APPLICATIONS OF HYBRID BAGASSE/KENAF FIBER REINFORCED WITH POLYPROPYLENE FOR AUTOMOTIVE COMPOSITES COMPONENT

AHMAD SHAFIQ BIN MOHD SHUKRI

B041820040

BMCG

B041820040@student.utem.edu.my

Progress Report

Projek Sarjana Muda II

Supervisor: PROF. MADYA DR. MOHD AHADLIN BIN MOHD DAUD

Faculty of Mechanical Engineering

Universiti Teknikal Malaysia Melaka

2022

APPLICATION OF HYBRID BAGASSE/KENAF FIBER REINFORCED WITH POLYPROPYLENE FOR AUTOMOTIVE COMPONENT

AHMAD SHAFIQ BIN MOHD SHUKRI

A report submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this project report entitled "Application of Hybrid Bagasse/Kenaf Fiber Reinforced with Polypropylene for Automotive Component" is the result of my own work except as cited in the references.

Signature : ……………………………………………..

Name : AHMAD SHAFIQ BIN MOHD SHUKRI

Date : FEBRUARY 2022

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.

Signature	: ....
Name of Supervisor	: PROFESOR MADYA DR MOHD AHADLIN BIN MOHD DAUD
Date	: FEBRUARY 2022

ABSTRACT

Nowadays, material and manufacturing sustainability, cost and energy consumption, the environment and health issues, are factors affecting production rates in automotive sectors. Therefore, most companies use natural fibers to overcome these difficulties. In addition, hybrid bagasse/kenaf fiber reinforcement with polypropylene (PP) as a matrix for producing composite materials. This innovation of composite is to increase the uses of waste of natural fiber. To make this happen, the mechanical and physical properties of this composite material need to be identified. Fiber and PP will be combined with different fiber compositions in each sample. To begin with, the natural fiber from bagasse are extracted from the sugarcane while kenaf is imported from another region then undergoes alkaline treatment. The tube was cut to 1 cm and then mixed with PP into the mould and compressed with a hot press and cooler at the specified temperature, pressure and time parameters. Another composites is prepared by same method which is bagasse/kenaf with PP. After the sample is prepared, it will undergo several types of tests, namely the density test, hardness test and tensile test. According to the results of the tensile test, it shown that the maximum load on hybrid bagasse/kenaf PP decreased linearly with increasing fiber content. Besides, the density trend also decrease with increasing fiber content in the sample. The result of hybrid bagasse/kenaf PP and kenaf PP composites are thoroughly compared.

ACKNOWLEDGEMENT

First and foremost, praises and thanks to the God, the Almighty, I am so grateful for His showers of blessings I am given the strength to be able to complete my final year project titled 'Application of Hybrid Bagasse/Kenaf Fiber Reinforced with Polypropylene For Automotive Component' in the given period, through thick and thin in my final year.

I would like to express my deepest and sincerest gratitude to my supervisor, Professor Madya Dr Mohd Ahadlin Bin Mohd Daud, for giving me the support and guidance to complete this project. Without the guidance, knowledge sharing, advice and encouragement I would not have been able to complete this project as presented here.

Moreover, my completion of this project assignment could not have been accomplished without the support of my mother, father, and all my beloved family members for their moral support. I would like to thank. Also, deep gratitude to all my fellow classmates and lab assistants for their encouragement on this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

PP	Polypropylene
KF	Kenaf fiber
FRPC	Fiber reinforced polypropylene composite
UV	Ultra violet
ASTM	American Standard Testing Method
UTS	Ultimate tensile strength

CHAPTER 1

INTRODUCTION

1.1 Background

As manufacturing industry looks to reduce the dependence on products and commodities based on petroleum, there are increasing needs to look at more environmentally sustainable, long-lasting materials to substitute the ones already in use. Interest in lightweight products reinforced with natural fibers has soared lately as a result of new environmental policies and consumer demand, prompting manufacturers to search for alternatives to traditional synthetic materials. Natural fiber reinforced composites have seen a substantial growth in use during the last decade, owing to their low cost of manufacture, lower density, and biodegradable qualities, as well as the fact that they provide nearly similar mechanical properties to synthetic fiber reinforced composites such as glass fiber and carbon fiber (Manish Kumar Lila et al., 2018).

