EFFECT OF TEMPERATURE AND HUMIDITY ON THE JOINTS BONDED WITH ELECTRICALLY CONDUCTIVE ADHESIVE

SITI NUR AISYAH BINTI ISMAIL

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

FACULTY OF MECHANICAL ENGINEERING

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I declare that this project report entitles "Effect Of Temperature And Humidity On The Joints Bonded With Electrically Conductive Adhesive" is the result with my own work except as cited in the references.

Signature : .....

Name : SM NUR AISYAH BT ISMAIL

Date : 28/6/2019

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 the degree of Bachelor of Mechanical Engineering with Honors (Plant and Maintenance).

Signature : .....

Supervisor's Name : DR. MIZAH BINTI RAMLI

Date : 28/6/2019

DEDICATION

To my beloved mother and father

ABSTRACT

Electrically conductive adhesives perform joints that can bond two surfaces by adequate strength and electrical interconnection between two bonded surfaces. In this study, the specimen is designed according to the ISO standard of single lap joint. Nowadays adhesively bonded joints are widely used in the product that might be exposed to different environmental conditions. Moisture and thermal surroundings are one of the factors that may corrupt the adhesive joints and can cause the failure of the adhesive interconnections. Thus, the objectives of this research are to measure the strength of joints bonded with ECA under the effect of temperature and humidity. This research is implemented by four conditions which temperature at 85°C and 6°C, and humidity at 40°C/85RH and 40°C/45RH. For each of these conditions, the time interval was set at 15 hours, 30 hours, 45 hours, 60 hours and 85 hours. The results of this research are a comparison of tensile strength for each condition. Test results show the higher the temperature gets lower lap shear strength and the same goes for the effect of humidity which low humidity have higher tensile strength compared to high humidity condition.

ABSTRAK

Perekat konduktif elektrik menjalankan sendi yang boleh mengikat dua permukaan dengan kekuatan yang memadai dan sambungan elektrik antara dua permukaan terikat. Dalam kajian ini, spesimen direka mengikut piawaian ISO sendi pusingan tunggal. Pada masa kini, sendi terikat secara melekat digunakan secara meluas dalam produk yang mungkin terdedah kepada keadaan persekitaran yang berbeza. Kelembapan dan persekitaran haba adalah salah satu faktor yang boleh merosakkan sendi pelekat dan boleh menyebabkan kegagalan sambungan perekat. Oleh itu, objektif kajian ini adalah untuk mengukur kekuatan sendi yang terikat dengan ECA di bawah kesan suhu dan kelembapan. Penyelidikan ini dilaksanakan oleh empat keadaan suhu di 85 °C dan 6 °C, dan kelembapan pada 40 °C / 85RH dan 40 °C / 45RH. Bagi setiap keadaan ini, selang masa ditetapkan pada 15 jam, 30 jam, 45 jam, 60 jam dan 85 jam. Hasil kajian ini adalah perbandingan kekuatan tegangan untuk setiap keadaan. Keputusan ujian menunjukkan semakin tinggi suhu mendapat kekuatan ricih pusingan yang lebih rendah dan yang sama berlaku untuk kesan kelembapan yang kelembapan rendah mempunyai kekuatan tegangan yang lebih tinggi berbanding keadaan kelembapan yang tinggi.

ACKNOWLEDGEMENTS

First of all, I would like to dedicate my appreciation to my respected supervisor, Dr. Mizah Binti Ramli from the Faculty of Mechanical Engineering Universiti Teknikal Malaysia Melaka (UTeM) for her guidance and assistance on the progress of this project and to help me resolve this investigation successfully.

I would also like to thank my parents for giving me the passion to complete this course. They have given me all the ease and moral support I have until I have accomplished this task. This appreciation is also directed to my colleagues who assisted me in this project.

Finally, I thank those involved directly or indirectly in the course of this course. Thank you.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACA	Anisotropic Conductive Adhesive
ASTM	American Society for Testing and Materials
CTE	The coefficient of Thermal Expansion
DCB	Double Cantilever Beam
DMA	Dynamic Mechanical Analysis
DSC	Different Scanning Calorimetry
ECA	Electrically Conductive Adhesive
ICA	Isotropic Conductive Adhesive
LCD	Liquid Crystal Display
PCB	Printed Circuit Board
RFID	Radio Frequency Identification
RT	Room Temperature
SEM	Scanning Electron Microscope
SLJs	Single Lap Joints
SMD	Surface Monitoring Device
TAST	Thick Adherent Shear Test
RH	Relative Humidity

TGA	Thermo Gravimetric Analysis
Tg	Glass Transition Temperature
IPA	Isopropyl Alcohol

CHAPTER 1

INTRODUCTION

1.0 BACKGROUND OF STUDY

Adhesives is a non-metallic substance (adhesive) are greatly being used in joining any parts in certain material which experiences a physical or chemical hardening reaction causing the parts to join through surface bonding (adhesion) and internal strength (cohesion). Generally, an adhesive can be called glue, paste, cement or mucilage that is capable of joints between surfaces to another surface and oppose their partition.

