Faculty of Mechanical and Manufacturing Engineering Technology

NATURAL FIBER / SYNTHETIC FIBER HYBRID LAMINATE FOR AUTOMOTIVE RUBBER COMPONENTS

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NATURAL FIBER / SYNTHETIC FIBER HYBRID LAMINATE FOR AUTMOTIVE RUBBER COMPONENTS

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ABSTRAK

Serat logam berlamina adalah suatu kelas bahan logam yang terdiri daripada beberapa lapisan logam yang telah disusun dengan lapisan komposit yang berasakan serat semulajadi / bahan serat sintetik. Serat logam berlamina ini telah menarik perhatian yang luas terhadap pelbagai aplikasi penggunaanya dalam industri. Kajian yang dijalankan bertujuan untuk mengkaji kekuatan tegangan dan kelesuan serat logam berlamina yang diperbuat daripada kenaf / gentian kaca yang diapit dengan keluli ringan yang berketebalan 1mm. Gentian logam berlamina ini terbentuk daripada mesin acuan mampatan tekan panas. ASTM E8 telah digunakan untuk menjalankan ujian lenturan dan tegangan dengan kadar purata kelajuan 2mm/min. Ujian lesuan dijalankan mengikut ASTM E466 dengan menggunakan 10,000 beban kitaran. Keputusan menunjukkan bahawa peningkatan dalam ujian tegangan, lenturan dan kelesuan dikenalpasti dalam serat logam berlamina berasaskan serat semulajadi berbanding serat sintetik. Kesimpulannya, ketebalan dan kekuatan lekatan antara serat itu memainkan peranan yang penting untuk menentukan kekuatan sesuatu serat logam berlamina.

ABSTRACT

Fiber metal laminates (FMLs) is a class of metallic materials that consist of few thin layers of metal stacking with layers of composite based natural / synthetic fiber materials. This FMLs have drawn a wide attention towards variety of application in the industry. The study conducted to investigates the tensile, flexural and fatigue strength of fiber metal laminates (FMLs) which hybrid kenaf / glass fiber were flanked with 1mm mild steel. These FMLs were formed by using hot press compression machine. ASTM E8 was used to perform flexural and tensile testing with 2mm/min rate of speed. Fatigue testing was run based on ASTM E466 where 10,000 cycle of cyclic load was examined. Result showed that improvement in tensile, flexural and fatigue were observed in natural fiber based fiber metal laminate compared to synthetic fiber. Overall, the thickness of fiber and strong bonding of adhesive play an important role to determine the strength of hybrid laminate composite.

DEDICATIONS

To my parents and family members,

Mohd Fadzil Bin Abdul Majid

Hazlina Binti Muda,

Muhammad Bukhari Bin Mohd Fadzil

&

Muhammad Ikhbar bin Mohd Fadzil

That gives me unconditional loves and support towards completing this report,

To my supporting friends,

That gives help to me along this journey,

Also,

The most important person, my supervisor for the guidance, time and patience,

And last,

For those whoever pray for my success in my life.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ASTM	-	American Society for Testing and Material
ARALL	-	Aramid Reinforced Aluminum Laminate
CFRP	-	Carbon-Fiber Reinforced Polymer
CMC	-	Ceramic Matrix Composites
$^{\circ}$C	-	Degree Celcius
FTK	-	Fakulti teknologi Kejuruteraan
FMLs	-	Fiber Metal Laminates
GFRP	-	Glass-Fiber Reinforced Polymer
GLARE	-	Glass Reinforced Aluminum Laminate
MMC	-	Metal Matrix Composite
M/K/G/K/M	-	Mild Steel / Kenaf / Glass Fiber / Kenaf / Mild Steel
M/K/K/K/M	-	Mild Steel / Kenaf / Kenaf / Kenaf / Mild Steel
NFRPCs	-	Natural Fiber Reinforced Polymer Composites
OM	-	Optical Microscope
PMC	-	Polymer Matric Composite
UTeM		Universiti Teknikal Malaysia Melaka
UTM	-	Universal Testing Machine

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter will explain the overview and the purpose of this project. The chapter includes the background of the study, problem statement, significant of study, objectives that are expected to be achieved and the scope of the study that is going to be conducted.

