UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A Comparison of Mechanical Properties between Kenaf Core Fiber and Kenaf Bast Fiber Reinforced Polyester Composites

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

By

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ABSTRACT

The purpose of doing this project is to study the comparison of mechanical properties and microstructure between kenaf core fiber and kenaf bast fiber reinforced polyester composites. The matrix material used in this study was based on commercially available unsaturated polyester, obtained from university's Polymer Lab. The matrix was mixed with curing catalyst, methyl ethyl ketone peroxide (MEKP) Butanox M50 at a concentration of 0.01 w/w of the matrix for curing. Short kenaf bast and core fibers were separated from mixture bast and core fibers using vibratory screen machine in Wooden Composite Lab, for used as the reinforcement and were provided by Forest Research Institute of Malaysia (FRIM). A combination of hand lay-up and compression moulding method was used to prepare the kenaf fiber reinforce polyester composite specimens. Moist kenaf bast and core fiber was first dried at 80 °C for 1.5 hours to remove storage moisture in an oven and some of the kenaf bast fibers are left to moist in order to investigate the effect of the moisture fiber composite specimens to the mechanical properties. The mould was coated with a plastic, sprayed with silicone mould release agent and subsequently coated with gelcoat. After pouring the resin, trapped air was gently squeezed out using a roller. The kenaf fiber and polyester resin were then left for about 3 min to allow air bubbles to escape from the surface of the resin. The mould was closed and the composite panel was left to cure in a hydraulic press at a temperature of 25 °C and at a compaction pressure of 10 bars for 24 hours. After being taken out from the hydraulic press, the panel being removed from the mould and was left to fully dry at a temperature of 25 °C for 2 weeks. Subsequently, the panel composites were cut to

desired dimension of specimen follows the ASTM standard. The randomly oriented bast and core fiber 5% – 40 % fiber volume fraction and unfilled composite were used to prepare using similar procedure for comparison purpose. The sizes of bast and core fibers used were found that 39.41µm and 563.6 µm respectively using Scanning Electron Machine (SEM) from Zeiss, model EVO 50. The specimens were tested for tensile, flexural, impact and provide the result as totally the kenaf bast fiber indicates the higher strength, the exposure to moisture results in significant drops in tensile, flexural and impact properties due to the degradation of the fiber–matrix interface. The core fiber is found lead in high absorbent rate due their geometry structural after being water absorption test. SEM analysis for surface topography found that the clean surface of bast and non-uniform in term of fiber shape and size of core fiber.

ABSTRAK

Projek ini adalah bertujuan untuk mengkaji perbandingan sifat mekanikal dan mikrostruktur di antara gentian daripada kulit dan empulur pokok kenaf diperkuatkan dengan termoset poliester komposit. Matrik yang akan digunakan adalah matrik daripada jenis polimer termoset iaitu poliester yang diperolehi dari Makmal Polimer universiti. Termoset poliester dicampur dengan pemangkin metil etil keton peroksida (MEKP) *Butanox* M50 dengan nisbah berat satu bahagian daripada seratus berat poliester bagi tujuan proses pengerasan komposit. Gentian daripada kulit dan empulur kenaf telah dibekalkan oleh Institut Penyelidikan Perhutanan Malaysia (FRIM), Kepong, Kuala Lumpur setelah dipisahkan dengan menggunakan '*Vibratory Screen Machine*' di Makmal Komposit Kayu, FRIM. Gentian telah dikeringkan di dalam oven selama satu setengah jam pada suhu 80 °C manakala sebahagian gentian daripada kulit kenaf dibiarkan tanpa proses pengeringan bagi menguji kesan kelembapan gentian kepada sifat mekanikal berbanding gentian yang telah dikeringkan. Pengacuan terbuka telah dibuat daripada kepingan besi bergalvani bagi tujuan penghasilan spesimen setelah acuan daripada *acrylic*, keluli lembut didapati gagal menghasilkan spesimen yang dikehendaki. Bagi ujian mekanikal, piawaian yang dirujuk ialah ASTM D5083 bagi ujian tegangan, ASTM D790 bagi ujian kelenturan dan ASTM D256 bagi ujian hentaman jenis '*Charpy*'. Kombinasi di antara kaedah bengkalai tangan dan kaedah mampatan tuangan telah digunakan bagi menghasilkan spesimen komposit gentian daripada kulit dan empulur kenaf diperkuat termoset poliester. Komposit dimampatkan pada tekanan 10 Bar pada suhu bilik dan dibiarkan mengeras selama 24 jam. Setelah dikeluarkan

