EFFECT OF PRESSURE ON COMPOSITE AND ALUMINUM BONDING

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted
in fulfillment of the requirement for the degree of
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DECLARATION

I declare that this project report entitled “Effect of Pressure on Aluminum and composite bonding” is the result of my own work except as cited in the references

Signature : .....

Name : .....

Date : .....

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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 of Supervisor : .....

Date : .....

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DEDICATION

To my beloved mother and father

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ABSTRACT

Composite and Aluminum bonding type material has been used extensively for years in various manufacturing industry. The stringent demand for this type of material in industry make it necessary to improve their mechanical properties by increasing their strength. Therefore, bonding pressure as a mechanism of bonding have been study in this research. This project starts with fabrication of Cabon Fibre using hand layup method and cutting process. Compression process is a crucial process as it will determine the effect of bonding pressure. The bonding pressure applied from 3 atm, 5 atm,7 atm until 9 atm. The tensile testing used to determine the strength of bonding by evaluation of shear stress value. From the tensile testing result it is found that bonding pressure affect the strength of aluminum composite bonding as the shear stress value obtained differed with different pressure. A bonding pressure under 3 atm pressure level is found has an optimum value of shear stress. However the further investigation and study in mechanism of bonding is suggested for comprehensive study.

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ABSTRAK

Bahan Aluminum-komposit telah digunakan secara meluas di dalam industry pembuatan. Permintaan yang tinggi daripada industri menyebabkan pentingnya untuk membaikpulih ciri – ciri mekanikal dengan menambah kekuatan pada bahan tersebut.Maka tekanan ikatan sebagai mekanisme ikatan akan dikaji dalam kes ini . Projek ini bermula dengan proses fabrikasi Karbon fiber Komposit dan proses pemotongan specimen.Proses penekanan adalah kritikal proses kerana melalui proses ini kesan tekanan ke atas ikatan dapat dikenalpasti .Nilai tekanan yang dikenakan adalah pada tahap tekanan 3 atm,5atm,7atm dan 8 atm.Ujian Tensil digunakan untuk menentukan kekuatan ikatan melalui penilaian pada nilai'shear stress'.Keputusan ujian Tensil menunjukkan tekanan ke atas ikatan memberi kesan kepada kekuatan bonding.Tekanan pada tahap 3 atm memberi kekuatan optimum kepada bonding.Walaubagaimanapun kajian yang lebih detail berkenaan mekanisme ikatan disarankan bagi mendapatkan kajian yang lagi menyeluruh.

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Cooperation, guidance, morale support and encouragements from my supervisor, technician, friends and family are giving me a strength to finish up my final year project and I would like to say many thanks to all of them. Lastly, I hope in the future the results of this project can contributed something to community.

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TABLE OF CONTENT

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LIST OF TABLES

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LIST OF FIGURES

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LIST OF APPENDICES

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LIST OF ABBREVATIONS

SLJ	Single Lap Joint
DLJ	Double Lap Joint
ASTM	American Society For Testing and Materials
CSM	Chopped strand mat

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CHAPTER 1

INTRODUCTION

1.1 Background

The Aluminum-composite bonding has been used widely in aerospace, automobile area and mineral processing component due to their excellent properties combination which is low density, high thermal conductivity and good strength. Composite advantages such as good strength weight ratio, high specific stiffness, high plastic flow strength, and corrosion resistance are perfect match for Aluminum that has ductile and ligh tweight properties to produce durable with light structural weight material. Significant savings in structural weight can be achieved by using this type of bonding material. It has been shown that Aluminum-composites bonding material are structurally an optimum design solution in cases where minimal weight and high stiffness are required.

Composite is a material made from two or more constituent materials and carbon fiber is one of the type of composite that have been frequently used. Bonding between aluminum and composite in this project are using epoxy adhesive bonding which is the most suitable for bonding of this two substrate, aluminum and reinforced carbon fiber. Two different materials such as composite and aluminum which undergo bonding process will experience one or more issues such as a failure of the bonding between two material. Bonding failure happen when the bonding reaching its maximum point where the bonding unable to stand before fail. Bonding failure test are based on difference pressure where the good bonding can be determined.

