UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECTS OF FIBER SIZE MODIFICATION ON THE MECHANICAL PROPERTIES OF KENAF FIBER REINFORCED POLYESTER COMPOSITE

Thesis submitted in accordance with the partial requirements of the Universiti Teknikal Malaysia Melaka for the Degree of Bachelor of Engineering (Honours) Manufacturing (Engineering Material)

By

Jafri Bin Jamaludin

Faculty of Manufacturing Engineering

Mac 2008

BORANG PENGESAHAN STATUS TESIS*

JUDUL: **EFFECTS OF FIBER SIZE MODIFICATION ON THE MECHANICAL PROPERTIES OF KENAF FIBER REINFORCED POLYESTER COMPOSITE**

SESI PENGAJIAN: 2/2007-2008

Saya **JAFRI BIN JAMALUDIN**

mengaku membenarkan tesis (PSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	TIDAK TERHAD	

Disahkan oleh:

(TANDATANGAN PENULIS) (TANDATANGAN PENYELIA)

Alamat Tetap:
KM 7, KAMPUNG KUBANG GAJAH,
02600, ARAU, PERLIS

Cop Rasmi:

Tarikh: _____

Tarikh: _____

* Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.

APPROVAL

This thesis submitted to the senate of UTeM and has been accepted as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Material). The members of the supervisory committee are as follow:

……

Main Supervisor

(Official Stamp and Date)

……..

Co – Supervisor

(Official Stamp and Date)

DECLARATION

I hereby, declared this thesis entitled "Effect of Fiber Size Modification on the Mechanical Properties of Kenaf Fiber Reinforced Polyester Composites." is the results of my own research except as cited in references

Signature : ……

Author's Name : ……

Date : ……

ABSTRACT

The purpose of this research is to study and analyzed the effect of fiber size modification on the mechanical properties of kenaf fiber reinforced polyester composite. The main materials used in this project are unsaturated polyester resin and kenaf fibers. Kenaf fibers used in this project are from the core and bast parts. There are two size of kenaf fiber used in this study, fine fiber and coarse. The kenaf fibers used has been refined in Forest Research Institute of Malaysia (FRIM) beforehand. The size of kenaf fiber is observed by using Scanning Electron Microscope (SEM). The fabrication process is done by mixing the 20% composition of kenaf fibers, polyester resin and MEKP hardener. Then the mixture is poured into the mild steel mold and compressed by using the cold pressing machine. After the curing process, the composite panel of kenaf fiber and polyester polymer is cut into specific dimension according to the ASTM testing standard depend on the types of testing. The specimens are tested for the impact testing, tensile testing, flexural testing and water absorption testing. The microstructure of tensile fracture surface is observed by using the SEM. From study, the kenaf bast fiber show the better mechanical properties compared with kenaf core fiber. The larger fiber size of kenaf fiber shows the greater mechanical properties than finer fiber size for flexural and impact properties. The fine size of kenaf fiber shows the better tensile properties than coarser fiber. The coarse fiber size can absorb more water than finer fiber size due to many gap and hole at the composite.

ABSTRAK

Kajian ini adalah bertujuan untuk mengkaji dan menganalisis kesan pengubahsuaian saiz gentian pada sifat mekanikal gentian kenaf yang diperkuatkan dengan komposit poliester. Bahan utama yang digunakan didalam projek ini adalah resin poliester dan gentian kenaf. Gentian kenaf yang digunakan adalah dari bahagian kulit dan empulur pokok kenaf. Terdapat dua saiz gentian kenaf yang digunakan iaitu gentian kenaf halus dan kasar. Gentian kenaf yang digunakan di dalam kajian ini telah menjalani proses penghalusan terlebih dahulu di Institut Penyelidikan Hutan Malaysia (FRIM). Saiz gentian kenaf yang bakal digunakan di dalam kajian ini diukur terlebih dahulu menggunakan Microskop Pengimbas Elektrod (SEM). Proses memfabrikasi komposit dilakukan dengan memcampurkan 20% komposisi gentian kenaf bersama resin poliester dan pengeras MEKP. Campuran tersebut kemudiannya dituang kedalam acuan keluli dan ditekan pada tekanan yang tinggi menggunakan mesin penekan hidrolik. Setelah melalui proses pengerasan, panel komposit dipotong mengikut dimensi tertentu berdasarkan piawaian ujian ASTM. Spesimen diuji untuk ujian tegangan, ujian kelenturan, ujian impak/hentaman dan ujian penyerapan air. Struktur mikro pada permukaan patah tegangan spesimen dilihat menggunakan SEM. Hasil kajian menunjukkan gentian kulit kenaf mempunyai sifat mekanikal yang lebih baik berbanding gentian empulur kenaf. Kajian juga menunjukkan saiz gentian kenaf yang lebih besar mempunyai sifat lengungan dan sifat hentaman yang lebih baik. Saiz gentian kenaf yang halus mempunyai kekuatan tegangan yang baik berbanding gentian yang lebih kasar. Komposit dengan gentian bersaiz besar mempunyai kadar serapan air yang lebih tinggi daripada gentian bersaiz halus kerana terdapat banyak kekosongan dan ruang diantara matrik dan gentian pada komposit tersebut.