Natural fibers such as kenaf, bagasse, bamboo, coir, and jute are among those being investigated for use as composite reinforcement. The yield of these crops has shown significant increment in these years, due to their considerable advantages in terms of strength and durability, as well as their ease of handling. Paulo Pecas et al. (2018) state that natural fiber-based composites hold promising potential for the automotive market because the need for lightweight and ecologically acceptable materials is increasing. While research indicates that natural fiber composites can lead to a 20% cost reduction and a 30% weight reduction in an automotive part, this effect is offset by the cost of the components. Following those writers, light weight of components allows for lower fuel consumption, greater recycling capabilities, less trash disposal, and fewer greenhouse gas emissions which are a few of the primary reasons for the application of natural fibers. For interior elements in automotive such as, door trims, front dashboards cushions, backrests, and cabin pillars, natural fiber reinforced composites are the dominant type of material used. On the other hand, in the application of exterior parts, natural fiber composite parts are rarely applied.

Different locations around the world develop and use a variety of natural fibers, and occasionally import or export them to other regions. For example, the European automotive sector primarily employs flax and hemp, whereas jute and kenaf are primarily imported from Bangladesh and India, banana fiber is largely imported from the Philippines, and sisal is imported from South Africa, the United States, and Brazil. For the German automotive manufacturing, flax fiber has been the most important natural fiber.

Specifically for this research, bagasse and kenaf fiber would be used as the main reinforcing materials since they are plentiful natural resources and simple to procure. Polypropylene will be utilised as a matrix and it is a popular thermoplastic medium used in the automobile industries. Hisham A. Maddah et al. (2016) demonstrated that polypropylene is a promising plastic due to its excellent chemical, thermal, and mechanical properties. Furthermore, researchers favour thermoplastic polymeric matrices over thermosets because thermoplastics have a shorter manufacturing time, lower recycling costs, and are more easily repaired (Quazi T. H. Shubhra et al., 2013).

1.2 Problem Statement

In today's world, industries are searching for environmentally sustainable materials extracted from natural energy to be used in their products, both to reduce their environmental footprint and to appeal to a growing number of environmentally aware customers. The automotive sector, in particular, is constantly looking for smaller, more environmentally sustainable materials that are nevertheless suitable for mass manufacturing at low cost without sacrificing material strength. (Samuel C.R. Furtado et al., 2014). Since academics and legislators are interested with greener automobile manufacturing and consumption solutions, they are highly engaged with how natural fibers may be used to these processes. Hence, using natural fiber composite materials as conventional materials for automotive component manufacturing is a reasonable assumption based on the research results.

The issues of existing materials are weighed down by their high weight, non-biodegradable, and high cost. In spite of the fact that natural fibers and synthetic fibers have a lot in common, a number of problems remain with regard to natural fibers. For example, there is a high degree of variability in mechanical characteristics, as well as reduced ultimate strength, reduced elongation, issues with nozzle flow circulation in injection moulding machines, and a lack of resistance to weathering.

1.3 Objective

This research aims to develop a natural fiber reinforced composite and examines the physical and mechanical properties of the composites utilising a variety of testing techniques, with an emphasis on the use of bagasse/kenaf natural fiber as reinforcement for polypropylene matrix. Throughout the study, there are a number of goals to be met.

1. To fabricate, perform testing and analyze the samples of bagasse and kenaf fiber reinforced polypropylene composites with various fiber composition using specific parameters and method.
2. To study the effect of density, hardness and tensile test on the fiber composite samples.

1.4 Scope of Study

The scope of this study is to fabricate bagasse/kenaf fiber reinforced polypropylene composites using structured methods and various composition ratios, as well as to examine the physical and mechanical properties of the those composites based on the data and results obtained from the conducted experiments. The scopes are as follows:

1. Preparation of fiber reinforced composites with different fiber percentage ratio at 7%, 14%, 21% and 28%.
2. Observation on the reaction of natural fibers and effect on the microstructure due to chemical treatment process.
3. Analysis to determine the mechanical properties of composites, including density, tensile, and hardness tests.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Natural fiber reinforced composites are made up of a polymer matrix with high-strength natural fibers such as jute, oil palm, sisal, kenaf, and flax incorporated in it. As for polymer, it is usually divided into two types: thermoplastics and thermosets. A thermoplastic, also called thermo-softening plastic, is a type of plastic polymer material that’s can be mould at higher temperatures and then roll back their properties as they cool, due to their dimensional molecular framework. Thermoset polymers, on the other side, are strongly cross-linked polymers that cure utilising only fire, heat and strain, and/or light irradiation. Thermoset polymers with this structure have strong properties including high versatility for tailoring preferred ultimate properties, great strength, and modulus. The properties and efficiency of composites may be influenced by a variety of techniques. The hydrophilic composition of the natural fiber, as well as the fiber loading, have an effect on the composite properties. To achieve good composite properties, high fiber loading is usually needed. In general, as the fiber composition in the composites increases, the tensile properties of the composites improve. The method parameters used are yet another essential factor that has a significant impact on the composites' properties and surface properties. Moreover, natural fiber chemical structure has a huge impact on the physical and mechanical properties of the composite, which are expressed by the percentages of cellulose, hemicellulose, lignin, and waxes in the composite. As a result, suitable methods and criteria should be selected properly to achieve the best composite characteristics.

2.2 Natural Fiber

Fiber derived from nature animal fibers, vegetable fibers, and mineral fibers are the common forms of natural fibers. These fibers are a readily available, easy-to-find commodity in nature. They display high tensile strength, biodegradability, specific stiffness and low cost per unit volume as outstanding material properties. Natural fibers are regarded to be naturally present composites made up of cellulose fibrils that are embedded in a lignin matrix. To maximise its tensile strengths, as well as provide stiffness, the cellulose micro fibrils are aligned throughout the fiber length. Natural fiber reinforces well due to the crystalline structure of cellulose. The majority of global automotive manufacturers are using natural fibers composites, as well as conventional materials, in their products as indicated in **Table 2.1**.

Table 2.1: Applications of natural fibers in automotive industry

Natural Fibres	Component Description	Other Constituents
Bast fibres (flax, hemp, kenaf, jute, sisal, etc.)	Carrier for covered door panels, covered components for instrument panels, covered inserts, carrier for hard and soft armrests, seat back panels, door panels, door bolsters, headliners, side and back walls, seat backs, rear deck trays, pillars, centre consoles, load floors, trunk trim	Polypropylene (PP) and polyester
Abaca	Under-floor panel and body panels	-
Banana	Wrapping paper	-
Flax/Sisal	In the interior door linings and panels, door panels	Thermoset resin
Kenaf	Door inner panel	PP
Kenaf/Flax	Package trays and door panel inserts	-
Kenaf/Hemp	Door panel, rear parcel shelves, other interior trim, Lexus package shelves, door panels	-
Wood	Carrier for covered door panels, carrier for covered door panels, covered or foamed instrument panels, covered inserts and components, covered seat back panels, fibre in the seatback cushions, inserts, spare tire, covers	Acrylic resin and synthetic fibre

2.2.1 Kenaf Fiber

Kenaf (Hibiscus cannabinus) is an annual crop that looks a lot like theokra (Abelmoschus esculentus) and cotton (Gossypium hirsutum), both of which belong to the same family (Malvaceae). The kenaf plant originated in Africa, but India and China account for more than 75% of global kenaf supply, making kenaf the most important bast fiber source in these countries. In Malaysia, Kenaf was acknowledged as a new industrial crop in 2000, assisting the country's commodities industry in diversifying. Thus, between 1996 and 2005, MYR 5.8 million (USD 1.53 million) was dedicated to kenaf research and development (R&D) in order to attract investors. Kenaf was developed throughout a four-phase period. Between 2004 and 2005, the National Tobacco Board's workforce was first exposed to kenaf. The following phase (2006-2010) focused on introducing the kenaf crop to producers, developing a kenaf production plan, and farming. Between 2011 and 2015, the emphasis moved to commercialization of kenaf crops and their associated products. The current phase (2016-2020) focuses on the commercialization of new potential approaches and brand development for kenaf.