daripada acuan, panel komposit dibiarkan pada suhu bilik selama 2 minggu bagi memastikan komposit kering sepenuhnya sebelum dipotong mengikut dimensi ukuran piawaian ASTM. Prosedur yang sama telah dijalankan bagi menghasilkan komposit gentian daripada kulit dan empulur kenaf diperkuat poliester dengan pertambahan peratusan berat pengisi bagi kedua-dua gentian. Komposit yang dihasilkan adalah 5%, 10%, 20%, 30%, 40% berat pengisi gentian dan komposit tanpa pengisi. Berdasarkan eksperimen, peratusan maksimum berat gentian kenaf yang boleh diisi adalah sebanyak 40% berdasarkan sifat resapan cecair semulajadi bahan. Ujian mekanikal telah dijalankan dan mendapati gentian daripada kulit kenaf diperkuat poliester memberikan nilai kekuatan tegangan, kelenturan dan hentaman lebih tinggi. Komposisi terbaik bagi menghasilkan nilai kekuatan tertinggi untuk gentian daripada kulit kenaf adalah sekitar 10%-20% manakala gentian daripada empulur kenaf adalah sekitar 5%-20% berat pengisi. Kelembapan gentian didapati mengurangkan sifat mekanikal gentian. Analisis topografi menggunakan *Scanning Electron Microscope* (SEM) keluaran Syarikat Zeiss, model EVO 50 mendapati keadaan permukaan gentian daripada kulit kenaf yang lebih halus dengan purata diameter 39.41µm manakala gentian daripada empulur kenaf mempunyai permukaan agak kasar, berlubang-lubang dan mempunyai bentuk yang tidak seragam dengan purata diameter yang lebih besar iaitu 563.6 µm. Berdasarkan struktur geometri gentian daripada empulur kenaf, kadar resapan cecair didapati lebih tinggi berbanding gentian daripada kulit kenaf setelah ujian resapan air dijalankan..

CHAPTER 1

INTRODUCTION

1.1 Introduction to Kenaf

Kenaf or its scientific name Hibiscus cannabinus L is a warm season annual fiber crop closely related to cotton and jute. Historically, kenaf has been used as a cordage crop to produce twine, rope and sackcloth. Nowadays, there are various new applications for kenaf including paper products, building materials, absorbents and animal feeds. In Malaysia, realizing the diverse possibilities of commercially exploitable derived products from kenaf, the National Kenaf Research and Development Program has been formed in an effort to develop kenaf as a possible new industrial crop for 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 has a single, straight and branchless stalk. Kenaf stalk is made up of an inner woody core and an outer fibrous bark surrounding the core. The fiber derived from the outer fibrous bark is also known as bast fiber. Kenaf bast fiber has superior flexural strength combined with its excellent tensile strength that makes it the material of choice for a wide range of extruded, molded and non-woven products. Kenaf fiber could be utilized as reinforcement material for polymeric composites as an alternative to glass fiber.

Natural fibers such as kenaf have some advantages over traditional reinforcement materials such as glass fiber in terms of cost, density, renewability, recyclability, abrasiveness and biodegradability. The efficiency of the fiber-reinforced composites depends on the fiber matrix interface and the ability to transfer stress from the matrix to the fiber. The main obstacles in the use of natural fibers in plastics have been the poor compatibility between the fibers and the matrix and the inherent high moisture absorption which could result in dimensional changes of the fibers that may lead to micro cracking of the composite and degradation of mechanical properties. Various chemical treatments have been used to improve the mechanical performance of the natural fiber including jute and hemp by many researchers in the past.

(a) (b) (c)

Figure 1.1: Kenaf plantation

Nowadays, kenaf was started to plant so much in Malaysia. Malaysian Agricultural Research and Development Institute (MARDI) and Tobacco Board of Malaysia were plant a lot of Kenaf tree in Kelantan and Terengganu such as in Setiu, Kota Bharu, Pasir Mas, Tumpat, etc. The Figure 1.1 (a) shows the plantation of kenaf, (b) kenaf's flower and (c) kenaf stalk which consists core and bast fiber. The research officer from MARDI mentioned that the kenaf grows 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.