DEDICATION

For all your guidance and support, this thesis is appreciatively dedicated to my family and my friends. Thank you very much for your continuous support and effort towards the publication of this thesis.

ACKNOWLEDGEMENT

Several people have contributed to this thesis. I would like to convey my thanks to the all person who had contributed in ensuring a successful occurrence throughout the duration of my final year project. I also greatfully acknowledge to my supervisor, Mr. Edeerozey Abd. Manaf and my examiner Mrs. Intan Sharhida Othman for their encouragement and support to provided me guidance and ideas for my project research. Their knowledge and experience actually motivated and drive me to complete my final year project succesfully. Also, my special thanks to Mohd. Jani Saad from FRIM for supplied kenaf fiber for my raw material of this thesis. Subsequently to Mohd Azhar Bin Abu Shah, Nazri Bin Mokte, Jaafar Bin Rajis and all technicians involved to complete this project. Finally, my truthful appreciation is dedicated to my mother and family and as well as the friends for their invaluable support during the process of this thesis.

TABLE OF CONTENTS

Abstract	iii
Abstrak	iv
Dedication	v
Acknowledgement	vi
Table of Contents	vii
List of Figure	xi
List of Table	xv
List of Abbreviations, Symbols, Specialized Nomenclature	xvi

1. INTRODUCTION 1

1.1 Background of the Study 1
1.2 Statement of the Purpose 2
1.3 Hypothesis 2
1.4 Problem Statement 2
1.5 Objectives 3
1.6 Scope of Study 4

2. LITERATURE REVIEW 5

2.1 Kenaf 5
2.1.1 Introduction to Kenaf 5
2.1.2 Kenaf Plant in Malaysia 6
2.1.3 Kenaf Growth Habits 6
2.1.4 Kenaf Bast 8

2.1.5 Uses of Kenaf 9
2.1.6 The Advantages and Disadvantages Natural Fiber Including Kenaf 10
2.2 Composite 11
2.2.1 Matrix 12
2.2.2 Reinforcement 12
2.2.3 Fiber Reinforced Composite 13
2.3 Thermosetting Plastic 13
2.3.1 Polyester 14
2.4 Catalyst MEKP 15
2.5 Mechanical Testing 16
2.5.1 Tensile Test for Tensile Strength 16
2.5.2 Impact Test 17
2.5.2.1Specimens for Charpy and Izod Testing 18
2.5.3 Flexural Test 19
2.5.4 Microstructure Observation 21
2.4.1 Scanning Electron Microscope (SEM) 21
2.6 The Previous Study on Kenaf Fiber Reinforced Composite 23

3. METHODOLOGY 24
3.1 Introduction 24
3.2 Kenaf Fiber Preparations 25
3.1.1 Kenaf Fiber Drying Process 27
3.2 Mould Preparation 28
3.3.1 Mould Designing 28
3.3.2 Mould Material Selection 29
3.3.3 Mould Fabrication 30
3.4 Kenaf Fiber Reinforced Composite Fabrication 31
3.4.1 Polyester Preparation 31
3.4.2 Hardener Preparation 32
3.4.3 Composite Preparation Process 32