1.1 Background of Study

Nowadays the usage of natural fiber or synthetic fiber in the automotive sector has become a trend that has been increasingly growth over the years. Currently, the automotive industry has implemented natural fiber and synthetic fiber in some parts of the automotive industry. This is due to their advantages that natural and synthetic fiber are widely known as lightweight and exhibit outstanding mechanical properties.

Based on Juliana et al. (2018), natural fiber such as kenaf which consist of bast and core have suitable for composite applications such wood plastic composite, non-woven materials and pultruded products. Kenaf bast fibers with high density and mechanical strength have the potential to be used in materials requiring high strength, such as composite, automotive and reinforcement applications. In different industries, glass fiber that comes from synthetic fiber

were widely used due to their excellent properties of strong, robust and lightweight material (Ramesh, Palanikumar and Reddy, 2013). Due to the advantages of the glass fiber itself, which are low cost, high tensile strength, high chemical resistance and exhibit excellent insulating properties glass fiber has commonly used in polymeric composites (Sanjay and Yogesha, 2017).

Composite consist of fiber, reinforcement and matrix. These reinforcement and matrix bind together to make sure the fiber attach to one another. There are few types of composite such as Polymer Matrix Composite (PMC), Metal Matrix Composite (MMC) and Ceramic Matrix Composite (CMC). Composite also come as hybrid and non-hybrid, which due to their layer of composite. Research by Oliver-Borrachero *et al.*, (2019) stated that when comparing their specific modulus of elasticity and resistance, the advantages of composite materials appear.

Fiber metal laminate is the most common type of hybrid composite used in the industry. A fiber metal laminates (FMLs) is one of a class of metal materials consisting of a multi-thin metal layer laminate bonded with composite material layers. The material then will behave like a simple structure of metal, but with considerable specific advantages in terms of properties such as metal fatigue, tensile strength, corrosion resistance and special strength properties. Fiber metal laminates are usually known as Aramid Reinforced Aluminum Laminate (ARALL) which based on aramid fibers and Glass Reinforced Aluminum Laminate (GLARE) which based on high-strength glass fiber. In automotive and aerospace industry, the demand for more efficient and lightweight materials cause emerged of new types of FMLs (Carrillo and Cantwell, 2009).

Mechanical testing of polymer composites that has been standardize includes flexural, tensile, shear, compression and impact with open and closed holes, meanwhile physical testing involves voiding content, water absorption, density, scratch resistance and hardness. Mechanical and physical testing are runs to ensure that the material meets the performance requirements of

industrial specifications, mainly in the aerospace, automotive, consumer, medical and defense industries (Saba, Jawaid and Sultan, 2018).

This project is about the natural fiber and synthetic fiber hybrid metal laminate for automotive rubber component. So, this study focusses on the mechanical properties of tensile strength and fatigue strength of the material. These fatigue and tensile strength are important to understand the endurance of the material.

1.2 Problem Statement

In the automotive industry, some of their components are usually made up from a solid metal. The characteristics of solid metal are known as glossy in their appearance, well conductor of heat and electricity but somehow solid metal is heavy. This is due to the thickness of the metal material itself. Weight of material gives effects to the fuel consumption as reducing weight can reduce the amount of fuel. Light weight is a key factor in the rapid expansion of the global automotive composite market today. Brooks, (2004) explained that, the use of composites in automotive applications has steadily increased in recent years and expected to increase further in the future. Hybrid composite such as fiber metal laminates are frequently used because of their light-weight feature and known to have superior mechanical properties. There are several researchers agreed that fiber metal laminates (FMLs) based composite are lighter than other conventional aluminum and steel and because of their amazing fatigue and impact properties, FMLs were used extensively (Subramaniam *et al.*,(2019), Dhar Malingam *et al.*, (2018), Feng *et al.*, (2017)).

