EXPERIMENTAL INVESTIGATION OF THERMAL PROPERTIES OF KENAF COMPOSITE

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SUPERVISOR'S DECLARATION

I declare that this project report entitled "Experimental Investigation Of Thermal Performance Of Kenaf Composite" is the result of my own work except as cited in the references.

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluids).

Signature :. .....

Name of Supervisor : .....

Date : .....

DEDICATION

My mother and father is the one who brings out the best of me.

To my beloved friends and all my lectures, thank you.

ABSTRACT

A composition material, also called as composite material is a material that is made from a combination of two or more materials at different physical characteristic, to produce a material at the new traits. Kenaf composite has been study in this research. The thermal conductivity of the kenaf composite was studied depth with the various composition of kenaf fibre and the polypropylene is act as the resin. It was found that the thermal conductivity of the kenaf composite decrease as the kenaf fibre composition increase in the composite. The infrared lamp was used to supply heat constantly to the composite. By using the equation of thermal conductivity, the thermal conductivity was calculated and the data is tabulated in this study.

ABSTRAK

Bahan komposisi, juga dikenali sebagai bahan komposit adalah bahan yang diperbuat daripada gabungan dua atau lebih bahan-bahan pada ciri-ciri fizikal yang berbeza, untuk menghasilkan bahan yang pada ciri-ciri baru. Kenaf komposit telah kajian dalam kajian ini. Kekonduksian terma komposit kenaf telah dikaji mendalam dengan komposisi pelbagai serat kenaf dan polipropilena adalah bertindak sebagai resin. Ia telah mendapati bahawa kekonduksian terma penurunan komposit kenaf peningkatan serat komposisi kenaf dalam rencam. Lampu inframerah digunakan untuk membekalkan haba sentiasa untuk rencam. Dengan menggunakan persamaan kekonduksian haba, kekonduksian haba telah dikira dan data yang dibentangkan dalam kajian ini.

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LIST OF ABBEREVATIONS

PP	Polypropylene

LIST OF SYMBOL

k	=	Thermal conductivity
m	=	Mass
Q	=	Heat flow (Power supply)
A	=	Area
ρ	=	Density
T	=	Temperature
ΔT	=	Temperature difference
L	=	Thickness
t	=	Time

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Composite is known as combine materials between a natural composite, consisting of one species of a polymer which is cellulose fibers with resin like polypropylene. A composite can improve utilization of their excellencies and minimizing some degree that effects of their deficiencies. The example of fibers that used in the composite are carbon, glass and sometimes the presence of wood or natural fibers. The polymer that are usually epoxy, phenol formaldehyde, vinylester or polyester thermosetting plastic resins. Most of composites are strong because of the rigid fibers in a matrix form. Manufactured strands (synthetic fiber) like glass fiber, nylon, carbon fiber and so forth are thought to be potential filler material for different applications like wear safe and basic parts. Glass fiber strengthened polymer framework composites are imperative building materials, basically on account of their low thickness in mix with amazing particular firmness and quality. This engineered fiber is observed to be potential filler for enhancing protection ability of different polymers on account of its low warm conductivity. Be that as it may, these manufactured fibers strengthened polymer composite have a few impediments like they are destructive and dangerous in nature, higher cost and non-biodegradable.

Kenaf, *Hibiscus Cannabinus L*. is a one of the faster crops to yield per year and can be used as the natural composite. Component parts in kenaf are bast fiber, leaves. Each of the component is used in the industry nowadays. The core of kenaf can be used as soil amendments, oil absorbents in chemical industry and as animal beddings. The fiber is the source in the cottage industry too trough out the world (Agbaje et al. 2008). The components of this plant contained two different type of fibers. The first one is; it has a long fiber strands which are composed by individual of smaller bast fibers. the second one is the whole trunk kenaf, that were used to produce paper, ropes, twine, burlap fiberboard and coarse (Hossain et al. 2011)**.** There are different in tensile strength between the core fiber and the bast fiber. Kenaf bast fibers have higher tensile strength between the kenaf core fiber. it was proved by Ishak et al. (2010) in his study where the tensile strength of bast fibers 20Mpa, which is higher than core fibers that is 16MPa. Kenaf is a mechanical yield with high potential for development in a tropical atmosphere. Various innovations and skill among scientists have been created to upgrade kenaf generation in Malaysia. Oil palm, rice, rubber, coconut and mixed horticulture are the major crops planted in Malaysia. As the third largest exporter of lumber industry in the world, there was about 76.3% of forest that covered the land in Malaysia and the percentage decrease gradually to 62% in 2009 due to high demand for lumber, causing the rate of deforestation increased (Hadi et al. 2014).