Figure 2.1: Kenaf fiber before treatment

Each of kenaf growing season lasts around 75–120 days from planting to harvest. Due to kenaf's ability to flourish in hot regions with moderate rainfall, it is best planted in Malaysia between March and June, with crop harvesting occurring in July. The stem of the kenaf plant has up to 40% useable fiber, approximately double that of jute, hemp, or flax. In compared to other plants, this yield percentage improves the cost-effectiveness of the fiber. Furthermore, it takes only short period of time for a kenaf plant to grow from seed to a height of 3.6m - 4.3m. In the past, kenaf fiber was usually extracted from the plant's bast and processed using a variety of methods. The extraction method entails soaking the stalks and manually removing the fibers, and it has been found to provide superior reinforcement efficiency.

The kenaf plant consists of several beneficial components, including leaves, seeds, and stalks. And each of these components contains useful components such as fibers and fiber strands, oils, proteins and allopathic substances. Numerous variables, including cultivating process, planting date, photosensitivity, growing season duration, plant population, and plant maturity, may alter the productivity and content of various plant components. **Figure 2.1** illustrates a schematic representation of the kenaf plant cell wall. This structure is referred to as a micro fibril, microfiber, or elementary fiber. **Table 2.2** summarises the micro fibril size and chemical composition of the kenaf stem.

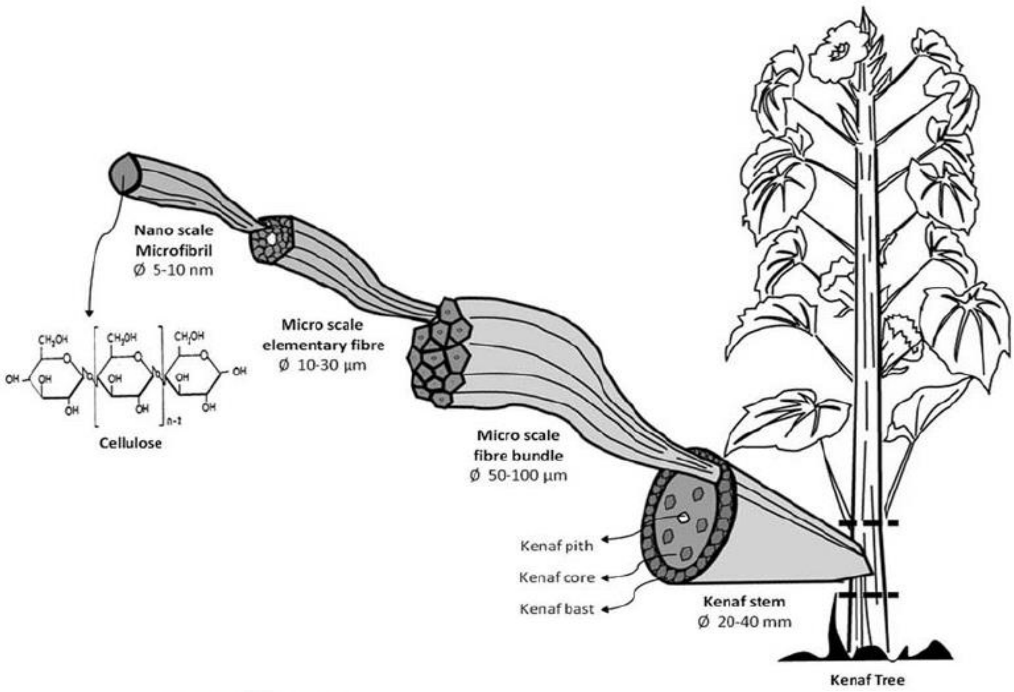

Figure 2.2: Schematic diagram of micro fibril in kenaf plant

Table 2.2: Chemical content of kenaf stem

	Bark	Core
Fibril length, L (mm)	2.22	0.75
Fibril width, W (µm)	17.34	19.23
L/W	128	39
Lumen diameter (µm)	7.5	32
Cell wall thickness (µm)	3.6	1.5
Cellulose (%)	69.2	32.1
Lignin (%)	2.8	25.21
Hemicellulose (%)	27.2	41
Ash content (%)	0.8	1.8

