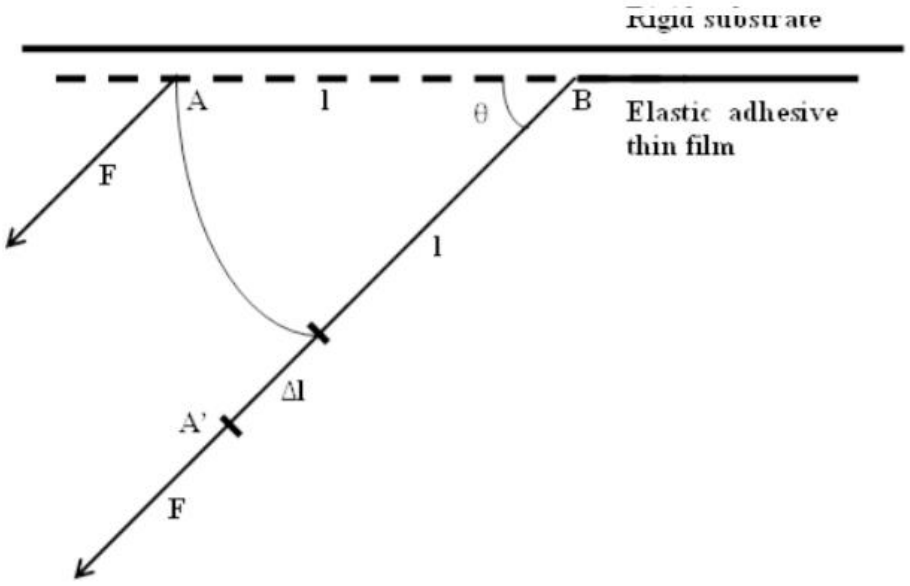

Figure 2.1 : Peeling System Illustration.

The Adhesive Layer Has A Thickness Of D, Width Of B And Elastic Modulus B (Yue Wang, 2014) However, the geometries of peel were divided into 3 main types, 90^{o} peel, 180^{o} peel and T-peel. The degree of the peel refers to the geometry of a peel test.

2.3 Mandrel Peel Method

A mandrel peel method is peeling test where the peel curve is controlled by a roller with radius. (L.F Kawashita, D.R Moore, J.G Williams, 2005[2]) By neglecting the frictional force, the setup of Mandrel peel test is as shown in Figure 2.2:

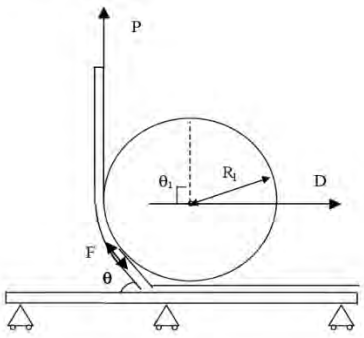

Figure 2.2 : Mandrel peel test[2]

The general governing equation for Mandrel peel test is: [2]

$$FR=PR \text{ or } F=P$$

The horizontal equation, D is given by: [2]

$$D=P(\cos\theta+\cos\theta_1)$$

If $\theta=90^{o}$ then the equation is as follows:[2]

$$G=(G_A+G_P)=(\frac{P-D}{b})$$

2.4 Jig and Fixture

A jig or fixture is created to hold workpiece and guide the cutting tools. In peel test, a fixture is designed to be used to hold the adhesive and specimen in place for peeling. Although the test can be carried out without a jig, but with the aid of a well-designed jig, the test can be simplified and the accuracy of the test can be improved. Figure 2.3 and 2.4 below show few examples of jig designed to be used in peel test.

