MECHANICAL PROPERTIES OF PAADY-HUSK POLYPROPYLYENE COMPOSITE

NUR SYAFIQAH BINTI SULAYAN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE MECHANICAL PROPERTIES OF PADDY-HUSK POLYPROPYLENE COMPOSITE

NUR SYAFIQAH BINTI SULAYAN

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

Faculty of Mechanical Engineering

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DECLARATION

I declare that this thesis entitled "The Mechanical Properties of Paddy husk Polypropylene Composite" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : Nur Syafiqah Binti Sulayan

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 of the award of the degree of Bachelor of Mechanical Engineering.

Signature	:..................................
Name	: En. Shamsul Bahari Bin Azraai
Date	:..................................

DEDICATION

A special dedication to my parents, Sulayan bin Indanan and Intan Baiduri binti Maaripat and also not forgotten to beloved family who always supported me in everything I do.

ABSTRACT

The demand for eco-friendly materials, the degradation frequency, and the petroleum-based plastics prices and pressing environmental regulations have all triggered growing interest in composite materials. Natural fiber is used as an alternative to conventional fiber reinforcement as it is cost-effective and environmentally friendly. This project investigates the mechanical properties of Paddy-husk reinforced polypropylene with different filler loading which are 20%, 30% and 40% of paddy-husk powder (PHP). The PHP was weighed according to their respective filler loading and then mixed with polypropylene in the internal mixer. Hot press machine was used to press the sample into a board. The board was then cut into shapes according to the standard ASTM for each testing. Three tests were carried out which are hardness test (ASTM D2240), tensile test (ASTM D039) and flexural test (ASTM D790). The data from the experiments were then tabulated and analysed to know their properties. The mechanical properties of the sample reduced as the paddy husk powder was not treated. Based on the experiments with increasing PHP filler loading of 20%, 30% and 40%, the hardness decrease, the tensile stress increased, the Young modulus increased. When the PHP filler loading increased, the flexural strength decreased, and the flexural modulus increased.

ABSTRAK

Permintaan untuk bahan mesra alam, frekuensi degradasi, dan harga plastik berasaskan petroleum dan peraturan persekitaran yang mendesak semuanya telah memicu minat yang meningkat terhadap bahan komposit. Serat semula jadi digunakan sebagai alternatif untuk pengukuhan serat konvensional kerana ia menjimatkan kos dan mesra alam. Projek ini menyiasat sifat mekanik polipropilena bertetulang padi-sekam dengan muatan pengisi yang berbeza iaitu 20%, 30% dan 40% serbuk padi-sekam (PHP). PHP ditimbang mengikut muatan pengisi masing-masing dan kemudian dicampurkan dengan polipropilena dalam pengadun dalaman. Mesin tekan panas digunakan untuk memasukkan sampel ke papan. Papan kemudian dipotong menjadi bentuk mengikut ASTM standard untuk setiap ujian. Tiga ujian dijalankan iaitu ujian kekerasan (ASTM D2240), ujian tegangan (ASTM D039) dan ujian lenturan (ASTM D790). Data dari eksperimen kemudian ditabulasi dan dianalisis untuk mengetahui sifatnya. Sifat mekanik sampel berkurang kerana serbuk sekam padi tidak dirawat. Berdasarkan eksperimen dengan peningkatan beban pengisi PHP sebanyak 20%, 30% dan 40%, kekerasan menurun, tegangan tegangan meningkat, modulus Muda meningkat. Apabila pemuatan pengisi PHP meningkat, kekuatan lenturan menurun dan modulus lenturan meningkat.