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Adhesive bonded connections comprise a significant class of joining methodologies, which can be used when attachment of composite to metal structure is required. Often times an adhesive joint is the method of choice when compared to mechanically fastened alternatives. However, careful attention to detail must be paid in use of adhesives for structural connections, especially when dissimilar materials are to be attached. Not only proper adhesive selection is critical but also proper techniques in application of the adhesive must be carried out. There are many issues to consider when selecting an adhesive joint for a structural component

1.2 Problem Statement

Carbon fibre and Aluminum bonding has been used widely in many manufacturing industry included aerocraft, naval, automotive and many other manufacturing. A higher strength of this type bonding with excellent mechanical properties are significance due to current industry requirement. In order to improve the strength of this bonding several factor that will increase the strength of carbon-fibre materials should be identify. In this study, we focused on effect of bonding pressure. The different bonding pressure are applied on the bonding to study the effect of pressure on the strength .The problem is does the compressing bonding pressure applied gives impact on the strength of bonding of Aluminum and Composite ?

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1.3 Objective

The objectives of this project are as follows:

1. To study the effect of the pressure applied on the composite-Aluminum bonding
2. To determine the optimum pressure for composite-Aluminum bonding

1.4 Scope of Project

The scopes of this project are:

1. Literature review on the bonding between carbon fiber (composite) and Aluminum
2. To apply pressure by compressing the specimen after substrates attachment process by using epoxy adhesive
3. To conduct static shear tensile test on the specimen

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CHAPTER 2

LITERATURE REVIEW

2.1 Composite and Aluminum Bonding

Structural composites proposes various advantages such as light in weight, resistance to corrosion, and versatility of design. Composites provide directed, purposeful stress management using strategic placement of reinforcing fibers, often combined with core materials to provide stiffness. Over years, Fiberglass reinforced composites have been extensively used in marine and other extreme environment industry. Carbon fiber reinforced composites propose the ultimate in strength-to-weight ratio and are now universal in aerospace and marine applications. Carbon fiber is considered one of the most applicable composite in industries due to high strength to weight ratio, good tensile strength but brittle and low coefficient of thermal expansion.

Aluminum is a one best known metal that is usually chosen in numerous manufacturing processes due to imperative physical properties including; light weight, corrosion resistance, excellent conductivity, and high strength, along with low cost. The ability for joining it properly using an epoxy adhesive is important in the manufacturing process since aluminum is such a common metal in manufacturing industries. Aluminium exist in several forms such as ironadized Aluminium but commonly alloyed with copper, magnesium, manganese, silicon, and zinc. With proper handling and preparation Epoxy can bond well to almost all types of aluminum and aluminum alloys .

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Recently, Aluminum is the second most used metal in the world industry after iron. The properties of aluminum which are low in density, high strength, superior malleability, easy machining, excellent corrosion resistance and good thermal and electrical conductivity are among aluminum's excellent properties. Aluminum alloys commonly have tensile strengths of between 70 and 700 MPa. Aluminum does not become brittle at low temperatures unlike most steel grades instead, its strength increases. At high temperatures, aluminum's strength decreases. At temperatures continuously above 100°C, strength is affected to the extent that the weakening must be taken into account. One of the well-known properties of aluminum is that it is light and their features facilitating easy jointing are often included into profile design.

Fiber reinforced composites and metals are both widely used as structural materials. These two materials are often used together and become an excellent bond mate within a single load carrying structure. Joining methods between composites and metals almost particularly depend on the joining techniques of adhesive bonding, the use of mechanical fasteners, or a combination of the two. Due to the differences between the two materials both adhesive bonding and mechanical fastening result in significant penalties in terms of structural efficiency (Joesbury,2015).

