APPLICATION OF COCONUT FIBER-PP COMPOSITE FOR FABRICATION ON INTERIOR PART OF AUTOMOTIVE COMPONENT

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This report is submitted
in fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering (Design and Innovation)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2017

DECLARATION

I declare that this project report entitled "Application of Coconut Fiber-PP Composite for Fabrication on Interior Part of Automotive Component" 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 (Design and Innovation).

Signature	:	....
Name of Supervisor	:	....
Date	:	....

DEDICATION

I dedicate this project to my beloved friends and parents for their endless support.

ABSTRACT

This study investigates the mechanical and physical properties of coconut fiber when reinforced with polypropylene (PP). Coconut or coir fibers were extracted from a bundle of fiber that obtained from the outer layer of the coconut palm. The extraction process was done manually by using cutter. The coconut fibers were treated using sodium hydroxide (NaOH) solution for 2 hours (at room temperature) to reduce surface roughness. Samples of the composite were fabricated with fiber's length of less than 10mm and four loading levels of CFB (10, 20, 30, and 40 wt%). The fabrication of composites was made by using hot press machine model of GT-7014-A until it becomes a thin plate. Physical and mechanical test such as tensile, hardness and density tests were conducted to investigate the effect of increment loading level of CFB in the composite, while the microstructure analysis was conduct to study and analyze the microstructure of the specimen after the tensile test. The experimental results shown that the composite with lowest percentage of CFB which is 10 wt% gave the highest value of tensile strength, tensile strain and maximum load which is 21.3MPa, 0.034 and 1065.24N respectively. Meanwhile, the lowest tensile strength is 17.56MPa which is obtained when the 40 wt% of CFB loading is used in the composite. The hardness and density of the CFB/PP composites showed significantly decreased from 10 wt% to 40 wt% CFB loading. The composite that gave the highest result in hardness test means that it is has high stiffness and able to withstand the given load. Meanwhile, low density means that the composite is not easily to sink when it is immerse in the water. The highest results from hardness test and density test are 67 Shore-D and 1.002 g/cm³ respectively. The results also revealed that alkaline treatment really influences the mechanical properties of CFB/PP composite because alkaline water caused to lower cellulose content on the surface of coconut fibers during surface treatment.

ABSTRAK

Kajian ini dibuat bagi mengkaji sifat-sifat mekanikal dan fizikal serat kelapa apabila diperkuatkan dengan polypropylene (PP). Serat kelapa diekstrak daripada gumpalan sabut kelapa yang diperolehi daripada lapisan luar pokok kelapa. Proses pengekstrakan telah dilakukan secara manual dengan menggunakan pemotong. Serat kelapa telah dirawat dengan menggunakan larutan natrium hidroksida (NaOH) selama 2 jam (pada suhu bilik) untuk mengurangkan kekasaran pada permukaan serat tersebut. Sampel komposit telah dihasilkan dengan menggunakan panjang serat tidak melebihi 10 mm dan empat peratus kandungan berat CFB yang berbeza iaitu 10, 20, 30, dan 40 peratus. Proses penghasilan komposit dibuat dengan menggunakan mesin mampat model GT-7014-A. Ujian fizikal dan mekanikal seperti tegangan, kekerasan dan kepadatan telah dijalankan untuk mengkaji kesan peningkatan kandungan CFB dalam komposit, manakala analisis mikrostruktur dilakukan untuk mengkaji dan menganalisis mikrostruktur spesimen selepas ujian ketegangan. Keputusan eksperimen menunjukkan bahawa komposit yang mempunyai peratusan kandungan CFB terendah iaitu 10% menghasilkan kekuatan tegangan, terikan tegangan dan beban maksimum yang paling tinggi iaitu 21.3MPa, 0,034 dan 1065.24N masing-masing. Sementara itu, kekuatan tegangan yang paling rendah adalah 17.56 MPa yang diperolehi apabila 40% kandungan CFB digunakan dalam komposit. Tahap kekerasan dan ketumpatan CFB/PP komposit menurun disebabkan oleh peningkatan kandungan CFB daripada 10% kepada 40%. Komposit yang memberikan hasil yang paling tinggi dalam ujian kekerasan bermakna ianya mempunyai kekuatan yang tinggi untuk menahan beban yang diberikan. Sementara itu, ketumpatan yang rendah bermakna komposit tidak mudah tenggelam apabila ianya direndam ke dalam air. Keputusan tertinggi daripada ujian kekerasan dan ujian ketumpatan adalah 67 Shore-D dan 1.002g/cm^3 masing-masing. Keputusan eksperimen juga menunjukkan bahawa rawatan alkali telah mempengaruhi sifat-sifat mekanikal CFB/PP komposit kerana penggunaan air alkali semasa rawatan telah mengurangkan kandungan selulos pada permukaan serat kelapa.