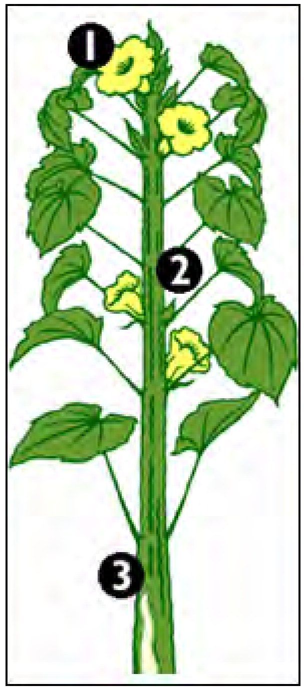


Figure 1.2: Kenaf stalks

From the Figure 1.2, no. 1 is shows the light yellow color of kenaf’s flower. The stalk of the kenaf plant consists of two distinct fiber types. The outer fiber is called bast and comprises roughly 40% of the stalk's dry weight. The refined bast fibers measure 2.6 mm and are similar to the best softwood fibers used to make paper as shown as no. 2 in the Figure 1.2 while the whiter, inner fiber is called core and comprises 60% of the stalk's dry weight as shown as no.3.

There are many advantages of using kenaf fiber. Because a technology of separating kenaf core and bast has been developed, there is a possibility of using the entire kenaf plant or its separated parts. The bast fibers offer the advantage of renewability and biodegradability that is essential for making environmentally friendly products. In addition, Kenaf production is less costly and less time consuming than other raw crops given that it produces a high yield with minimal use of chemicals.

The advantages of natural fibers over traditional reinforcing materials such as glass fibers and mica are acceptable specific strength properties, low cost, low density, high toughness, good thermal properties, reduced tool wear, reduced dermal and respiratory irritation, ease of separation, enhanced energy recovery and biodegradability. It has been demonstrated that wood fiber reinforced polypropylene (PP) composites have properties similar to traditional glass fiber reinforced PP composites.

Traditionally, bast and leaf fibers, especially jute, abaca, pineapple, and kenaf, have been used for products such as ropes, twine and burlap. But nowadays natural fiber reinforced polymers have become more prevalent in are used in the automotive and construction industry because natural fibers exhibit many advantageous properties such as low weight, low cost, low density, high specific properties and availability from renewable resources. It is shown that kenaf has become a potential natural fiber source for both apparel and industrial applications. Actually the research work to use kenaf for paper, forage, animal bedding and other a product began in the 1960’s and continues today.

1.2 Statement of the Purpose

The purpose of this research is to study and analyzed the mechanical properties such as tensile, flexural and impact properties and physical properties such as water absorption test between the kenaf core fiber and kenaf bast fiber reinforced polyester composites.

1.3 Hypotheses

i). The use of different part of kenaf fibers i.e. core and bast fiber as reinforcement will affect the mechanical properties of the composite.

ii). Varying the volume fraction of kenaf core and bast (5% - 40%) will affect of the mechanical properties kenaf fiber reinforced polyester composites.

1.4 Problem Statements

The use of natural plant fibers as reinforcement in polymer composites for making low cost engineering materials has generated much interest in recent years. New environmental legislation as well as consumer pressure has forced manufacturing industries (particularly automotive, construction and packaging) to search for new materials that can substitute for conventional non-renewable reinforcing materials such as glass fiber. The advantages of natural plant fibers over traditional glass fibers are acceptable as good specific strengths and modulus, economical viability, low density, low weight, reduced tool wear, enhanced energy recovery, and reduced dermal and respiratory irritation, good biodegradability and availability from renewable resources. Natural plant fiber reinforced polymeric composites; also have some disadvantages such as the incompatibility between the hydrophilic natural fibers and hydrophobic thermoplastic and thermoset matrices requiring appropriate use of physical and chemical treatments to enhance the adhesion between fiber and the matrix.

Kenaf or its scientific name Hibiscus cannabinus L is a warm season annual fiber crop and has started to plant widely in Malaysia. Kenaf are the only commercial sources of long natural fibers grown in the Malaysia Plant stems are processed by various mechanical methods to extract the fiber. Fibers from kenaf stems have been widely used in the production of cords and clothing and have potential for reinforcement in polymer–

matrix composites (PMCs). Recently, car manufacturers such Bavaria Motor Works (BMW) have started manufacturing non-structural components using kenaf fibers such for foot paddle in 5 series model due to their higher specific strength and lower price compared to conventional reinforcements.

Studies on the mechanical properties of unsaturated polyester composites reinforced with other natural fibers such as sisal and jute have been done. Kenaf fiber consists of two different fiber types i.e. bast and core with different properties. In this project, core and bast fiber of kenaf will be used as reinforcement to fabricate polyester composites and their mechanical properties will be compared and studied.

1.5 Objectives

The purpose of this project is:

i) To study the mechanical properties of the kenaf bast fiber reinforced polyester composites.

ii) To study the mechanical properties of the kenaf core fiber reinforced polyester composites.

iii) To study and analyze the difference in term of mechanical properties and microstructure between kenaf core fiber and bast fiber reinforced polyester composites.

iv) To study the effect between the moisture fiber to the mechanical properties of composites.

v) To find the best formulation of matrix and fiber.