Natural fibers, such as kenaf fibers, comprise around 60-80% cellulose, 5-20% lignin (pectin), and up to 20% moisture. The cell wall is a hollow tube composed of four unique layers: one main cell wall, three secondary cell walls, and a lumen, which is an open channel running through the centre of the micro fibril. Each layer is made up of cellulose contained in a matrix of hemicellulose and lignin, mimicking composites reinforced with artificial fibers. Hemicellulose is a network of polysaccharides with a high degree of branching, such as glucose, mannose, galactose, and xylose. Lignin is a polymer made up of aliphatic and aromatic hydrocarbons that forms a protective coating on fibers. Through hydrogen bonds and other connections, the cellulose components of the fibers supply the fibers with strength and stiffness. Hemicellulose is responsible for the biodegradation, moisture absorption, and thermal breakdown of fibers. Unlike lignin (pectin), which is thermally stable but contributes to UV destruction, lignin (pectin) is photodegradable.

The majority of natural fibers are made of cellulose and lignin. The cellulose content dictates the mechanical properties, which are influenced by a range of parameters, including fiber length, fiber loading or percent volume of fibers, fiber vertical alignment, fiber orientation, and interfacial adhesion between fibers and matrix.

According to a study (Nishino et al., 2010), the form, scale and strength of natural fibers are largely determined by the cultivation method. Kenaf fiber is subjected to a variety of treatments and surface changes in order to improve its condition and properties. Alkaline treatment with sodium hydroxide (NaOH) solution is the most common chemical treatment, followed by silane treatment and other mixed treatments like alkaline-silane, alkaline-bleaching, alkaline-steam and alkaline-electron irradiation. As fibers are treated in a variety of ways, they provide excellent mechanical properties when incorporated into composites. Chemical treatments have been shown to improve fiber-matrix interface adhesion by chemically bonding the adhesive to the material. Overall, each treatment has a different effect on fiber strength, suitability, and fiber-matrix adhesion, which is also dependent on the fiber composition.

The figure below illustrates the example of research results that been obtained using kenaf fiber involving different composition of alkaline treatment. These qualities will have an effect on the mechanical properties of the manufactured fiber reinforced composites.

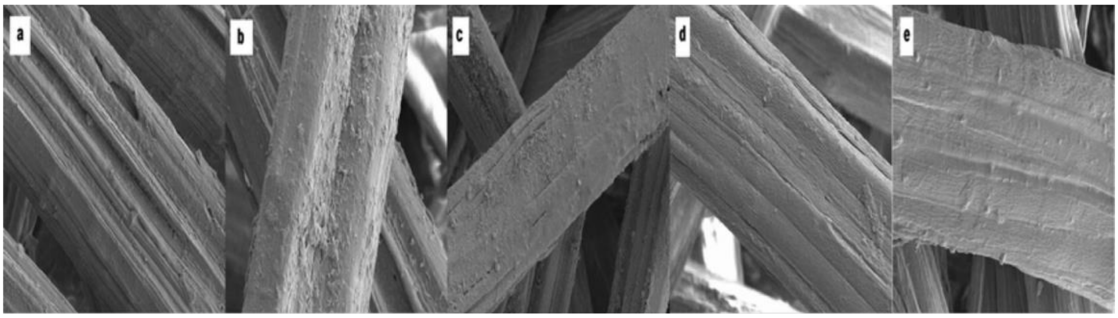

Figure 2.3: SEM micrograph of kenaf fiber (a) untreated fiber, (b) 2% NaOH, (c) 4% NaOH, (d) 6% NaOH and (e) 8% NaOH

2.2.2 Bagasse

Sugarcane (Saccaharum officinarum) is a readily available and plentiful source of lignocellulosic biomass. The solid residue remaining after juice extraction is referred to as sugarcane bagasse or bagasse in general. Sugarcane is an agricultural crop that provides several advantages to humans and other living creatures. Bagasse accounts for around 32% of each tonne of the sugarcane output. Malaysia has a total sugarcane bagasse planting area of roughly 34 500 acres. Due to the fact that around 1.1 million tonnes of sugarcane were produced in 2002, bagasse is readily available in Malaysia (Lee and Mariatti, 2008). Bagasse is a renewable agricultural product that is underutilized. Bagasse ranges in colour from grey-yellow to pale green. It is dense and quite disorganised in terms of particle size. Bagasse is utilised as fuel in power plants since it is produced at sugar mills. This is a low-efficiency method due to its poor caloric