3.5 Composite Panel Cutting Process 34
3.6 Number of Specimens 35
3.7 Final Specimen 36
3.7.1 Tensile Specimens of Kenaf Fiber Reinforced Composite 36
3.7.2 Flexural Specimens of Kenaf Bast Fiber Reinforced Composite 37
3.7.3 Impact Specimens of Kenaf Fiber Reinforced Composite 38
3.8 Testing Method 39
3.8.1 Tensile Testing 39
3.8.1.1 Procedures 39
3.8.2 Impact Testing 40
3.8.2.1 Procedures 40
3.8.3 Flexural Testing 43
3.8.3.1 Procedures 43
3.8.4 Water Absorption Test 44
3.8.5 Microscope Observation of Surface Topography of Kenaf Fiber 45

4. RESULT 46
4.1 Observation of Fiber Length 46
4.2 Mechanical Testing 48
4.2.1 Tensile Test 48
4.2.2 Flexural Test 50
4.2.3 Charpy Impact Test 53
4.3 Physical Testing 54
4.3.1 Water Absorption Test 54

5. DISCUSSION 57
5.1 Characteristic Influence the composite Properties 57
5.1.1 Fiber Length 57
5.1.2 Fiber Orientation 58
5.1.3 Fiber Phase 58

5.2 Challenges Faced During the Study 58
5.3 Data Analysis 62
5.3.1 Mechanical Testing 62
5.3.1.1 Tensile test 62
5.3.1.1.1 Observation of Tensile Fracture= 66
5.3.1.2 Flexural Test 70
5.3.1.3 Impact Test 73
5.3.2 Physical Testing 75
5.3.2.1 Water Absorption Test 75
6. CONCLUSION AND RECOMMENDATION 78
6.1 Conclusion 78
6.2 Recommendation 79

REFERENCES 80

APPENDIX A 83
APPENDIX B 84
APPENDIX C 85
APPENDIX D 86
.

LIST OF FIGURE

1.1	Kenaf Plant	1
1.2	Dried Kenaf	2
2.1	Parts of Kenaf Plant	9
2.2	Structure of MEKP	15
2.3	The Grip of Tensile Machine	17
2.4	Specimen Position for Charpy and Izod Impact Test	18
2.5	Impact Testing Machine	20
2.6	Specimen Position for Flexural Test	21
2.7	Scanning Electron Microscope	22
3.1	Main Stage of the Project	25
3.2	Kenaf Core Fiber (Fine	25
3.3	Kenaf Core Fiber (Coarse)	26
3.4	Kenaf Bast Fiber (Fine)	26
3.5	Kenaf Bast Fiber (Coarse)	26
3.6	Kenaf Drying Process	28
3.7	Mould from Top View	29
3.8	Mold Upper Plate, Main Mould and Lower Plate.	29
3.9	Laser Cutting Machine	31

3.10	Polyester resin	31
3.11	MEKP Catalyst	32
3.12	Polyester resin is weighted	33
3.13	Mixing process of kenaf fiber and polyester resin	33
3.14	Kenaf fiber and polyester resin lay at mould	34
3.15	Pressed of hydraulic cold press machine	34
3.16	Handsaw	35
3.17	Tensile specimens of kenaf bast fiber	36
3.18	Tensile specimens of kenaf core fiber	37
3.19	Flexural specimens of kenaf bast fiber	37
3.20	Flexural specimens of kenaf core fiber	38
3.21	Impact specimens of kenaf bast fiber	38
3.22	Impact specimens of kenaf core fiber	39
3.33	Universal Testing Machine	40
3.34	Impact Tester Machine	41
3.35	The Charpy Impact Jig	42
3.36	Notching Process	42
3.37	Three point bending process	44
3.38	Water absorption testing	44
3.39	Micrograph kenaf bast fine fiber	46

3.40	Micrograph kenaf bast coarse fiber	46
3.41	Micrograph kenaf core fine fiber	47
3.42	Micrograph kenaf core coarse fiber	47
4.1	Graph for Tensile Strength vs. Kenaf Fiber Size	49
4.2	Graph for Young's Modulus vs. Kenaf Fiber Size	50
4.3	Graph for Flexural Modulus vs. Kenaf Fiber Size	51
4.4	Graph for Flexural Strength vs. Kenaf Fiber Size	52
4.5	Graph for Impact Strength vs. Kenaf Fiber Size	54
4.6	Graph for Average of Weight Gain vs. Kenaf Fiber Size	56
5.1	Mixture not filling the mold	59
5.2	Inhomogeneous kenaf fiber reinforced polyester composite panel	60
5.3	Broken corner of the composite panel	60
5.4	Poor surface of the composite panel	61
5.5	Poor cutting of the tensile specimen	62
5.6	Graph for Maximum Force vs. Kenaf Fiber Size	62
5.7	Graph for Tensile Strength vs. Kenaf Fiber Size	64
5.8	Graph for Young's Modulus vs. Kenaf Fiber Size	65
5.9	Micrograph tensile fracture surface of kenaf bast fine fiber	67
5.10	Micrograph tensile fracture surface of kenaf bast coarse fiber	68
5.11	Micrograph tensile fracture surface of kenaf core fine fiber	69