Furthermore, solid metal is a recyclable resource but also gives problem to the industry as it is a non-renewable. The manufacturing of solid metal requires a new virgin raw material to produce them. Besides that, solid metal is expensive as compared to the natural fiber. Based on Elanchezhian *et al.*, (2018), natural fibers are renewable, can be recycled and low in density and price. Synthetic fibers that is man-made fibers also being implemented in composite as they offer user-friendly functions such as waterproofing and dirt resistance. Even though synthetic fiber like glass fiber is expensive, the mechanical properties of them are outstanding (Shahinur and Hasan, 2019). Moreover, they have a satisfactory mechanical property that make them attractive in industry.

1.3 Significance of Study

The significance of the study are as follows:

i) In industry, automotive components are usually fabricated with solid steel which known as heavy. Hence, this study is aimed to investigate the capability of natural fiber / synthetic fiber hybrid laminate to be replace of solid metal.

ii) Gives relevant information for better understanding of natural fiber / synthetic fiber hybrid laminate to be used in automotive component in the industry.

iii) Fiber metal laminate of hybrid composite has more benefits in physical and mechanical properties as natural fiber / synthetic fiber itself have advantages compared to solid metal. Hence, this study focused on their fatigue strength and tensile strength of fiber metal laminates which stacking of kenaf / kenaf / kenaf (K/K/K) and kenaf / glass / kenaf (K/G/K).

1.4 Objectives

The objectives of the project are to: -

i) To fabricate hybrid mild steel / kenaf /glass fiber reinforce composite.

ii) To investigate the mechanical properties of hybrid mild steel / kenaf / glass fiber reinforce composite.

iii) To propose a preferred configuration of hybrid fiber metal laminates.

1.5 Scope

This project is about natural fiber / synthetic fiber hybrid laminate for automotive rubber components. This involves the fabrication of metal (mild steel) laminates with layered composites contain hybrid and non-hybrid composites such stacking of kenaf / kenaf / kenaf (K/K/K) and kenaf / glass / kenaf (K/G/K). Besides, non-woven kenaf, and woven glass fiber are used. Hot press compression molding, adhesive and epoxy are used to make sure the stacking of metal and composites are strong enough to attach each other. The mechanical properties of tensile strength and fatigue strength of this hybrid and non-hybrid composite metal laminates are studying. Towards this fabrication, a new hybrid natural fiber / synthetic fiber laminate for automotive rubber component has been assumed to have a higher mechanical strength and longer fatigue life.

1.6 Organizations of the Project Study

This project was divided into five chapters that describe the analytical and experimental research that have been performed. The effect of the usage of natural fiber and synthetic fiber for composite in hybrid metal laminate for automotive rubber component have been studied to view the physical and mechanical properties of the hybrid mild steel / kenaf /glass fiber reinforce composite. The organization of this project study is as follows.

The first chapter begins with an introduction towards the study of this project that includes background of the study, stated problem statement towards this project, objectives, scope and an overview of this project.

Next chapter, which is chapter two is about the literature review that has gathered. This chapter starts with a discussion on the history of composite which includes the reinforcement and matrix of the composite, the type of fibers which briefly explained specifically on natural and synthetic fiber that have been used. Comprehensive review about fiber metal laminates are also included.

Chapter three includes detailed explanation of the methodology used for overall research work, raw materials, process where the hot press method uses to fabricate fiber metal laminates and procedure property analysis that had been done.

Chapter 4 explained the result of this study. The result of various studies and test which the specimens are cut according to their standard ASTM which for tensile and flexural test is ASTM E8 and for fatigue test is ASTM E466 are revealed in this chapter. The data from tensile, flexural and fatigue test of both sample mild steel / kenaf / kenaf / kenaf / mild steel