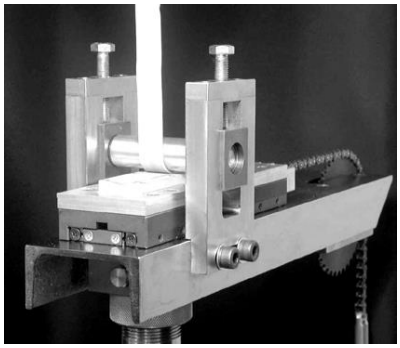

Figure 2.3

Figure 2.4

In this project, the design of jigs and fixture follows the standard of ASTM D3330/D3330M. The method is referred as Method F in the standard. Test Method F is a 90° peel. A strip of tape is taped onto a test platform and then peeled from the platform at a 90° angle at a certain rate while the time and the force required to peel the tape off is recorded. (ASTM D3330/D3330M, 2010). The maximum load of the peel test is 10kN and the standard speed of the peel is 300mm/min.

There are many designs of jig in the market that are suitable to be made as reference in this design project. Figure 2.5 and 2.6 show the design of peel test jig from Shimadzu Company with sample results which can be referred as to design a jig for peel test in this project. (Shimadzu Data Sheet no.18) This design of jig is very close and similar to the jig design in this project because this jig is also specially designed for the use on UTM machine of Shimadzu Company. The laboratory uses also used the same UTM machine by Shimadzu.

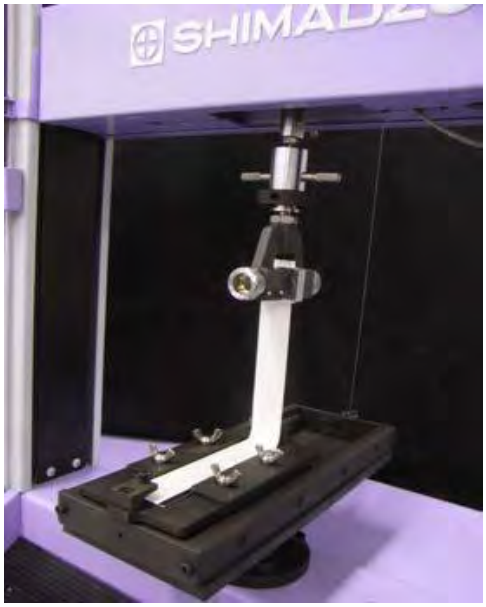

Figure 2.5 : Shimadzu Coporation Jig AGS-X

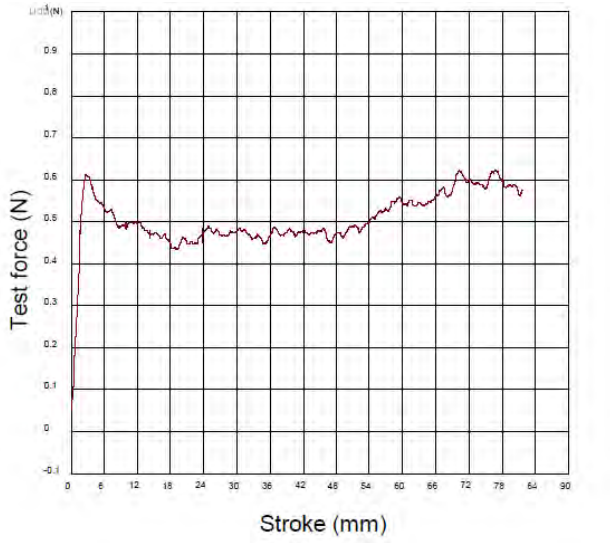

Figure 2.6 : Sample result of the test ran with AGS-X

CHAPTER 3

METHODOLOGY

The methodology of this project will begin from title selection until the testing of designed jig on UTM machine. At the beginning of this final year project, the information about adhesive and peel test is studied thoroughly. Research journals and articles are reviewed to understand the adhesive, peel test and jig design for peel test. There are a number of suitable designs that can be used for peel test, but only the most suitable design of jig will be chosen and modified so that it compatible with UTM machine.

3.1.Methodology Researchs

At the beginning, major amount of time are used in case study, research paper study and article study related to the title of this project. Previous research paper on uses of adhesive, strength of adhesive, peel test, type of peel test, design of jigs for peel test are referred and reviewed to understand peel test as well as designing a jig to aid peel test. Throughout the time during methodology research, there are several designs of jig that are