



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**EFFECT ON MECHANICAL AND PHYSICAL PROPERTIES OF
COTTON FIBER IN HYBRID LAMINATED COMPOSITE FOR
HARD PANEL APPLICATION**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) (Honors)

by

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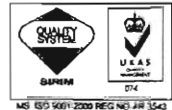
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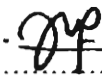
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I hereby, declared this report entitled “Effect on Mechanical and Physical Properties of Cotton Fiber in Hybrid Laminated Composite for Hard Panel Application” is the results of my own study except as cited in references.


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APPROVAL

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ABSTRAK

Dalam kajian ini, sifat-sifat campuran komposit berlamina dengan menggunakan kaedah *hand lay up* telah dikaji untuk aplikasi panel keras. Bahan mentah yang digunakan adalah resin poliester tak tepu, cotton dan jaringan dawai. Kajian ini bertujuan untuk mengkaji kesan cotton ke atas sifat mekanikal dan fizikal dalam campuran komposit berlamina untuk aplikasi panel keras. Di samping itu, kajian ini juga bertujuan untuk mengenal pasti lapisan dan susunan terbaik dalam panel keras. Selain itu, kajian ini juga untuk mengenal pasti tingkah laku kegagalan campuran komposit berlamina apabila menjalani ujian mekanikal dan fizikal. Sebelas sampel campuran komposit berlamina telah direka mengikut bilangan lapisan, susunan dan diuji berdasarkan piawaian ASTM. Berdasarkan ujian mekanikal dan fizikal ke atas campuran komposit berlamina, didapati bahawa komposit SN 7 memberikan sifat optimum berbanding dengan yang lain. SN 7 dengan jumlah sepuluh lapisan cotton di mana lima lapisan cotton di atas dan lima di bawah jaringan dawai memberi nilai terbaik untuk setiap ujian. Bagi kekuatan tegangan, SN 7 memberi 29.354 MPa, kekuatan lenturan dengan 61.08 MPa, kekerasan dengan 84.2 dan tolakan nat dengan 4452.66 N. Ini membuktikan bahawa SN 7 adalah lebih baik daripada sampel lain.

ABSTRACT

In this research, the properties of the hybrid laminated composite by hand lay up method had been investigated for hard panel application. The raw material used were unsaturated polyester resin, cotton fiber and wire mesh. This research was aimed to investigate the effect of cotton fabric on the mechanical and physical properties in hybrid laminated composite for the hard panel. In addition, this research also sought to identify the best layer and arrangement in hard panel and to identify the failure mode behavior of hybrid laminate composite upon mechanical and physical testing in different layer and arrangement of reinforcement. Eleven samples of hybrid laminated composite were fabricated according to the number of layer, arrangement and ASTM standard. Based on the mechanical and physical testing on the hybrid laminated composite, it has found that the laminated composite SN 7 give the optimal mechanical and physical properties compared to the other. SN 7 is a laminate with total ten layer of cotton fiber where five layer of cotton at the top and five layers at the bottom of the wire mesh give the best value for each testing. For tensile strength, SN 7 gave 29.354 MPa, flexural strength with 61.08 MPa, hardness with 84.2 and bolt push with 4452.66 N. It was concluding that SN 7 was better than other sample.

DEDICATION

Thank You, ALLAH for the opportunity to accomplish this Final Year Project and for the mercies you laid upon me.

Thank You for understanding and supporting me especially to my father Amir B. Adam and my mom Tini Binti Marauna . Also not forgetton to my brother, Shahrul B. Amir and sister, Sarti Binti Amir. Thank You for your encouragement.

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LIST OF ABBREVIATIONS AND SYMSBOLS

ASTM	-	American Society for Testing and Materials
CMC	-	Ceramic Matrix Composite
Eq	-	Equation
GPa	-	Giga pascal
T_g	-	Glass transition temeprature
G1	-	Group one
G3	-	Group three
G2	-	Group two
M_i	-	Mass initial
M_f	-	Mass final
MPa	-	Mega pascal
MPa/s	-	Mega pascal per second
MMC	-	Metal Matrix Composite
MEKP	-	Methyl Ethyl Ketone Peroxide
mm/min	-	Milimeter per minute
E_c	-	Modulus of composite
E_{ct}	-	Modulus of cotton
E_m	-	Modulus of matrix
E_{wm}	-	Modulus of wire mesh
PMC	-	Polymer Matrix Composite
S/N	-	Sample Number
SN	-	Series number
T_{use}	-	Temperature use
UTM	-	Universal Testing Machine
UP	-	Unsaturated Polyester
UPR	-	Unsaturated Polyester Resin
UV	-	Ultra Violet

V_m	-	Volume of matrix
V_{ct}	-	Volume of cotton
V_{wm}	-	Volume of wire mesh
W_A	-	Water Absorption
$^{\circ}C$	-	Celcius
g/cm^3	-	Gram per centimeter cubic
$>>$	-	Greater than
in	-	Inch
kN	-	Kilonewton
kN/mm	-	Kilonewton per millimeter
m/min	-	Meter per minute
mm	-	Milimeter
mm^2	-	Millimeter square
min	-	Minute
Nm/s^3	-	Newton per millimeter square
%	-	Percentage
ε	-	Strain
σ	-	Stress
Θ	-	Teta
E	-	Young modulus