5.12 Micrograph tensile fracture surface of kenaf core coarse fiber 70

5.13 Graph for Max Force vs. Kenaf Fiber Size 71

5.14 Graph for Flexural Strength vs. Kenaf Fiber Size 72

5.15 Graph for Flexural Modulus vs. Kenaf Fiber Size 72

5.16 Graph for Energy Absorb vs. Kenaf Fiber Size 74

5.17 Graph for Impact Strength vs. Kenaf Fiber Size 75

5.18 Graph for Weigh Gain Percentage vs. Kenaf Fiber Size 76

LIST OF TABLE

3.1	Number of specimens prepared	35
4.1	Data of Tensile Testing	48
4.2	Data of Flexural Testing	50
4.3	Data of Charpy Impact Testing	53
4.4	Data of Water Absorption Testing	54

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

UTM	-	Universal Testing Machine
Max	-	maximum
Min	-	minimum
^{0}C	-	degrees Celsius
%	-	Percent
SEM	-	Scanning Electron Microscope
FRIM	-	Forest Research Institute of Malaysia
MEKP	-	Methyl Ethyl Ketone Peroxide
G	-	Giga
M	-	Mega
Pa	-	Pascal
ASTM	-	American Standard Testing Material

CHAPTER 1
INTRODUCTION

1.1 Background of the Study

Combining kenaf fiber with other resources provides a strategy for producing advanced composite materials that take advantage of the properties of both types of resources. It allows the scientist to design materials based on end-use requirements within a framework of cost, availability, recyclability, energy use, and environmental considerations. Kenaf fiber is potentially outstanding reinforcing filler in thermosetting composites. Results indicate that kenaf fibers are a viable alternative to inorganic/mineral-based reinforcing fibers as long as the right processing conditions and aid are used, and for applications where the higher water absorption of the fiber composite is not critical. The objective will be to combine two or more materials in such a way that a synergism between the components results in a new material that is better than the individual components. One of the big new areas of development is in combining natural fibers with thermosetting. Since prices for plastics have risen sharply over the past few years adding a natural powder or fiber to plastics provides a cost reduction to the plastic industry (and in some cases increases performance as well). This study will continues the previous study about properties of kenaf fiber reinforced polyester composite. This study will focus on the properties of kenaf fiber reinforced polyester composite with the different kenaf size modification. The kenaf fiber reinforced polyester composite is fabricated by using compression molding method with the addition of 1% composition of MEKP catalyst hardener for the composite cure. The kenaf fiber is differentiating with two different sizes that is coarse and fine fiber. The different size of kenaf fiber is done by the disc milling

process and cut into several sizes by using drum chipping machine. The process is continuing by sieve the kenaf fiber to separate it into several size need. The testing involves for this study is tensile test, flexural test, impact test and water absorption test. The result of the kenaf fiber reinforced polyester composite testing will be discuss at the end of this study.

1.2 Statement of the Purpose

The purpose of this research is to study and analyzed the effect of fiber size modification on the mechanical properties of kenaf fiber reinforced polyester composite. The mechanical properties studied in this research are tensile, flexural and impact properties and the physical properties is water absorption test.

1.3 Hypotheses

i). The different fiber size of kenaf bast and kenaf core used for this study will affect the mechanical properties of the composite.

ii). The different composition of the kenaf fiber and the polyester used for this study will affect the mechanical properties of the composite.

iii). The different properties between core and bast fibers will affect the composite properties.

1.4 Problem Statements

The usage of the natural fiber in the polymer composite as the replacement of conventional fiber can reduce the production cost of the polymer composite product. Global environmental issues have led to a renewed interest in bio-based materials,

with the focus on renewable raw materials can be biodegradable or recyclable at reasonable cost (C.K. Hong et, al. 2007).