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Bismillahirrahmanirrahim,

Alhamdulillah. Thanks to Allah SWT, who with His willing give me the strength and healthy body to complete this Final Year Project with title “Application of Coconut Fiber-PP Composite for Fabrication on Interior Part of Automotive Component”. This final year project report was prepared and submitted in fulfillment of the requirement for the degree of Bachelor of Mechanical Engineering (Design and Innovation).

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LIST OF ABBREVIATIONS

ABS	Acrylonitrile Butadiene Styrene
ASA	Acrylonitrile Styrene Acrylate
ASTM	American Society for Testing and Materials
CFB	Coconut Fiber
HDPE	High-density Polyethylene
PA	Polyamide
PC	Polycarbonate
PBT	Polybutylene Terephthalate
PP	Polypropylene
PE	Polyethylene
PET	Polybutylene Terephthalate
PMMA	Acrylic
POM	Polyformaldehyde
PUR	Polyurethane
PS	Polystyrene
PVC	Poly-vinyl-chloride
SEM	Scanning Electron Microscopy

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter explains the background, problem statement, objectives and scope of the project. Introduction is the first part of my project report that acquaint with the basic points of the research and the direction of my study.

1.2 BACKGROUND

Natural fibers have recently become more popular as a substitute for synthetic fiber reinforcements in thermoplastic composites such as polypropylene (PP) and polyethylene. Natural fiber can be categorized by two types of fiber which are plant fiber and animal fiber. There are several types of plant fibers for example, as kenaf, jute, sisal, flax, and hemp been increasingly used in the automotive, packaging, construction sport and leisure application (Andrzej K. Bledzki et al, 2010). In order to protect the earth from rapid aging, natural fiber is more suitable to be replaced with synthetic fiber due to their low cost, flexible, better for recycling processes, lightweight, availability, good mechanical properties, high toughness, non-abrasive, environmental friendly and bio-degradability characteristics (Ayrilmis et al, 2011).

Since 1950s, plant fiber have been used in automotive industry for making interior part of automotive component such as seat back, headliners, door panels, package trays, pillar and others (Promper, 2010). Among various types of plant fiber, coconut fibers have durability to withstand heat and it is more resistant to moisture compared to others fibers. Coconut fiber, otherwise known as coir fiber, is a natural fiber extracted as fiber bundles from the husk of coconut. Coconut fiber can be found between the internal shell and the outer coat of a coconut. Before surface treatment, the color of coconut fibers are pale and its wall contained a lot of lignin and cellulose. The purpose of treatment is to clean the surface by removing each impurity (Fior et al, 2015) and to investigate the effect of the treatment when reinforced with polypropylene (O.M.L. Asumani et al, 2012).

Surface treatments are often used to improve the performances of natural fiber reinforced composites by bridging the bonding between the fiber and matrix in composite materials. From previous studies, surface treatment can increase the aspect ratio, which results in better fiber matrix interfacial adhesion (Fior et al, 2015). There are various types of surface treatment to improve the compatibility between lignocellulosic fibers and polymer matrices such as alkali treatment, silane treatment, acetylation, benzoylation, peroxide treatment, permanganate treatment, and isocyanate treatment. Among various types of treatment, alkaline and silane treatment is the most popular solution for surface treatment of fiber. Alkaline treatment involves dipping the fibers in sodium hydroxide (NaOH) while silane treatment soaking the fibers in silanol and alcohol.