CHAPTER 1

INTRODUCTION

1.1 Background of Research

According to Daniel and Suong (2003), composite material is different from common heterogeneous materials. Kaw (2005) alleged that composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are soluble in each other. One constituent is called reinforcement and the other one is called matrix. Armstrong *et al.*, (2005) stated that composite are combinations of materials differing in composition or form where the individual constituent retain their separate identities and do not dissolve or merge together. Application of composite materials represented as 70 % of market value, 23 % automotive, 21 % public work, 23 % building, 17 % aeronautics and 11 % sport as studied Shakila (2006). One example of the applications of composite materials that had caught people's interest is the artificial rock wall climbing panel. Kaw (2005) declared that a laminate is made of a group of single layers bonded to each other. Each layer can be identified by its location in the laminate, its material and its angle of orientation with a references axis. From study by Daniel and Suong (2003) laminate composite usually made by hand lay up process. This is because it is low cost and consists of any size configuration.

Research done by Kaw (2005) shows composite parts has both advantages and disadvantages when compared to other material for example metal. First of all, composite has a higher performance in improved strength, stiffness, and fatigue and impact resistance. Besides that, composite material also makes it easier to achieve

smooth aerodynamic profiles for drag reduction. Armstrong *et al.*, (2005) suggested that the complex double-curvature parts can be made in one manufacturing operation to get smoother surface finish. In addition the repaired composite introduce new problems because materials require refrigerated transport and storage and have limited shelf lives. High cost of fabrication also a critical issue. For example, part made of epoxy may cost up to 10 to 15 times the material cost (Kaw, 2005). Thus, to reduce the cost of fabrication, polyester had been used in this research. Polyester have excellent electrical and that large structure can be mould at low pressure and low cost tooling. Lubin (1998) claimed that properties of polyester can be varied by using different combination of diacid and glycols.

Bourne and Danielli (1984) cotton fiber is white colour and can be used for variety purpose especially in textile manufacture. This is because the properties of the cotton such as lightweight and dry. While cotton fiber is a single celled outgrowth from individual epidermal cells on the outer integument. History of cotton was start with the evaluation of the genus about 10-20 million years ago. Country such as Africa, Arabia, Australia and Mesoamerica become the center of cotton fiber during the millennia as studied by Smith and Cothren (1999). According to Lacape *et al.*, (2005) there are several types of cotton which have different properties and application. First of all is upland cotton, *G. hirsutum*. This types cotton is dominates the cotton fiber production, representing 90 % of the production was based on this types cotton. Second is the *G. barbadense* which has superior fiber length, strength, fineness and giving a higher spinning and manufacture performance.

1.2 Problem Statement

Before development of hybrid laminate composite, there several issues should be considering for example the design flexibility and manufacturing cost. Design is should be consider because to accommodate complex shape and thickness changes. Besides

that, the cost is to reduce the higher material for hybrid laminated composite. Thus in this research, the design and cost of the hybrid laminated composite was design by using low cost material (National research council, 1996).

According to Allen (1995), laminated composite also has poor interlaminar properties like woven fabric reinforced such as low interlaminar strength and toughness. Thus, to improve the interlaminar fracture behavior and mechanical properties of such composite generally focus on the reinforcement with development of three-dimensional reinforcement, matrix material via thermoset and thermoplastic, fiber and matrix interface by improved coupling agent. Using matrix additives to enhance the toughness also have been reported (Caruso *et al.*, 2008; Rafiee *et al.*, 2009; and Rafiee *et al.*, 2010).

Therefore this research was focused on the fabrication of the hybrid laminated composite by using the cotton fiber for hard panel application to reduce the manufacture cost of laminated composite structure. Thus, the material that had been chosen in this research is polyester resin, cotton fiber and wire mesh. The polyester resin would act as matrix material while cotton fiber would act as reinforcement material. To improve the structure and properties of the hybrid laminated composite including strength and stability, wire mesh was added in the hybrid laminated composite. Lastly, this research comes out with the best thickness, layer orientation and arrangement with low cost a simple fabrication method in order to improve the mechanical properties of the hybrid laminated composite.

1.3 Objectives

The purposes of this research are:

- (a) To study the effect of cotton loading on the mechanical and physical

properties of hard panel hybrid laminated composite.

- (b) To identify the best layer and arrangement in the hybrid laminated composite.
- (c) To determine the failure mode behavior of hybrid laminated composite upon mechanical and physical testing in different layer and arrangement of reinforcement.