1.2 PROBLEM STATEMENT

Malaysia is known as equator climate and has average 2500 millimetre (calculated from November to February). This climate results in the room

temperatures, especially in the office, building and houses to increase. The air conditioning and the air ventilation system are used to cool down the room or building temperature in some building such as government office or classroom. However, there is also another because that effect the temperature alone, which is the ceiling tiles that was applied in the room. Noticed that the ceiling in the major office is a fiberglass type ceiling and has low thermal conductivity. This allowing the heat to be transferred easily into the building and reheat the room temperature.

1.3 OBJECTIVE

The objective of the project as this follow:

a) To study the thermal properties of different ratio of fibers/polypropylene.
b) To obtain thermal properties of kenaf composite.
c) To provide a complete analysis of thermal conductivity of kenaf composite

1.4 SCOPE OF PROJECT

The scope of this project are:

a) Only results of analysis and thermal performance of kenaf composite are presented in this report.
b) Determination of thermal conductivity by experimental method.
c) Fabrication of kenaf composite involved the hot-pressing technique.
d) Carry out the thermal properties analysis.

1.5 GENERAL METHODOLOGY

The actions that is need to be carried out to achieve the objectives in this project are listed below.

1) Literature review

   Journals, articles, books, or any other resources regarding the project will be reviewed.

2) Inspection

   The ceiling of the office in the building will be inspected and identify the material used to for the ceiling.

3) Preparation

   Preparing apparatus and materials that is needed to conduct the experiment.

4) Analysis

   Analysis will be presented about the thermal conductivity of the kenaf composite and the result will be discussing and compared with the ceiling based on the analysis.

5) Report writing.

   A report on this study will be written at the end of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Kenaf

Kenaf (*Hibiscus cannabinus L.*) is a warm season woody-herbaceous plant from *Malvaceae* family. It is an important short-day annual plant with fast growing and straight, single and branchless stem. It will produce branches if grown under wider arrangement. Kenaf has a resemblance with okra (*Hibiscus esculentus*), cotton (*Gosypium hirsutum L.*), hollyhock (*Althaea rosea*), and hibiscus (*Hibiscus hibiscum L.*) (Charles et al. 2002).

Table 2.1-a: Scientific information of kenaf (Source: Author)

Kingdom	Plantae (Planta, plants)
Division	Magnoliophyta (angiosperms, flowering plants, angiospermes)
Class	Magnoliopsida (dicots, dicotyledons)
Other	Malvales
Family	Malcaveae (mallows)
Genus	Hibiscus (hibuscus, rose mallow)
Species	cannabinus (brown Indian hemp)

The origin of kenaf was reported from Africa (North Africa, east Africa) and has been grown for food and fiber to produce rope, twine, and sackcloth. Kenaf is grown anually but it can become perpetual under a certain environments. It has a high potential in terms of lignocellulosic material or fiber and a fast growing plant. In a

three months, the growth of kenaf can achieve to three meters even it was plant in moderate ambiet conditions, with a stem diameter of 25mm to 51mm. It is also can growth to five – six meters if plant under good conditions in six to eight months. Most of kenaf colors are in green but it was reported there are several purple and red stemmed accessions (Aji et al. 2009).

The stem consists of three layers which phloem (an outer cortical tissue layer-bark), xylem (an inner woody tissue layer-core), and a thin central pith layer that has sponge-like tissue with mostly non-ferrous cells and it is a dicotyledonous plant. The bark and core can be differentiate by their chemical composition, structural characteristics and chemo-physical properties. For example, the core lignin is different from the bark lignin in content and chemical structure, the core is the main tissue of the stem and has larger cross-sectional area compared with the bark. The core or inner fiber together with the pith covers 60% of the stem's dry weight while the bark portion covers around 40% of the stem's dry weight.

Fibers from the core are about 0.6mm long and resemble hardwood fibers while from the bark portion of the stem are about 2.5 m long. The bark have higher compositions in α-cellulose, ash content and extractive while the core are higher in holo-cellulose and lignin (Abdul Khalil et al. 2010). There is difference in the quality of core and bark fibers. The core that rich in lignin produce a pulp with poor strength properties as the cross-linking characteristics of the lignin macromolecule and three-dimensional structure causing in poor initial fiber bonding and collapse (Mossello et al. 2010).

Kenaf plant has a relatively deep, wide-raging lateral root system and a long effective taproot system, making the plant drought tolerant (Nasreen et al. 2014). The

kenaf's leaf can be mistaken for the illegal weed because it looks like marijuana (Cannabis sativa) and looks like cotton and okra (Stricker et al. 2006). Kenaf plant maturity influencing the composition and quality of plant components, as well as total biomass harvested. As the age and height of kenaf plant increase, the crude protein percent and leaf biomass percentage decreased. Kenaf cultivars influenced by the growing season, adequate soil moisture, and the average day and night temperatures (Webber & Bledsoe 2002).