Polypropylene is widely used in a lot of application including automotive components such as bumpers, chemical tanks, cable insulation, battery boxes, bottles and petrol cans. It is a semi-crystalline polymer that is used expansively due to its properties, cost and ease to fabricate. Polypropylene is normally tough and flexible, especially when copolymerized with ethylene. Therefore, it is suitable to be used as an interior part of automotive component compared to other plastic such as Acrylonitrile Butadiene Styrene (ABS). When it comes to the use of polypropylene, the temperature of the machine has to be constantly aware during manufacturing process. This is because polypropylene has a tendency to become loamy and harden to be destructed if the machine is overheats.

1.3 PROBLEM STATEMENT

Since the first production automobile was introduced in the last 120 years in Europe, the automobiles have become an important role in the economic development of the country. Due to the increasing of demand and automobile's production, this gave an impact to the health of the natural environment. This is because most of automobile’s manufacturers produce automobile components with synthetic fiber reinforcements in thermoplastic composites such as polypropylene (PP) and polyethylene. Synthetic fibers are often used in various industries, but it is very harmful to be used in automotive application because it cannot withstand heat, malleable and non-biodegradable characteristic.

In order to protect the earth from rapid aging, the natural fibers especially coconut fiber have recently become considerable attention as a substitute for synthetic fiber reinforcements in thermoplastics. An automotive component made from coconut fiber composites contributes for a better life quality due to recycling of the natural ingredient can cause to decrease fuel consumption and gases emission. However, the uses of natural fiber in fabrication of interior part of automotive components are may not necessarily be able to guarantee safety to users. Thus, this study was done to investigate the mechanical and physical properties of coconut fiber when reinforced with polypropylene (PP) composites.

1.4 OBJECTIVES

The objectives of this project are:

1. To investigate the mechanical and physical properties of coconut fiber reinforced with polypropylene (PP) as a matrix with varying fiber weight fraction.
2. To observe the microstructure of coconut fiber reinforced polypropylene composite by using Scanning Electron Microscopy (SEM).

1.5 SCOPE

This project focuses on the effect of coconut fiber when reinforced with polypropylene (PP) as well as on their physical and mechanical properties. This project involve with two (3) types of test which are mechanical test, physical test and microstructure analysis. In physical test, each sample must undergoes density test (ASTM D792) and hardness test (ASTM D2240). For mechanical test, they must undergo only tensile test (ASTM D3039/D3039M). Coconut fiber must treat with alkaline water and chop into length of less than 10 mm. Before it is going to be tested, the polypropylene must crush and blend until it becomes delicate powder. Then, four loading levels of the coconut fiber content of 10, 20, 30, and 40 percent are separate based on the composition by weight percentage and mix with the PP powder to compress until it becomes a thin plate.

CHAPTER 2

LITERATURE REVIEW

2.1 COCONUT FIBER

Coconut or coir fibers are extracted from fiber bundles that obtained from the outer layer of the coconut palm. The name ‘coir’ for coconut fiber is obtained from the Tamil and Malayalam word ‘Kavur’, which means rope. A single coir fiber has a coarse surface with mean width of 0.02 mm and a mean length of 2.5 mm. Coconut fiber has the highest lignin content compared to other fiber such as flax, hemp and wool (Jayasekara & Amarasinghe, 2010). The advantages of coconut fiber are that it is non-abrasive, porous, stiff, resilient, hydroscopic, viscoelastic, biodegradable, compostable and combustible (Ali, 2011). As a fiber, it has a high strength, low in energy conversation and has good insulation properties.

