UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY THE MECHANICAL PROPERTIES OF MARINE COMPOSITE MATERIAL

This report submitted in accordance with requirements of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Material) with Honours.

by

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

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I hereby, declared that this report entitled “Study the Mechanical Properties of Marine Composite Material” is the result of my own research except as cited in the references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Material) with Honours. The member of the supervisory committee is as follow:

……………………………….

(Principal Supervisor)

(Mohd Yuhazri Bin Yaakob)

ABSTRACT

The marine and aerospace composite material is produced from advanced material and high complex technology processing. The hybrid synthetic fiber Kevlar and fiberglass with epoxy developed to study the mechanical properties of marine composite material. Different layers begin with 20 layers, 22 layers, and 24 layers of reinforcement design produced based on layers arrangement and material use. The composite designs produce with using Vacuum Infusion technique. There are four mechanical tests involves which are Tensile Test, Flexural Test, Impact Test, and Hardness Test. These entire tests will be following the ASTM D 3039, ASTM D 790, ASTM D 256, and ASTM D 2240 standard respectively. Specimen Type 5 as a reference specimen provided from SIRIM. Young's modulus value for Specimen Type 2 and 3 are 41.41 % and 49.81 % higher from reference specimen and delamination is the common failure mode for almost specimen. From impact test, the specimen Type 4 impact energy higher 23.62 % and impact strength 15.58 % lower from the reference specimen. Specimen Type 2 more hardens 0.95 % from the reference specimen. The combination of Kevlar and fiberglass can replaced current material from observation and data analysis. The best composition is Type 3 which contains 11 plies of WV Kevlar and fiberglass with thickness 7.5 ± 0.2 mm has Young's modulus, impact strength and hardness value are 4757.75 MPa, 0.633 J/mm^2 and 83.5. All the specimen result has small different percentage compare to the reference specimen where it made from different processing method that involved high technology such as using autoclave to cure the specimen respectively.

ABSTRAK

Penghasilan bahan termaju dan teknik pemprosesan yang rumit digunakan dalam bidang marin dan aeroangkasa. Kajian sifat mekanikal dilakukan ke atas bahan komposit marin dengan gabungan Kevlar dan gentian kaca digunakan. Rekaan 20 lapisan, 22 lapisan dan 24 lapisan akan dihasilkan dengan perbezaan penyusunan tetulang dan bahan yang digunakan. Semua rekabentuk tersebut dihasilkan menggunakan kaedah *Vacuum Infusion* teknik. Sebanyak empat jenis ujian mekanikal terlibat iaitu Ujian Tegangan, Ujian Lenturan, Ujian Hentaman dan Ujian Kekerasan dan berdasarkan piawaian ASTM D 3039, ASTM D 790, ASTM D 256 dan ASTM D 2240. Spesimen rujukan yang diperolehi daripada pihak SIRIM dikenali sebagai Spesimen *Type 5*. Spesimen *Type 2* dan *3* mempunyai nilai modulus keanjalan sebanyak 41.41 % dan 49.81 % tinggi daripada spesimen rujukan dan jenis kegagalan *delamination* terjadi kepada hampir kesemua spesimen. Daripada ujian hentaman, didapati tenaga hentaman spesimen *Type 4* mempunyai 23.62 % tinggi dan tenaga hentaman 15.58 % rendah daripada speismen rujukan. Spesimen *Type 2* 0.95 % lebih keras daripada spesimen rujukan. Daripada pemerhatian dan analisa mendapati bahawa gabungan Kevlar dan gentian kaca boleh menggantikan penggunaan bahan marin yang sedia. Spesimen *Type 3* adalah komposisi yang terbaik dimana mengandungi 11 lapisan Kevlar dan gentian kaca dengan ketebalan 7.5 ± 0.2 mm serta mempunyai nilai modulus keanjalan, tenaga hentaman dan kekerasan iaitu 4757.75 MPa, 0.633 J/mm^2 and 83.5. Semua keputusan spesimen hanya mempunyai perbezaan peratusan yang kecil berbanding dengan bahan yang sedia ada dimana ia dihasilkan daripada proses yang berbeza dengan penglibatan teknik berteknologi tinggi seperti penggunaan *autoclave* untuk memastikan specimen kering sepenuhnya.

DEDICATION

My beloved mum "Pn. Normawati" and my dear Siti Eaisyah Kamaruzaman. I'm trying my best to make you guys proud.