Kenaf yields been highest in area with abundant soil moisture, high temperature and a long term growing season. The kenaf plant is held to have larger range of adaptation to soils and climates than any other fiber plant in viable production. As stated by LeMahieu et al. (n.d.), diversity development for acceptance to soil temperature and cool air can expand kenaf's region of productive adaptation. Kenaf cultivation recommended to have higher than 12.5 hours of daytime to avoid reduction in growth related with flowering and fruit development. Kenaf is suitable grown in 45°N to 30°N that are located a warm temperature zone to the equator with a maximum elevation of around 500 meter (El Bassam, 2010).

According to Blackburn (2005), although kenaf can grow effectively in a varied range of soils, from sandy desert soils to high organic turf soils, it grows best on fertile soils at neutral pH, well-drained. It can withstand at low soil fertility and flooding season. However, it does not do well in prolonged stages of standing water and severe drainage problems (LeMahieu et al., n.d.).

2.1.1 History of kenaf

Kenaf was introduced to China in 1935 by Russia as Russia has started producing it in 1902. During World War II, kenaf production and research has begun in the United States as it purposes to supply cordage material for the war. Kenaf was an excellent basis of cellulose fibers for a huge range of paper goods such as bond paper, newsprint and corrugated liner board (LeMahieu et al. n.d.). As stated by Abdul Khalil et al. (2010), the interest in kenaf has increased for its potential use as a commercial fiber crop due to the good fiber quality and fast growth for the manufacture of paper goods and other pulp.

Even though kenaf initiated from Africa, its production is very low. As stated in table 2.1-b, in 2007/08, the production of kenaf by Africa was only $11.2e10^3$ tonnes, which is 4,19% of the total global production. More than 20 countries have commercially cultivated kenaf production and mainly in India and China (International Jute Study Group 2012).

Table 2.1-b: Global word production of kenaf (International Jute Study Group 2012)

Country	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
China	86.8	84.3	75.2	75.2	78.0	78.0
India	139.7	120.0	131.2	140.0	140.0	120.0
Indonesia	4.7	4.1	3.8	4.0	4.0	4.0
Thailand	2.2	2.9	2.0	1.7	1.7	1.3
Vietnam	25.7	7.8	12.1	5.0	3.2	6.0
Cambodia	0.3	0.3	0.5	0.3	0.4	0.4
Africa	11.2	11.2	10.3	11.8	13.4	13.4

2.1.2 Kenaf plant in Malaysia

In Malaysia, the National Kenaf Research and Development Program has been formed as they realise there are the potentials of commercially practical resulting products from kenaf. It purposed to develop and introduce kenaf as the new industrial crop in Malaysia. Under 9th Malaysia Plan (2006-2010), the government has decided to allocated RM12 million for research and development of kenaf industry. Malaysian Agricultural Research and Development Institute (MARDI) started to plant kenaf in Malaysia. A lot of kenaf plant has planted in Terengganu and Kelantan by Tobacco Board of Malaysia (LTN). Kenaf grows quickly as it can reach to height of 3.66m-4.27m as Malaysia has 12 hours of daylight time which is almost good requirement to grow kenaf.

2.1.3 Advantages of natural fiber including kenaf

Kenaf, one of the natural fibers have some benefits for strengthening materials compared with glass fiber in terms of density, renewability, recyclability, cost, biodegradability and abrasiveness. This results kenaf have good mechanical properties and environmentally harmless. The ability to transfer stress from matrix to the fiber and fiber matrix interface determine the efficiency of the fiber-reinforced composites. In automotive parts, natural composites such as kenaf and polypropylene (PP) have been applied (Shibata et al. 2010).

2.2 Composite

2.2.1 Study on natural fiber composite

A study of shock wave impact of flax fiber reinforced polymer composites on different orientations of fiber was conducted showing that cross polymer fiber orientation has better impact strength than unidirectional fiber orientation. The specimen was prepared by vacuum assisted resin infusion technique and compression molding process method (Huang et al., 2016). Another researcher has study on degradation behaviour of natural fiber reinforced polymer matrix composite that mixed with 5% of wood sawdust and wheat flour for 15 weeks. The composites were exposed in the moist soil, water, atmosphere and brine solution resulted that biodegradability of pure polypropylene has increased due to present of microorganisms and chloride ion in brine solution at atmosphere condition. The wheat polypropylene showing that it has higher biodegradability than wood sawdust due to the ability of wheat to absorb water (Fakhrul & Islam 2013). Ramachandran et al. (2016) have study on various mechanical behaviour on bamboo using linen and banana fiber reinforced polymer composite presented that bamboo epoxy resin composite has lowest result on IZOD and CHARPY test, and bamboo-banana epoxy resin composite score the highest.

2.2.2 Study on thermal conductivity of fiber reinforced polymer composites

Schuster et al. (2008) studied the effect of three-dimensional fiber reinforcement on the out-of-surface thermal conductivity of composites materials. It shows that thermal conductivity increased as the fiber volume fraction increased.