In the past, coconut fiber has been considered as a low quality. The quality of the coconut fiber depends on the extraction process. Normally, many people extract the coconut fiber by using traditional process. Traditional extraction process of coconut fiber involves harvesting and husking, retting, difebering and finishing process (Kavitha, n.d). In generally, the fiber was extracted from the husk that have been soaked for 6-9 month in a sea water or lagoon water, and then beaten with a wooden mallet. The retting process can soften and reduce the lignin of fiber. Sustainable methods in production of fibers have potential to produce constant quality of fibers. Biotechnological approach with specific microbial enzymes and shorten the retting time method can activate the fiber surface to react more easily with dyes.

2.1.1 Structure of Coconut Fiber

Coconut fibers are found between the skin and inner shell of a coconut. Every single of fiber cells has a narrow, thick wall that consists of cellulose. Each cell has 1 mm long and 10 to 20 µm in diameter. The coconut fiber bundles have varies size depends on the place in which it is grown and also with the environment condition. According to Schnegelsberg (1999), coir fibers bundles can be divided into white coir, brown coir, bristle, omat, mattress and mixed. The immature's fiber is white color, but once it grown it will become brown as a layer of lignin is deposited on their walls. By comparing between both types of fibers, fiber with brown color is stronger, thick and has high abrasion resistance. Both fibers are typically consists of 0.1 to 0.3 mm length. The fiber that contain more lignin and cellulose is more stronger because cellulose consist of thousands glucose unit that can stack to form crystalline with intramolecular hydrogen bonds providing a stable, hydrophobic polymer with high tensile strength (Akin, 2010). The Figure 2.1 below shows the molecule structure of crystalline cellulose.

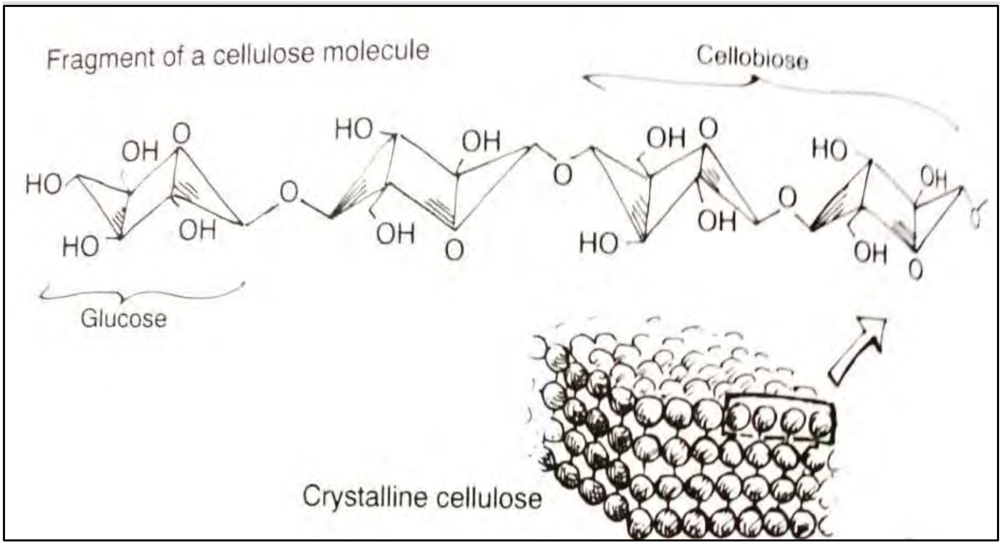

Figure 2.1: The molecule structure of crystalline cellulose

2.1.2 Chemical Properties of Coconut Fiber

The main chemical components of coconut fiber bundles are cellulose, hemicellulose and lignin (Ali, 2011). These three types of composition can affect the properties of coconut fiber. Most of plant fibers consists more than 70% of cellulose. Cellulose is an inactive metabolism of structural carbohydrate and polysaccharide that consists of a linear chain of $C_6H_{10}O_5$. Hemicelluloses occur mainly in the primary cell wall and have contains many different sugar monomers with varied chemical structure. The combination of cellulose and hemicellulose is known as holocellulose. Lignin is a polymer of phenylpropanoid units and has an aromatic structure. Lignin is formed from three different phenyl propane alcohols known as coumaryl alcohol, coniferyl alcohol and sinapyl alcohol. Lignin in the cell walls provides stiffness and color. It is also able to decrease absorption of water across the cell walls. Lignin also plays as important roles in the transport of water, nutrients and metabolites in the vascular system of plants. Furthermore, lignin in plant cells helps to maintain stiffness of the cell wall and provides obstacle towards compression and bending, as well as a protection against attack by microorganisms. The lignin and hemicellulose provides the adhesive to increase the bonding of molecule structure of the fiber.