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2.2 Adhesive Bonding

An adhesive may be defined as a material which when applied to surfaces of materials can join them together and resist separation. Adhesive is a non-metallic substance with capability of joining materials and resist separation. The term adhesion is used when referring to the attraction between the substances, while the materials being joined are commonly referred to as substrate or adherends (Diharjo K et al,2013)

Adhesive bonding is a joining process of materials in which an adhesive, placed between the adherends surfaces, solidifies to produce an adhesive bond. Adhesive bonded joints are increasing alternatives to mechanical joints in engineering applications that provide many advantages over conventional mechanical fasteners. (Diharjo K et al,2013). Bonding is the best method compare to joining due to relatively low stress concentration of material, weight saving, and cost saving and improve damage tolerance. The application of these joints in structural components made of fiber-reinforced composites has increased significantly in recent years (Diharjo K et al ,2013). The advantages of traditional fasteners is commonly result in the cutting of fibers, and hence introduce stress concentrations, both of which minimize structural integrity.

Adhesive bonding minimizes weight and complexity in the fabrication of many structural components, most noticeable in the automotive industry. For example, chasis are made from metal whether steel or aluminum alloy by adhesive bonding composite panels to a low density with exceptional specific stiffness (Diharjo K et al, 2013). Adhesive bonding become as primary method to repair structural composites for scarf and doubler repairs. In recent times, composite doubler repairs have also been extended to Aluminum and composite components

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where a bisphenolic-fiberglass composite patch is applied to the metal surface using an epoxy adhesive film. (Diharjo K et al, 2013). The composite doubler and the adhesive film are co-cured for creating a composite patch spanning the substrate crack. These patches extend the lifetime of the parent structure and thus reduce the cost for expensive repair.

2.3 Epoxy as Adhesive

Epoxy adhesives is universally used in manufacturing industry and is also one of the most various adhesive available. In the unhardened state, the chemical structure is characterised by the ring-like shape of the epoxide group, explained how epoxy adhesive gets its name. All epoxy adhesives contain two or more of these groups per molecule of adhesive. Although they are all similar in this respect, the form in which they are available diverse in term of variant, from low-viscosity liquids to solid pastes or films. The diversity of basic epoxy resins, in consolidation with over 70 different curing agents - ranging from simple amines to complex anhydrides - give the group its diversity.

The mechanism of curing is always the same through out all the variations. The ring structure is broken by an active molecule - typically an amine - and the two monomers link. A polymeric network is formed thus harden the adhesive in result from constant repetition of this process. The accurate quantities of resin and hardener necessary for this mechanism, hence the need for precise mix-ratios and the thorough mixing of resin and hardener in two-part systems. Without these, the polymer will not form correctly and often inferior properties will result typically lower strength and reduced environmental resistance.

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Single-part epoxy adhesives are available, in liquid, paste or film form. The resin and catalytic hardener are pre-mixed but polymerisation cannot occur as the catalyst is in an inactive form at room temperature. It only becomes reactive towards the epoxide group as the room temperature is raised in excess of 100 C. Curing process of the two-part adhesives can be accelerated by heat.The higher the temperature, the faster the reaction becomes thus obtain shorter curing times.These materials have good mechanical strength and chemical resistance, do not volatilize during curing, and have low shrinkage. Therefore they form extremely strong with most materials in well designed joints. The development of toughened formulations has increased the demanding uses of these type adhesives in various industries today. The Figure 2.1 shows the example of Epoxy type Adhesive .

Figure 2.1: Example of Epoxy type Adhesive

2.4 Joint Design

Optimization of joint design is an important consideration when designing adhesive bonding applications. Adhesive joints have no limit in term of geometrical the way as in mechanical fastener. Hence it is free to design specific joint that focus only on the mechanical and chemical stresses behaviour. Particular attention must be pay during the design phase such as the distribution of shear stress due to the non-symmetric external tensile load. Tensile load or tensile strength is the ability of the

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