1.6 Scope of study

The composites are fabricated using cold press molding technique. Tensile, flexural and impact tests were carried out to determine the mechanical properties of the composites. Water absorption test was carried out to determine the physical properties of the composites. Their microstructures were observed using SEM.

CHAPTER 2

LITERATURE REVIEW

2.1 Kenaf

2.1.1 Plant Component Partitioning and Composition

Yield component research with five kenaf cultivars in Oklahoma over a two year period produced plants at harvest which averaged 26% leaves and 74% stalks by weight. In the same research the kenaf stalk's average composition was 35% bark and 65% woody core by weight as shown in Figure 2.1 (a). The outer of the kenaf stalk contains the long fiber strands as shown in Figure 2.1 (b) that are composed of many individual smaller fibers, normally called bast fibers. These individual bast fibers, held together by lignin, are the building blocks of the bast fiber strands, which historically were used to make the cordage products. The woody core material of the stalk as shown in Figure 2.1 (c), the portion remaining when the bast is removed, contains core fiber. The individual bast fibers are longer and thinner than the individual shorter, thicker core fibers. Whole stalk kenaf that is bast and core fibers has been identified as a promising fiber source for paper pulp. The bast and core kenaf fibers can be pulped together or separated and pulped individually depending on the pulping process and the paper pulp to be produced.

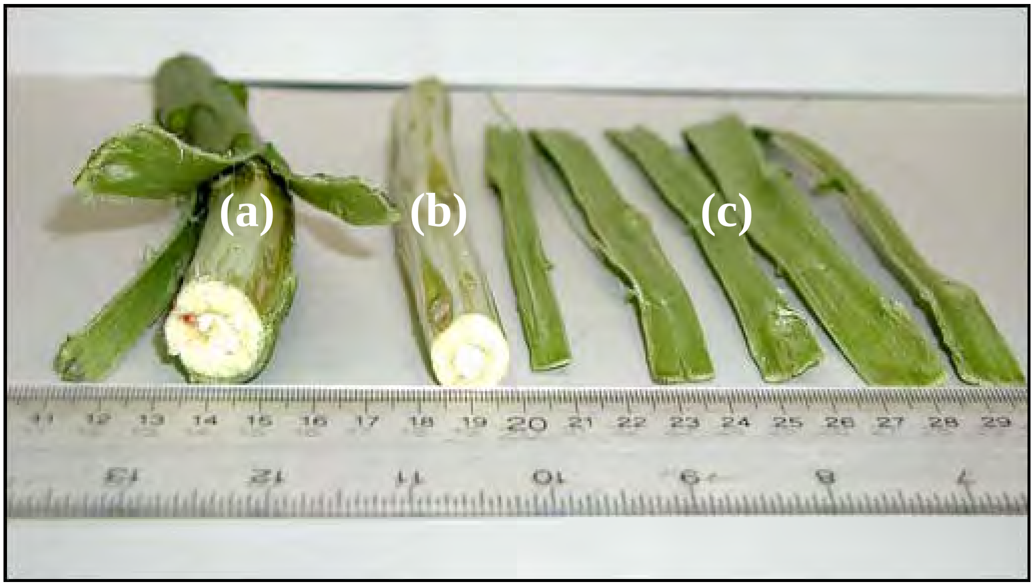


Figure 2.1: Kenaf stalk with bast and core material.

2.1.1.1 Whole Stalk

Whole stalk kenaf can be pulped by kraft, soda, neutral sulfite, sulfate, mechanical, chemimechanical, thermomechanical, and chemithermomechanical processes. Whole stalk kenaf pulps have been processed into high quality bond, surface sized, coated raw stock, and newsprint papers. Commercial presses have printed on kenaf paper using letterpress, offset, rotogravure, flexograph and intaglio techniques. The combined bast and core bleached fiber yield from chemical pulping is about 46% by weight.

Whole stalk kenaf can also be used in corrugated medium. The whole stalk plant material can also be used in non pulping products such as building materials such as particleboard and within injection molded and extruded plastics. Unlike the pulping process with whole stalk plant material which yields fewer than 46% by weight, the use of non pulped whole stalk material yields nearly 100% usable materials. The difference is the result of the intentional removal of non fibrous materials such as lignins and sugars during the pulping process, whereas the removal of these intercellular materials is not required for the non pulped products.