2.1.3 Applications of Coconut Fiber

Production based on coconut fiber have developed in many countries especially in India, Tanzania, Kenya, Bangladesh, Burma, Thailand, Sri Lanka, Nigeria, Ghana and Malaysia. The coconut fibers are widely used in making spinning of yarns, ropes, doormats, mattings, mattings, carpets, rugs, brushes and others (M. Kavita, 2015). In three decades ago, the application of coconut fiber has expanded extensively for the manufacture of interior part of automobile. This is because the coconut fibers have possibility to decrease weight and cause to better crash absorbance and sound insulation when applied to door trims, instrument panels, package trays, glove boxes, arm rests and seat backs (Szeteiova, n.d.). Apart from that, the coconut fiber also been used as a material in the fabrication of furniture, cabinets, boxes and vases and others (Ali, 2011). It also can be used to replace construction materials such as tiles, bricks, plywood, and asbestos and cement hollow blocks. In other engineering technology, coconut fibers are suitable to be used in composites for different purposes such as reinforcement of natural fiber and polymer as a substitute material.

2.2 POLYPROPYLENE (PP) COMPOSITE

Polypropylene (PP) is a semi-crystalline polymer that is widely used in a lot of application due to its unique combination of properties, cost and ease to fabricate (Sakthivel et al, 2014). All polypropylene have grades that consist of polymer, a neutralizer and antioxidants. Other additives like clarifiers, nucleates, slip additives, UV stabilizers, silica, talc, and calcium carbonate are added to resins to protect the polymer during fabrication process and to enhance better performance. The polymer might be a pure homopolymer made from polymerizing propylene while a random copolymer made from propylene and another monomer such as ethylene or an impact copolymer is made from dispersing rubber in polypropylene matrix. Polypropylene can be fabricated in various types of method like film/sheet extrusion, non-wovens, multifilament, injection molding, blow molding and profile extrusion.

In 1954, the first polypropylene was polymerized by Professor Giulio Nattain in Spain. Production of polypropylene expanded in a lot of application such as textiles, stationery, food container, automotive part and others. In 2013, the global market for polypropylene was spread about 55 million tonnes. Polypropylene is almost used to fabricate in all car's component such as bumpers, doors, windows, headlight and side view mirror, trunk lids, hoods, grilles and wheel covers. Based on the Table 2.1 below, 32 percent out of total plastic used in car is polypropylene (Katarina, n.d). Production of polypropylene takes place by gas phase process in which involves exposing the propylene monomer to heat and pressure in the presence of a catalyst system. Polymerization is achieved at relatively low temperature and pressure and the product produced is translucent and ready in colored. Differences in catalyst and production conditions can be used to change the properties of the plastic.

Table 2.1: Main types of plastic used in Automotive

Component	**Main Types of Plastic**
Bumpers	PS, ABS, PC/PBT
Seating	PUR, PP, PVC, ABS, PA
Dashboard	PP, ABS, SMA, PPE, PC
Fuel systems	HDPE, POM, PA, PP, PBT
Body (incl. panels)	PP, PPE, UP
Under-bonnet components	PA, PP, PBT
Interior trim	PP, ABS, PET, POM, PVC
Electrical components	PP, PE, PBT, PA, PVC
Exterior trim	ABS, PA, PBT, POM, ASA, PP
Lighting	PC, PBT, ABS, PMMA, UP
Upholstery	PVC, PUR, PP, PE
Liquid reservoirs	PP, PE, PA