The problem faced by the researchers and manufacturers is to find the good natural fiber for polymer composite in the several factors such as mechanical properties and physical properties of the fiber. Kenaf fiber is a natural fiber thus has the potential to substitute fiberglass and other synthetic fibers that are currently used. Previous researches on kenaf have found that many good mechanical properties. The good properties of kenaf fiber include good specific strengths and modulus, economical viability, low density and low weight. However, there are not many research done to study the effect of the size and dimension of the fiber used in the natural fiber reinforced polymer composite. In this project, the effect of the fiber size on mechanical properties can affect the properties of the composite produced.

1.5 Objectives

The purpose of this study is:

a) To study the mechanical properties of different sizes of fibers in kenaf bast fiber reinforced polyester composite.

b) To study the mechanical properties of different sizes of fibers in kenaf core fiber reinforced polyester composite.

c) To compare the mechanical properties and the microstructures of different part of kenaf fiber reinforced polyester composite (kenaf core fiber and kenaf bast fiber).

d) To find the best composition of the kenaf fiber and the polymer matrix.

1.6 Scope of study

In this study, the fabrication process involved the cold press or compression molding process to produce the composites. Before fabricate the composite, the kenaf fiber must be process first to find the different size of kenaf fiber. Then, the mechanical tests and physical test are carried out on this composite. The tests that involved are impact test, tensile test, flexural test and water absorption test. The microstructure of this composite will be observed by using the Scanning Electron Microscope (SEM).

CHAPTER 2
LITERATURE REVIEW

2.1 Kenaf

2.1.1 Introduction to Kenaf

Kenaf or Hibiscus cannabinus is a species of Hibiscus that can be found in southern Asia. However, the kenaf natural origin is unknown. The fiber obtained from this plant also called as kenaf fiber. Kenaf fiber is similar with the jute fiber and the characteristic of this both fiber also almost same. The other names of kenaf are Bimli, Ambary, Ambari Hemp, Deccan Hemp, and Bimlipatum Jute. There are several colors of the kenaf flower, white, yellow, or purple.

Kenaf has a single, straight and branchless stalk. Kenaf stalk content an inner woody core and an outer fibrous bast around the core. The stems of the kenaf produce two types of fiber, bast and core. Bast is a coarser fiber in the outer layer. Kenaf core fiber is a finer fiber in the core. Kenaf plants mature in 100 to 1000 days. The traditional uses of kenaf fiber are in the manufacture of the rope, twine, coarse cloth, and the production of paper.

2.1.2 Kenaf Plant in Malaysia

In Malaysia, realizing the possibilities of commercially usable resulting products from kenaf, the National Kenaf Research and Development Program has been created to develop kenaf for possible new industrial crop in Malaysia. The government has allocated RM12 million for research and further development of the kenaf-based industry under the 9th Malaysia Plan (2006–2010) in recognition of kenaf as a commercially viable crop.

Kenaf started to be planted in Malaysia by Malaysian Agricultural Research and Development Institute (MARDI). Tobacco Board of Malaysia (LTN) has planted a lot of Kenaf trees in Kelantan and Terengganu. In Malaysia, kenaf grows quite quickly, rising to heights of 3.66m-4.27m (12-14 feet) in as little as 4 to 5 months. Other studies show that kenaf yields of 6 to 10 tons of dry fiber per acre per year are generally 3 to 5 times greater than the yield for pine trees which can take from 7 to 40 years to reach harvestable size. Upon harvest, the whole kenaf plant is processed in a mechanical fiber separator similar to a cotton gin.

2.1.3 Kenaf Growth Habits

Kenaf is a member of the mallow (Malvaceae) family, with okra and cotton as relatives. Kenaf plant can grow about 1.5 to 3.5 m tall with a woody base. The stems diameter is about 1-2 cm. The leaves of kenaf plant are 10-15 cm long with the variable shape. The diameter of the flowers is about 8-15 cm diameter. The stem's outer bark contains the long soft bast fibers which are useful for cordage and textiles. Bast fibers make up 20 to 25% of the stem on a dry weight basis. Beneath the bark, a thick cylinder of short woody fibers surrounds a narrow central core of soft pith. Stem color of most varieties is green, but there are several red-stemmed and purple-stemmed accessions. Leaf shape varies considerably. While the first few leaves of kenaf seedlings are not lobed, some varieties develop post-juvenile leaves that are very deeply lobed. The root system is very extensive, with a deep tap root and wide spreading lateral roots. Flower production is indeterminate. Kenaf is primarily self-