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I have met many people during this time who are friendly and share their knowledge and experience of this study with me. I have learned a great deal from them. If they had their expertise and advice, the project would not have been feasible. So, I will use this time to thank both. In the other hand, it is a pleasure for me to give a token of thanks to all my friends and family who participate in this work directly or indirectly. Finally, I hope this research may be useful as a reference point for future works.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

PH	Paddy husk
PP	Polypropylene
PHP	Paddy husk powder
MCM	Metal matrix composite
PMC	Polymer matrix composite
CMC	Ceramic matrix composite
NFC	Natural Fiber composite
FRP	Fiber reinforced polymer
PRP	Particle reinforced polymer
AMC	Advanced composite materials
ASTM	American society for testing and materials
UTM	Universal testing machine

CHAPTER 1

INTRODUCTION

1.1 Background

Increasing demand for eco-friendly materials, the degradation frequency, and the petroleum-based plastics prices and pressing environmental regulations have all triggered growing interest in composite materials (A.N.Netravali, 2003). Composite materials are produced by combining two or more materials to enhance the properties of their original components. When one or more of the materials used are derived from biological origins, they are then defined as biocomposites (P.A. Fowler, 2006).

Natural fibres are additionally frequently utilized as reinforcements. For example, jute, hemp and flax are commonly utilized as reinforcing material in composites. The composite can be relegated as thermosetting or thermoplastic polymer to compose a composite that has propitious properties like low energy engenderment, biodegradable and low manufacturing hazard (Bambach M.R, 2017). However, composite with natural fiber consist of intrinsic vigor that this potential can be enforced in many sector and industry as long as we understand to analyse the mechanical deportment.

Paddy husk (PH) is one of the new natural fiber that has gained popularity. Paddy (Oryza sativa L.) is a primary food source for billions of people and one of the world's biggest crops. This occupies nearly 1% of the surface of the earth (F. Adam J. N., 2012).

Statistics show that the average annual global rice production in the 2010–2013 period was 725 million metric tons, with Asia alone supplying more than 90 percent of total global rice production (J.FAO,2012). Paddy husk (PH) is an inexpensive byproduct of rice processing and is separated from rice grain during the rice milling process. It is reported that, for every ton of rice produced, about 0.23 tons of PH is formed. Rice milling is one of the most important industries in countries such as China, India, Indonesia, Malaysia, and Bangladesh (E. Aprianti, 2015).

In general, polymer composites consist of a polymer resin as the matrix and one or more fillers are added to serve specific objectives or requirements. For example, composites for aerospace and sports applications require high mechanical and thermal properties. Traditionally synthetic fibers such as carbon or glass fibers have been used to reinforce composites and are able to produce such properties. However,with the growing global environmental concerns, their slow biodegradability is a disadvantage.Therefore researchers are finding other viable approaches to enhance or accelerate the biodegradability of polymeric composites. For this reason natural fibers provide good prospective as reinforcements fillers in thermosets, thermoplastics, and elastomers. Some main advantages of using natural fibers in composites are low cost, sustainability, light weight, and being nonabrasive and nonhazardous and more importantly they can accelerate biodegradability of the polymeric composites (K.P. Kumar, 2014).

Filler-reinforced polypropylene has been a popular subject to accept numerous types of fillers and reinforcements due to the flexibility of polypropylene. In recent years, the use of filled polypropylene in electrical and automotive engineering has increased mainly due to its excellent rigidity properties, which enable it to replace conventional materials in demanding engineering applications. Fillers that merely increase the volume of bulk and therefore reduce the price are known as extender fillers, while those that improve mechanical properties are known as reinforcing fillers, in particular tensile strength. Plastic fibers, plastic balls, talc, asbestos, wood starch, calcium carbonate, silica and mica are common fillers and reinforcements for polypropylene.

1.2 Problem Statement

Conventional synthetic fibers used these days have more difficulty than natural fibers. Natural fiber is used as an alternative to conventional fiber reinforcement as it is cost-effective and environmentally friendly through the use of natural fillers or reinforcement in composite polymer (Salmah. H et al, 2013).