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Last but not least, thank you to those involve for great phrase of praise, awareness, support and anxiety that been share together in order to complete this project.

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NO.	TITLE	PAGE

LIST OF ABBREVIATIONS

AMC	-	Alkyds
ASTM	-	American Society for Testing and Materials
Bhd	-	Berhad
CSM	-	Chopped Strand Mat
DGEBA	-	Diglycidyl ether of bisphenol
DGM	-	Middle gage failure mode
EP	-	Epoxy
FKP	-	Fakulti Kejuruteraan Pembuatan
HE	-	High elongation
ILSS	-	Inter Laminar Shear Strength
LE	-	Low elongation
LGM	-	Lateral gage middle failure mode
M	-	Malaysia
MF	-	Melamine Formaldehyde
PF	-	Phenolics
PSM	-	Projek Sarjana Muda
RTM	-	Resin Transfer Molding
SIRIM	-	Standards and Industrial Research Institute of Malaysia
SRIM	-	Structural reaction injection molding
Sdn	-	Sendirian
UF	-	Urea Formaldehyde
UP	-	Unsaturated Polyesters
UTM	-	Universal Tensile Machine
Vol	-	Volume
WR	-	Woven Roving

LIST OF SYMBOLS

°C	-	Celsius
°F	-	Fahrenheit
g	-	Gram
%	-	Percentage
σ	-	Engineering stress
ε	-	Engineering strain
ε_f	-	Strain in the outer surface
E_f	-	Modulus of elasticity in bending
±	-	tolerance
cm	-	centimeter
cm^3	-	volume in centimeter
min	-	minute
mm	-	millimeter
mm^2	-	area in millimeter
mph	-	miles per hours
In	-	inch
J	-	Joule
Gal	-	Gallon
Lbs	-	Pound
J/mm^2	-	Joule per are in millimeter
kg/m^2	-	density
mPa	-	mili pascal = 1×10^{-3}
kPa	-	kilo pascal = 1×10^{3}
Mpa	-	mega pascal = 1×10^{6}
GPa	-	giga pascal =1×10^{9}
Ec	-	corrected energy
A	-	Area of sample
b	-	Width
d	-	Depth of tested beam
D	-	Maximum deflection of the center of the beam

E	-	Young’s Modulus
F	-	Force acting area
h	-	Thickness
L	-	Length
L	-	Support span
m	-	Slope of the tangent
N	-	Load
P	-	Load at a given point on the load deflection curve

CHAPTER 1

INTRODUCTION

1.1 Problem statement

Application of composite materials within the marine surface ship has been limited to date. Recently, however, there has been growing interest in applying composite material to save weight, reduce acquisition, maintenance, life time cycle cost and enhance signature control. The most considering structure in terms of material fabrication is hull, deckhouse foundations and machinery components. These applications have generated a research to verify the producability, cost benefit, damage tolerance, moisture resistance, failure behavior and design criteria. Due to these needed, an acceleration using composite based material is being enhanced especially in the marine environments. This project is basically to study the mechanical properties of marine composite by vacuum infusion process fabricating.

1.2 Objectives

(a) To identify the appropriate materials for marine composite fabrication using vacuum infusion method.
(b) To identify and select the best lamination technique using vacuum infusion method.
(c) To study the mechanical properties of marine composite materials.

1.3 Scopes

(a) Marine composite material used.
(b) Fiberglass and kevlar as hybrid material in marine application.
(c) Vacuum infusion technique in marine fabrication.
(d) Study the mechanical properties of marine hybrid composite.

1.4 Rational of Research

In recent years, the composite material in marine applications has steadily increasing. To find the particular composite material and produce a new composite design in marine development. At the same time, using low cost of reinforcement and matrix, also having the best mechanical properties needed and improve the previous research in composite material in marine applications.

1.5 Thesis Frame

For this project, chapter one known as the introduction chapter and will include the objectives of the research which is having three main objectives. Follow with scopes of research to avoid this research not too far out of main objectives. This research idea came from problem statement that also included. Then rational of research to answer people question why this research should be done.

In chapter two, begin with introduction marine composite. In this part more to the theory of composite raw material such as epoxy resin, Kevlar and fiberglass, then continue with interply hybrid laminates in previous research. Also fabrication of hand lay up and vacuum infusion method theory involved. At the end of this chapter has summary of collecting journal that related to this research.