Electrically conductive adhesives play an important role in manufacturing across a wide range of industries including electronics, solar cell, medical instrument, aerospace, and automotive components. Compared with conventional joining by screws, welding and riveting, adhesive joining offers more benefits, for example, reduced fabrication costs, the increased fatigue resistance of components, enhanced optimal design and impressive weight reduction. For example, (Larsson, 2017) state that (Henkel Norden AB, 2017) manage to replace 800 screws in a caravan with adhesive in the caravan industry. This reduced the weight of the construction and created a more watertight construction because the holes from the screws could be avoided. Another example where adhesives have replaced spot welding that is more beneficial to bond different materials rather than steel on steel in the automotive industry.

There are two types of electrically conductive adhesives which are isotropic and anisotropic that are usually used in many sensitive structures on circuit boards such as liquid

crystal display (LCD) connections, contacting flexible printed circuit board (PCB) and bonding antenna structures on radio-frequency identification (RFID). Isotropic conductive adhesives (ICA) is an element that contains sufficient amounts of conductive particles to conduct electricity in all directions meanwhile anisotropic conductive adhesives (ACA) are electrically conductive that contains lesser conductive particles in the μm range, which conduct electricity only in one direction (Sancaktar & Bai, 2011).

Despite offering very attractive advantages over customary joining methods, there are still have a problem regarding the effect of temperature and humidity. The polymeric nature and the mechanical properties of the adhesive joints probably change under different temperature and humidity. For instance, to guarantee the safety and reliability of vehicle in the administrative procedure of the adhesive structure, it is imperative to give adequate strength under a wide range change of temperatures (Na, Mu, Qin, Tan, & Pu, 2018). The effect of humidity is important to ensure the durability of the adhesive joints because when the water content increase, it will reduce the fatigue joint strength and lifespan of adhesive bonded (Viana, Costa, Banea, & Da Silva, 2017).

In this project, the effect of temperature and humidity on the joints bonded with electrically conductive adhesive were researched. An epoxy adhesive that is broadly utilized for holding numerous applications structures was chosen. The epoxy-based adhesive metal single lap joints (SLJ) were used to evaluate the strength. The conventional test techniques, for example, tensile, shear and four-point probe tests were conducted to evaluate the probability distribution of adhesive strength.

1.1 PROBLEM STATEMENT

There are a few factors that need to be considered in order to produce the product consist of adhesive joints, for instance, environmental conditions, mainly temperature and humidity. Generally, each adhesive has its temperature range that will affect their performance. High temperature can damage the electric circuit because overheating will melt the plastic casing of the chip. Influence of humidity that involves the temperature of the surrounding air can defect the electrically adhesive joining of electrodes. This will disturb the conductivity of electricity.

1.2 OBJECTIVES

The objectives of this project are as follows:

1. To measure the strength of joints bonded with an electrically conductive adhesive under the effect of temperature.
2. To measure the strength of joints bonded with an electrically conductive adhesive under the effect of humidity.

1.3 SCOPE OF PROJECT

The scopes of this project are:

1. This project is designed according to the ISO standard of a single lap joint that involve joints bonded with the electrically conductive adhesive (ECA).
2. This project is to study the factors of temperature and humidity that affect the strength of joints bonded electrically conductive adhesive (ECA).
3. The changing of mechanical properties was observed and mechanical testing was conducted under different temperature and humidity.

1.4 GENERAL METHODOLOGY

This project will investigate the strength of the adhesive bonding based on different temperature and humidity. There are acquirements that need to be carried out to achieve the objectives of this project:

1. Literature review

   A literature review was conducted by studying past journal, research paper, books and other material regarding this project.

2. Experiment

   The experiment will be conducted on how the experiment of the mechanical properties of an adhesive joint under high and low temperature and various humidity.

3. Analysis

   An analysis will be presented on how to analyze the problem of an adhesive joint under different temperature and humidity.

4. Report writing

   When every aspect of this project is finish and acceptable, a report on this study will be written.