Past studies show that the use of natural fiber composite as reinforcing material has better mechanical properties, reduced wear of implements, unlimited availability, low price, and free disposal of dilemmas due to the less abrasive nature of natural fibers. The use of natural fibers creates a safer working environment than the synthetic fibers. Cutting and installing glass fiber components causes skin vexation and respiratory diseases among employees due to the glass fiber particles. For example, some evidence of a condition of asbestos form emerged from fiber handling (Cheremisinoff, N.P, 1990).

Paddy husk rises in agro-waste. This means the paddy husk will be discarded after being used in cultivation. Therefore, it is important to produce a sample set of composites to analyze the mechanical properties using paddy husk as an agro-waste to ensure a healthy environment in the future through the use of agro-waste in composite. This is important for the future development of composites to be used in many fields in the future, such as construction materials, marine cordage, fish networks, furniture and other household appliances (Karthikeyan and Udhayasankar, 2015).

1.3 Objective

Natural fibres, which are plentiful in nature, are low-cost raw material, and renewability is of greater interest.Natural fibres, including carbon glass and aramid, are cheaper than man-made fibres. The project knows samples with high mechanical properties are produced at low cost, which is strictly environmentally friendly. The engenderment of synthetic fibre depends mainly on fossil fuels and needs more energy as compared to natural fibre. The objectives of this project are as follows;

1. To determine the mechanical properties of the paddy husk polypropylene composite.
2. To determine the Young modulus.
3. To compare experimental data with other natural fibers.

1.4 Scope of Project

The flaw of composites is conventionally the cost which the raw material is often sumptuous. Consequently, the material cull for this project is circumscribed due to budget constraint.

The scopes of this project are:

1. To formulate paddy husk polypropylene composite.

2. To conduct experiments testing the hardness, tensile and flexural properties of paddy husk polypropylene.

3. To compare the experimental data with other natural fibers.

4. Filler concentration of composite varies from in weight (g) 10%, 20%, 30% and 40% only. Previous studies show that the mechanical properties are poor if the filler is too concentrated in the composite.

CHAPTER 2

LITERATURE REVIEW

2.1 Building materials using composites

Research and innovation in natural fiber composite (NFC) have been growing rapidly today. This is due to the advantages of NFC over other types of fibers, such as synthetic fibers. NFC is claimed to have a lower environmental impact as well as a low cost that has potential to be used in a variety of applications. As a result, demand for ecological building materials is growing rapidly on the market, especially with regard to materials for the isolation of renewable resources. Many researchers initiated the study of these natural materials, primarily researching their thermal insulation and mechanical properties (Maria, 2017).

Jute (Korjenic, 2011), cork (Silva, 2005), corncob (Pinto, 2012), sugarcane (Kodah, 1999), wood wool and rock wool (Ren, 2007), loose-filled cellulose (Nicojsen, 2005), and hemp (Dalmay, 2010) are the most studied fibers. A great deal of effort has been made to increase their mechanical efficiency to expand this class of materials capacities and applications.

Based on research by (Maria, 2017), the tests showed a maximum ultimate strength varying from 5.82 to 12.91 MPa and an almost continuous flexural resistance equal to 6.00 MPa in terms of mechanical properties.Samples with a smaller amount of fibers have been shown to be more resilient, but, on the other hand, have a more delicate nature, as shown by the lack of plastic activity in the curve. Compared to a mixture of lime and hay, the mechanical tests performed on the biocomposite showed that the replacement of lime with resin as binder greatly increases the mechanical properties of the biocomposite.

In order to improve the thermal and mechanical properties of the biocomposite, further analysis must be carried out. A thorough study on the preparation of the mix is currently underway in this regard. In more depth, the role of the amount and granulometry of shives in the solution, the pressure applied when filling the mould and the impact on the mechanical properties of the biocomposite of the length and modality of the drying process were studied.