The third chapter starting with raw material preparation involved in this research. Then follow with vacuum infusion fabrication technique and composite designs consist of lamination and reinforcement layers arrangement. After that the specimens will be tested with four mechanical tests which are Tensile Test, Flexural Test, Impact Test and Hardness Test and the geometry of specimens referring international standard.

The chapter four begins with hybrid composite panel that has been discussed at chapter three about the composite design. The result and discussion begin with tensile test and another test same as mention from previous chapter and compilations of average data for all result.

Last chapter conclude about from observation and data analysis and achieving the aim of this research. The recommendation added to mention about the material, composite design and processing should be improved or alternative way to produced good composite material.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Marine Composites

The last few decades, the demanding of high performance materials with criteria such as light weight, corrosion resistance, also unique mechanical properties, ease of fabrication and low cost is increased. Recently materials use before composite been discovered, often reach their limitation. To solving these problems, engineers and scientists take these opportunities make research to develop the new material which is known as composite material with unique characteristics. Composite materials date from the first light of earliest recorded history (Matthews, F. L., et al., 1999). The use of composites in the marine industry is a concept that holds a tremendous amount of water.

In fact, composite materials are being used more widely in the construction of ships and marine structures than ever before. Composites have a higher stiffness and strength by weight than most other materials, including metals such as steel and aluminium. Used in various parts of a commercial or pleasure craft, the result is a far lighter boat that can achieve a higher rate of speed than the same type of boat constructed of aluminium or steel. Otherwise, the lighter weight keeps fuel costs down and that a significant savings for a boat that may hold hundreds or even thousands of gallons of fuel.

There is another factor associated with the lighter weight, speed. A perfect example is the high-speed passenger ferry, Jet Rider, which operates in Norway and carries 244 passengers at 48 mph. With composites making up a large percentage of its structure, the lightweight craft is not only more cost efficient to build than a comparable metal craft, but also able to move quickly. Other composite-hull vessels include a 259 foot ferry that can carry 570 passengers and 137 cars at speeds up to 54 mph (Mc, M. R., 2008).

The use of composites in boat hulls while obviously advantageous is a relatively recent phenomenon. About 20 years ago, composite hulls were limited to smaller vessels, such as pleasure yachts and small commercial fishing boats. Composites were too new and expensive to incorporate into larger vessels. The most common early composite application for larger vessels was military minesweeper hulls made from fiberglass. Today many larger vessels are made from composites, with these materials being used in a variety of areas, including hulls, floor and wall panels, decks and bulkheads, as well as ducting systems, oil tanks and waste water tanks, sonar domes, piping, pumps, valves and superstructures.

Composites are being employed more extensively in a ship's superstructure especially above a ship's deck. Composite materials used reduce weight, which means that more equipment can be installed above the waterline without sacrificing roll stability. Although boats are designed to sustain a certain amount of roll without capsizing, a strong enough force against a top-heavy structure will cause it to capsize. Larger superstructures can be fabricated from composites without proportionally increasing the risk of capsizing.

2.2 Matrix Material

Matrix constituent is continuous and present as the major compound in composite materials. Bind and transfer separately load to the reinforcement. It provides rigidity and shape to the structure and depends to the interface binding.

2.2.1 Thermoset

Thermosets are polymers which do not melt when heated. The strong cross-link bonding affects the chain pulling together. Cross-linking is irreversible therefore thermosets can not be reprocessed (re-melt). Thermosets are stronger and stiffer than thermoplastics. Stiffness of thermosets is even higher than some metals such as aluminum. Thermosets also have higher thermal, chemical and creep resistance than thermoplastics. Thermoset materials may contain filler materials in form of powder or fibers, providing improvement of specific material properties such as strength, stiffness, modulus of elasticity, thermal resistance, and lubricity. Common filler materials are glass in various forms, metal powders or graphite.

Thermoset group:

(a) Epoxy (EP)
(b) Unsaturated Polyesters (UP)
(c) Phenolics (PF)
(d) Amino Resins
(e) Urea Formaldehyde (UF)
(f) Melamine Formaldehyde (MF)
(g) Alkyds (AMC)

2.3 Epoxy

Epoxy resins are a class of thermoset materials used extensively in structural and specialty in composite applications because they offer a unique combination of properties that are unattainable with other thermoset resins. Available in wide variety of physical forms from low-viscosity liquid to high-melting solids, they are amenable to a wide range of process and applications. Epoxy resins show the best performance characteristics of all the resin used in the marine industry in which weight reduction is extremely important for competitive advantages (Mallick, P. K., 2007).