2.1.1.2 Bast Fiber

When bast material is mechanically pull out from the core as shown in the Figure 2.1, it was chemically pulped without the core, it produced a 57% yield of bast fiber as mention earlier. On a whole stalk dry weight basis, the bast comprises 17.4% to 28.6%. The individual bast fibers are up to 5.0 mm long averaging 2.6 mm in length and 20 mm in width. Chemical bast pulp is well suited for specialty papers, such as high quality stationery or filter paper. Bast pulp, compared to softwood pulp, has a similar tensile strength, but greater tear strength and bulk fiber, thus it could serve as a replacement for softwood pulp. Pulping kenaf bast and core fibers can benefit the environment because the process requires fewer chemicals and less energy compared to standard pulping processes for wood fibers.

The kenaf fibers can also serve as a virgin fiber for increasing recycled paper quality and paper strength. Although the kenaf bast fiber strands were once only considered for use as a cordage fiber in such products as rope, twine, carpet backing and burlap. A variety of additional uses has developed for the bast fiber strands as shown in Figure 2.2. These include use in automobile dashboards, carpet padding, corrugated medium as a substitute for fiberglass and other synthetic fibers, textiles and as fibers for injection molded and extruded plastics. Kenaf bast fiber strands are presently in commercial use in other environmentally friendly products such as fiber lawn mats impregnated with grass seed and spray on soil mulches for use along highway rights of way or construction sites to prevent soil erosion from water and wind.

Figure 2.2: Bast fiber material; (a) Kenaf bast fiber strands while fiber strands after harvesting with a forage chopper, (b) retted combed fiber strands and (c) fiber strands compressed into a square cube.

2.1.1.3 Core Fiber

Chemical pulping of the woody core will yield about 41% core fiber from the original woody portion of a kenaf stalk as shown in the Figure 2.3. The core fibers make up from 20% to 40% of the entire stalk by weight. The average length of the core fibers range from 0.49 to 0.78 mm long with average length of 0.6 mm and an average diameter of 37.4 mm. The core pulp, compared to hardwood pulps, has lower tear strength but greater tensile and burst strength. Due to the high absorbency of the woody core material, researchers have investigated the use of kenaf as an absorbent, as a poultry litter and animal bedding, as a bulking agent form sewage sludge composting and as a potting soil amendment. In addition to the above core products, which are all now available in the market place, several kenaf core products are available which are successfully used for toxic waste cleanup, oil spills on water and the remediation of chemically contaminated soils.

Figure 2.3: Core fiber material; (a) small, (b) medium, (c) large and (d) compresses into a square cube.

2.1.2 Uses of Kenaf

2.1.2.1 Traditional Use of Kenaf

Kenaf has been cultivated in Egypt since around 4000 B.C. China also has actively developed this plant and now is one of the largest kenaf producers in the world. Kenaf has been used for thousands of years mainly to make cordage, rope, burlap cloth and fish net due to its rot and mildew resistance. Today, one of the major values of kenaf is used on a limited scale to produce pulp and paper in some countries as the substitute for wood. Kenaf offers many significant advantages in this application, including a short harvestable period and no chlorine bleaching. Kenaf paper is stronger, whiter, longer lasting, more resistant to yellowing, and it has better ink adherence than tree paper.

2.1.2.2 Value Added Produces from Kenaf

The stock of kenaf can be used almost entirely. Kenaf leaves and stems have a potential as livestock feed. Dried leaves contain 30% crude protein and are used as vegetables in some part of the world. In recent years, with increasing concerns for environmental protection, kenaf has found more applications. The breakthroughs and advances in environmental technology have resulted from intensive testing and research in the kenaf industry. Here are some examples:

i) Kenaf Fiber/Plastic Compounds

Kenaf fiber/plastic compounds based on kenaf can replace glass reinforced plastics in many applications such as automotive industry, packaging and construction or housing. The compounds have the mechanical and strength characteristics of glass filled plastics but are less expensive and in many instances are completely recyclable.

ii) The Automotive Industry

The 1996 Ford Mondeo which sold abroad features interior automobile panels made of kenaf fiber. Kenaf international supplies the fiber, which is processed by the supplier to Ford. The company expects that sales to European automobile manufacturers will steadily increase as the industry becomes comfortable with the product and the kenaf products from automotive group are capable of meeting required demand.

iii) Construction and Housing Industry

Kenaf/plastic compounds molded into lightweight panels can replace wood and wood based products in many applications. This product has the potential to be the first economically priced plastic lumber that can be engineered for use as building materials in housing industry. In some cases, emphasis has centered in the utilization of core of the plant. Kenaf core has been used as packaging material, animal bedding, oil absorbents and poultry litter.