1.4 Scopes

The research scope's of research are:

- (a) Study the mechanical properties for example tensile strength and flexural strength of the hybrid laminated composite.
- (b) Study the effect of layer orientation reinforcement in hybrid laminated composite.
- (c) Study the cotton fabric as reinforcement and polyester resin as matrix in hybrid laminated composite.
- (d) Study the properties of cotton fabric, polyester resin and wire mesh in hybrid laminated composite.
- (e) Study the failure mode of each specimen when undergo a mechanical testing such as tensile test and flexural test.
- (f) Study the of the fabrication technique hand lay-up in processing hybrid laminated composite.

1.5 Rational of Research

In this research, the cotton fiber was used to studies the effect on the mechanical and physical properties in hybrid laminated composite for hard panel application. Thus in

order to improve the mechanical and physical properties of the hybrid laminated composite this research was focused on the hybrid laminated orientation and hybrid laminated arrangement. The hybrid laminated composite was arranged according to the number of layer cotton fiber and position of the wire mesh to determine the best series number for the hard panel application. Therefore, the hybrid laminated composite had been categories into three groups which are group one, group two and group three. In addition, this research also focused on the thickness of the hybrid laminated composite to improve the properties in term of mechanical and physical properties.

Furthermore in this research, the fabrication technique used is hand lay up process method. Hand lay up is simple and only needed low cost of fabrication (Sevkat and Brahim, 2011) and (Garcia *et al.*, 2008) since the low manufacture cost was needed in fabricate hybrid laminated composite. Furthermore, costs for tooling and other expenses also can be saved. Besides that, the material used also low cost for example polyester resin, cotton fiber and wire mesh.

1.6 Research Methodology

The research methodology is needed to achieve the objectives of this research. The raw material chosen for this research are wire mesh, polyester resin and cotton fiber. After the right material chosen, the next step of this research is to design the hybrid laminated composite. In this step, the arrangement and orientation of the laminate is determined. Eleven series number had been prepared for this research according to the number of layer and arrangement. All the material is prepared according to the 0/90° and the number of layer for cotton fiber is increased from SN 3 until SN 7 with the wire mesh was at the middle. For SN 8 until SN 11, the number of cotton is the same but the position of the wire mesh was change from the middle to the bottom. Then, the hybrid laminated was fabricated by using hand lay up process. The sample was cured at room temperature for 24 hour. After 24 hour, the sample was pull out from the mould. Finally,

the hybrid laminated composite will undergo several testing such as tensile, flexural, hardness, water absorption and water swelling according to ASTM standard to determine the properties of the hybrid laminated composite.

1.7 Thesis Frame

For chapter one, the introduction of the research has been discussed in this chapter. Basically, this chapter including the background, problem statement, objectives, scopes, rational of research, research methodology and thesis frame. Furthermore, in this chapter, the general information regarding the hybrid laminated composite and composite had been discussed in the background subtopic. For problem statement, the disadvantages and difficulties of the research was discussed at this subtopic. The scopes of this research are determined based on the objectives and the rational of the research was argued at rational of research subtopic. In research methodology, the raw material, fabrication technique, mechanical and physical testing had been discussed to be used in this research.

Chapter two was discussed about the literature review for this research. This including about the composite, hybrid laminated composite, failure mode, material used in this research, previous study by the researcher and finally summary. Firstly, the definition, classification of the composite had been briefly explained in the introduction subtopic. Besides that, the failure of the laminate composite also had been discussed to determine the failure mode of the sample in this research after undergo the mechanical and physical testing. Furthermore, the information about the raw material used in this research also had been argued to determine the best raw material used for this research. For matrix material, the information about the polyester and epoxy resin was discussed to choose the suitable resin used for this application. While for reinforcement material the cotton fabric and woven fabric was make comparison. After being discussed, polyester resin, cotton fiber and wire mesh was used as raw material in this research.

The technique process for this research also been discussed in this chapter and the details of the hand lay up process was discussed under fabrication method subtopic. Finally, the previous study of the researcher also had been discussed under previous study subtopic to make the comparison and references using the analysis.

Chapter three was discussed about the methodology of this research. Generally, in this chapter included the raw material selection, fabrication technique, hybrid laminated composite design and finally the testing for the hybrid laminated composite. First of all, the polyester as matrix material, cotton fabric as reinforcement was discussed in raw material selection subtopic. Besides that, the wire mesh also discussed under the subtopic because wire mesh was used as the back bone of the hybrid laminated composite and to increased the strength of the hybrid laminated composite. Under the laminate design, the laminate size, orientation, arrangement and number of sample was discussed. While for fabrication method, the process of the hand lay up process was discussed. Last but not least, the mechanical and physical testing for the sample was argued based on the step of the testing and criterion of the dimension for each testing according to the ASTM standard.

Chapter four discussed about the result and discussion of this research. In this chapter, the sample was argued according to the testing such as density, water absorption and swelling test, hardness test, tensile test, flexural test and bolt push test. For each testing, the result of the sample was explain and been discussed according to the number of sample based on the previous researcher. Besides that, from the result for each testing, the best series number in term of properties can be obtained.

Chapter five discussed about the conclusion and recommendation of this research. The objective of this research was discussed in order to make the conclusion for this research. Lastly, the recommendations were suggest improving the research in future.