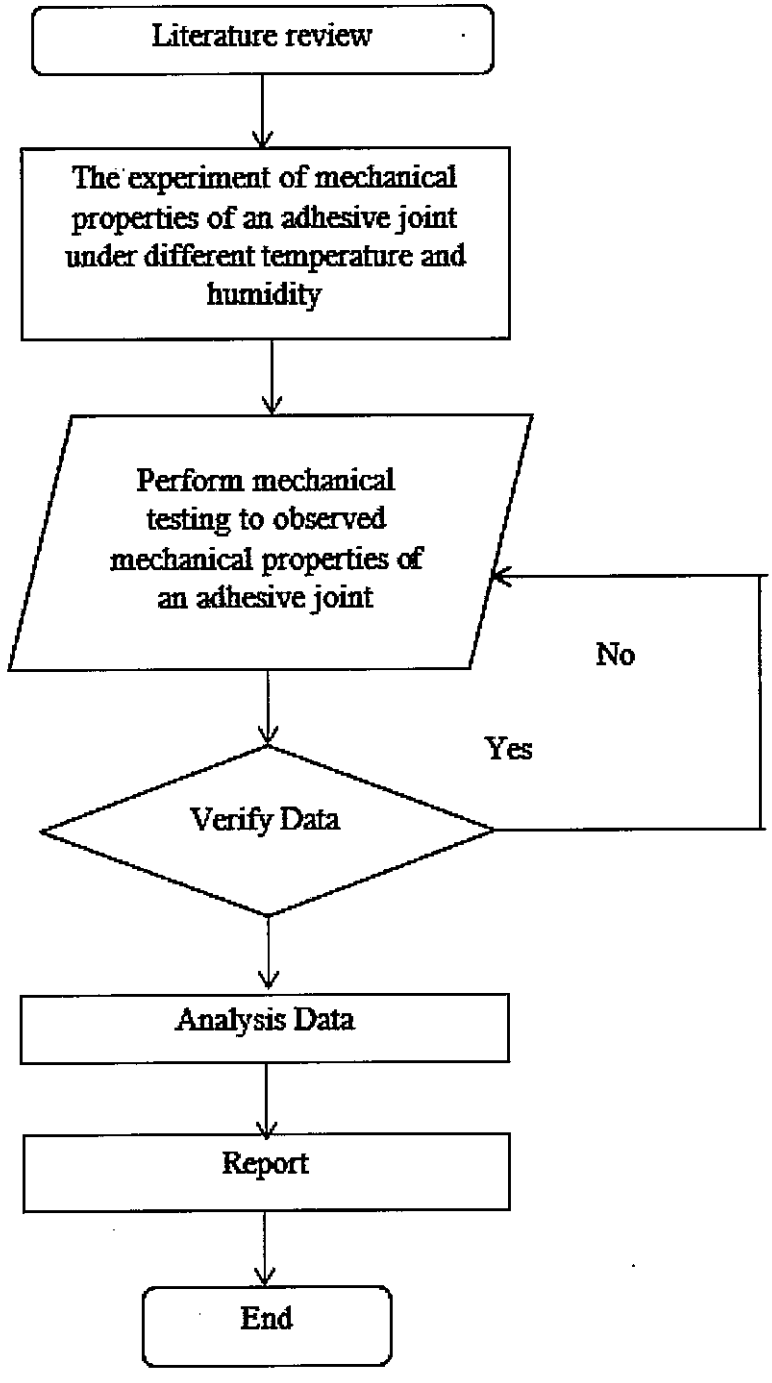

Figure 1.1: Flowchart of the methodology

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

Adhesive bonding is a joining technique, broadly used in structural applications of metallic and composite materials including aerospace, automotive, electronics and electrical industries (Santos et al., 2004). Besides, there are two types of joints which are mechanical and bonded joints. Mechanical joints are made by securing the substrates with bolts or rivets meanwhile bonded joints use an adhesive interlayer between the adherents (Maloney & Fleck, 2018). Mainly, in an adhesive joint, any adhesive that is applied between two plates can be defined as adherent.

Adhesively bonded joints show many advantages in mechanical assembly compared to conventional joining such as excellent cohesive strength, high peel strength, resistance to cyclic fatigue, and high durability. The adhesives materials allow the substrate to joint with different geometries, sizes, and composition, for instance, adhesive with metal, plastics, glass, and ceramics.

The use of adhesive also does not produce any damage and aggression to the substrate, hence, reduce the manufacturing cost, can accelerate the production process and improving the aesthetics of the product. For example, by replacing the use of welds and rivets in the manufacturing process for joining the interior parts to form the racks of the car with the adhesive make the cars lighters and safer.

2.1 TYPES OF ADHESIVE

An electrically conductive adhesive (ECA) comprises of a polymer binder which gives mechanical strength, and conductive fillers, which offer electrical conduction. Epoxy fastener materials are usually utilized in the hardware business because of their numerous unrivaled properties, for example, low shrinkage, a great bond, and good resistance to moisture and substance assault (Xu, Dillard, & Dillard, 2003).

Electrically conductive adhesives perform joints that can bond two surfaces by adequate strength and electrical interconnection between two bonded surfaces. The conductive used typically is carbon black, graphite flakes, and micron or nano-sized metal particles such as silver, nickel, copper or aluminum (Seo & Lim, 2005). Carbon black particles have the graphite-type crystalline structure, giving a good electric conductivity. Carbon black likewise give stable resistance and therefore is used as electronic equipment related material in various display components (Correia, 2016). Carbon black conductive is recommended for low voltage usage with DC power sources, not more than 12VDC to avoid any failure in the further application (Floor et al., 2012).

The procedure of mixing and deliberateness glue and hardener are important. Overabundance or absence of hardener is the reason for the low quality of the joint. At that point of joints might be delicate, moist and ductile or have low strength (Resinlab, Corrosive, Resinlab, & Data, n.d.). The consistency of adhesives and their homogeneity are the reason for the quality of the joint. The abundance of glue gives a thick joint which dries a while and has poor strength. An absence of glue makes issues with wettability of the surface which will give thin and poor joint (Kubit, Ciecińska, & Drozd, 2015).

Adhesive stress interrelationship needs to be considered in the failure of adhesive joints. A brittle adhesive such as an epoxy is the best choice in a joint with dominating shear stresses and negligible peel stresses. The displacement capacity in shear and tensile