iv) Food Packaging Industry

Pellets made from a kenaf/plastic compound can be molded into commercial food storage containers and virtually any other product now made of plastic. Non food related packaging opportunities are also numerous including bulk chemical and pharmaceutical packaging, parts packaging in the electrical and electronics industries and disposable packaging for large consumer appliances. In every instance, fiber composites have distinct technical and pricing advantages over plywood and cardboard and are recyclable as well.

v) Oil & Chemical Absorbents

The core is very absorbent and one of its main uses is to clean up oil spills and similar chemicals. One unique feature of Kenaf absorb is that it absorbs oil before taking on water once oil is absorbed; the product floats on the surface, which makes collection easier. This product is also non toxic, non abrasive and is more effective than traditional remediants like clay and silica. This product is distributed for use in oil fields but the product also absorbs gasoline, diesel, transmission fluid and coolant spills. In addition to use by individuals for personal garages, bulk applications include clean up operations in refineries, utility companies, land and sea spills, oil rigs, industries that handle bulk storage terminals and for military field refueling applications.

vi) Animal Bedding and Poultry Litter

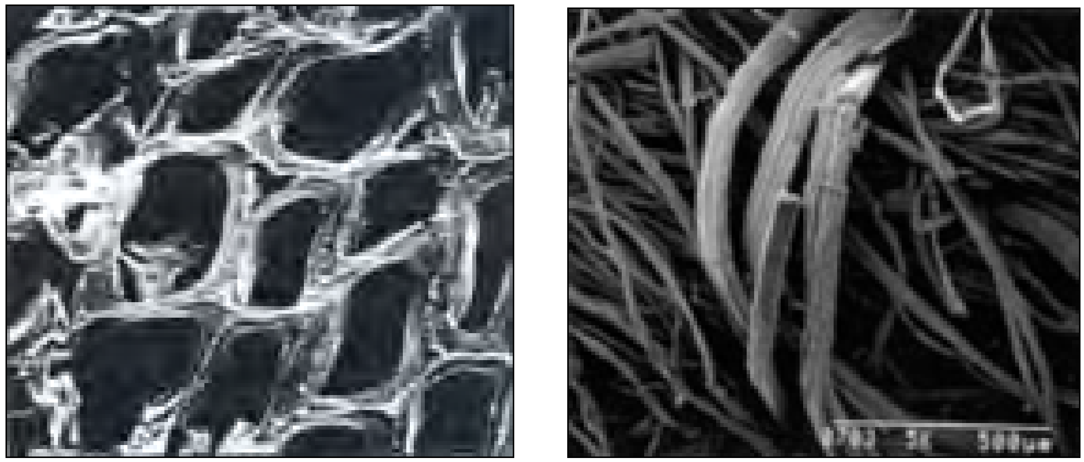
Kenaf bedding is sold in bags to farm and ranch supply stores and in bulk to large buyers such as stables, zoos and poultry farms. This product has superior absorbency, requires fewer changes, is cost competitive with most traditional litter and bedding products comprised of wood shavings, saw dust or shredded paper.

vii) Soil free Potting Mix

This product competes with commercial potting soils and can also be custom mixed for different horticultural applications. Kenaf has a long term supply arrangement with a nursery products wholesale business. The products are blended and mix with peat moss, compete with commercial mixes containing mostly peat moss or pine bark.

2.1.3 General Properties of Kenaf Fibers

Raw kenaf fiber obtained from outer bark is actually a bundle of lignocellulosic fibers. The fiber bundle size depends on the number of ultimate cells in each bundle. Most lignin is present between the ultimate cells. Kenaf contains approximately 65.7% cellulose, 21.6% lignin and pectin and other composition. Lignin must be extracted to separate the fibers. The physical dimensions of the fiber are one of the most important factors in apparel industry. Kenaf single fibers are only about 1-7 mm long and about 10-30 microns wide thus too short for textile processing. A specific average length is not used because of the wide variability in the samples studied. Figure 2.4 shows the photomicrographs of an individual kenaf fiber and fiber bundle. The measurement of single fiber dimension can be achieved by various methods. A large part of these differences is probably due to such factors as cultivars, location and climate, besides the differences in the techniques used for analyses. In addition, fiber characteristics are also probably dependent on the maturity of the plant. The most economical process is projection the image from a microscope on a wall or on a board, so the fiber dimension can be measured manually or by a digitizer. By using an electronic indicator, digitizing can be achieved by identifying both ends of the fiber.



(a) Kenaf fiber cross section 3000 X (b) Kenaf fiber bundles 500 X

Figure 2.4 Kenaf Fiber Images [9]

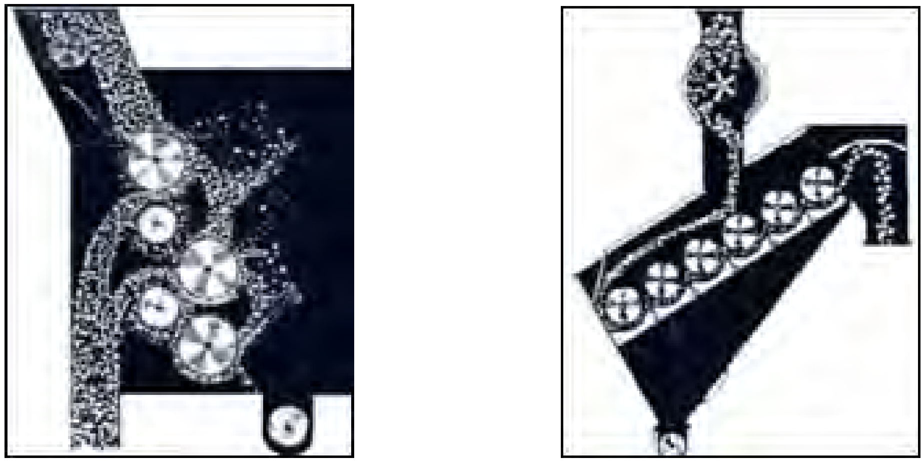
Kenaf fiber image the cellular structure of kenaf can be separated using dissociation method. Generally speaking, the lengths kenaf fibers are shorter at the bottom of the stalk and longer at the top. The increase in length from the bottom to the top was not gradual but S shaped. There is more variation of the fiber length at the top of the stalk. Also, the longest fibers are located at the top. On the other hand, different parts of a plant have different mechanical properties. That is the chemical composition and fiber properties of plant tissue taken from the root, stem, trunk and leaves are different. And the mechanical properties of plant tissue are also different at different stages of the growing season. Fiber length increased in the early part of the growing cycle and then decreased again as the plant matured. This may be an advantage in harvesting fiber at some time earlier than from a mature plant.

2.1.4 Separation of Kenaf Fibers

The process of separating the long and short fibers depends on the method of harvesting. In frost free regions, the kenaf stalk is cut while green with special equipment. In cooler regions, the plant is typically frost killed and a natural drying of the stalk occurs, making harvesting with conventional farm equipment possible. The separation equipment is designed to accommodate the raw material in either whole stalk or chopped.

2.1.4.1 Mechanical Separation Method

There are many methods to separate the kenaf fibers. Mechanical separation of fiber is a quite economical way. The bast kenaf fibers that separated most of the core material are feed to the Rando Cleaner, a roller type cleaner equipped with fine saw tooth wire. There are two kinds of Rando cleaner, stick machine and trash master. Standard stick machine equipped with three 355.6 mm diameter saws with and without Pelxiglas. The trash master is a six cylinder incline cleaner with 12.7 mm space between grid bars and the degree of incline may be different, for example, 30° or 45°. Figure 2.5 shows that the standard of stick machine and 30 ° trash master. In order to get the cleanest fiber, it is necessary to process the bast fibers through both stick machine and trash master that equipped with different saws and incline degree.



(a) (b)

Figure 2.5: Schematic of Stick Machine (a) and Trash Master (b)

In the procedure of separating kenaf into its two fractions, moisture content is a significant predictor of final fiber content, in this case, moisture content of whole stalk kenaf and humidity of ambient air need to be tested carefully. The Figure 2.5 shows the schematic of Stick Machine and Trash Master separation machinery should also be considered. The separation efficiency and processing rate are two important parameters to consider. By using drying or separation during periods of low ambient humidity separation efficiencies of 95% to greater than 99% can be obtained. Whole stalk kenaf above the moisture content of about 18-20% is difficult to separate. Separation efficiency is low when the ambient humidity is above 60% and must be accomplished with the aid of drying. The stick machine is more efficient at fiber and core separation than the 6 cylinder cleaner. The slower process rate can also increase separation efficiency.

2.1.4.2 Water Retting Method

It is a wet process by which the bundles of cells in the outer layers of the stalk are separated from nonfibrous matter by the removal of pectins and other gummy substances.The available retting processes are mechanical retting means by hammering, chemical retting (boiling & applying chemicals), steam or vapor retting, and water or microbial retting. Among them, the water or microbial retting is a century old but the most popular process in extracting fine bast fibers. However, selection of these retting processes depends on the availability of water and the cost of retting process.

To extract fine fibers from kenaf plant, a small stalk is harvested for pre-retting. Usually, this small stalk is brought before 2 weeks of harvesting time. The fiber can easily be removed from the kenaf core and tied into bundles and submerged in soft running water. The stalk stays submerged in water for 20 days. However, the retting process may require less time if the quality of the fiber is better. In most cases, the fiber extraction process of bast fibers in water retting is done by the farmers while standing under water as shown in Figure 2.6 (b).

The other most popular method process in extracting fine bast fibers is mechanical retting. The fiber is pulling out the fiber from the hurd or core as shown in Figure 2.6 (a), then hitting with wooden hammer and washing with water as shown in Figure 2.6 (b) and lastly squeezing out the water and stocking as shown in Figure 2.6 (c).

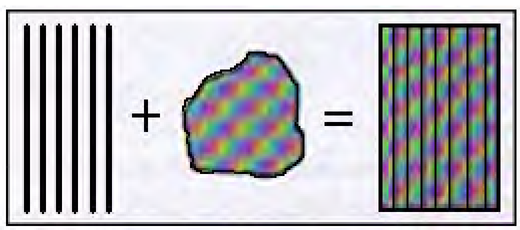
(a) (b) (c)

Figure 2.6: Water retting process

2.2 Composite

2.2.1 Introduction

A composite material is made by combining two or more materials or gives a unique combination of properties. The above definition is more general and can include meals alloys, plastic copolymer, minerals and wood. The main concept of a composite is that it contains matrix materials. Typically, composite material is formed by reinforcing fibers in a matrix resin as shown in Figure 2.7. The reinforcing fibers are found in different forms, from long continuous fibers to short chopped fibers as shown in the Figure 2.8. Each configuration results in different properties. The properties strongly depend on the way the fibers are laid in the composites. All the detail explanation that may influence the properties of the composites will be discussed in this project.



Fibers + Resin = Composites

Figure 2.7: Formation of a composite material using fibers and resin.

(a) **(c)**

Figure 2.8: (a) Continuous fiber composites and (b) short fiber composites

2.2.2 Matrix

2.2.2.1 Types of Matrix Resin

The common matrix used for fiber reinforced plastic/thermoset composite process such as Epoxy, Unsaturated Polyester (UP), Vinylester, Urea Formaldehyde, Urethanes, Melamine, Phenolics, etc. In this experiment require to use polyester thermosetting as the matrix. Roughly description of resin compound is given which may assist in understanding of resin used for reinforcement.

2.2.2.2 Matrix Characteristics

One definition of resin is any class of solid, semi solid or liquid organic material which generally the product of natural or synthetic origin with high molecular weight and with no melting point. The 10 basic thermosetting resins all have able to expose to the elevated temperature bottommost to attaining of 232.22 ºC or 450 ºF. It has family members which each member has its own set of individual chemical and based upon their molecular makeup and their ability to either homopolymerize, copolymerize or both. The other significant beneficial factor here to consider is their characteristic is their physical, thermal and chemical properties cross linking polymerization reaction which contributes to their ability to maintain and retain the properties when exposed to environmental conditions. Thermoset material once cured cannot be remelted or reformed. During crosslinking, they form three dimensional molecular chains, called cross linking as shown in the Figure 2.9. Due to these crosslinking, the molecules are not flexible and cannot be remelted and reshaped. The higher the number of crosslinkings, the more rigid and thermally stable the material will be.

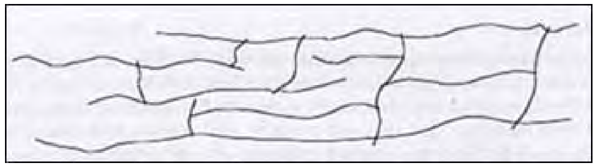


Figure 2.9: Crosslinking of thermoset molecules during curing.

2.2.3 Reinforcement

2.2.3.1 Types of Fiber Reinforcement

As generally, there are two examples of fiber which can be differentiate roughly. The most popular of fiber reinforcement used for fiber reinforced plastic/thermoset composite processes which have been utilized for a long time in industry is called synthetic fiber such as Glass, Carbon, Aramid fiber, etc. While the fiber reinforcing which start capturing the attention of industries in recent years is fiber based agricultural. It means natural fiber such as Hemp, Kenaf, Sisal, Banana, Jute, Pineapple Fiber, etc.

2.2.4 Manufacturing Techniques

When manufacturing composites, manufacturing related issues to consider in design are related to three major consideration factors.

i) Requirements due to component performance specifications
ii) Requirements on manufacturing technique imposed by raw material
iii) Requirements on manufacturing technique imposed by geometry