2.2 Introduction to Composite

Polymer Matrix Composites (PMC) is the type of composite to be generated and studied in this section. Broadly speaking, matrix identification can be made based on the composite matrix material. Which are:

i) Ceramic Matrix Composites (CMC)

ii) Metal Matrix Composites (MMC)

iii) Polymer Matrix Composites (PMC)

CMC are kenned for its fiber attribute to resist temperature. Ceramic fibers can be found abundant as alumina and silicon carbide. They are salutary in very high temperature applications, and where environment assailment is an issue. Poor properties of ceramic fibers results in tension and shear, and due to these attributes, most applications of ceramic fibers as reinforcement are mostly particulate form. Ceramic Matrix Composites (CMC) are use in environments with high temperature since it is able to resist temperature, the matrix is reinforced with short fibers, or whiskers made from silicon carbide and boron nitride.

Metal Matrix Composite (MMC) is commonly used as housings, pipes, wires, heat exchangers, structural component due to high transverse strength, low corrosion resistance and higher categorical unit positive qualities over monolithic materials. The high density is the downside for composites of the metal matrix and therefore results in poor categorical mechanical properties relative to composites of the polymer matrix.

Polymer Matrix Composite (PMC) can be relegated into according its matrix, either thermosets or thermoplastic polymer. The material utilized as matrix are polymer that will determine the properties PMC. In PMC, vigor and stiffness of PMC are lower if in comparison to MMC and CMC. In order to surmount this quandary, reinforcing other materials to the polymer can elucidate the matter. In integration, fabrication of PMC does not require high temperature and pressure and involute equipment. PMC can be divided into two relegation classes, that are Fiber Reinforced Polymer (FRP) and Particle Reinforced Polymer (PRP). These composites show higher overall properties to individual components of polymer and ceramic.

Ceramics, glasses, metal particles such as aluminum and amorphous materials are the parts used in PRP. Particles are used as a composite matrix to elevate the matrix modules. It resulted in a decrease in the matrix's ductility. The incentive to use particles is to minimize the composites ' costs.

FRP materials is very consequential since it has high value of modulus and tensile vigor when reinforced with fibers. Furthermore, FRP shows better vigor and modulus compared to metallic materials due to its low concrete gravities, the vigor-to-weight ratios and modulus-to-weight ratios (Shackelford and Alexander, 2000).

Nowadays, materials such as steel and concrete are competing with FRP in many engineering industries such as in automobiles, boats, aircrafts industry as well as construction materials. These industries are usually found abundant with FRP.

Fiber reinforced plastics are attentive composite in many industries. It is because of its estimable categorical mechanical properties, high strength to weight ratio and corrosion resistance (Courtney T.H, 1990). Relegations of composite materials were according to its own matrix material. It can be divided into particulate reinforced composites, fiber reinforced composites and structural composites.

2.2.1 Definition of a Composite

Composites should not be regarded simple as a coalescence of two materials. In the broader consequentiality, the coalescence has its own distinctive properties. In terms of vigor or some other desirable quality, it is better than either of the components alone or radically different from either of them. They are compound materials, which is different from alloys which, the individual components keep their original attribute but are so incorporated into the composite as to take advantage only of their attributes and not of their shortcomings, in order to obtain an improved material (Prakash T, 2009).

Composite materials as homogenous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can be additionally considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property. It also provides characteristics not available from any discrete material. They are cohesive structures made by physically coalescing two or more compatible materials, different in composition and characteristics and sometimes in form (Verma et al, 2013).

2.2.2 Characteristics of Composite

Properties of composites are vigorously dependent on the properties of constituent materials and the interaction among them. The shape, size and size distribution of the reinforcement influences the properties of the composite. The shape of the discontinuous phase, the size and size distribution and volume fraction determine the interfacial area of composite. This is paramount since it determines the extent of the interaction between the reinforcement and the matrix. Concentration of composite can be controlled during fabrication. Concentration of parameter plays role in influencing the properties of composite. The concentration can be quantified as volume or weight fraction.

2.2.4 Polymer Matrix Composites (PMC)

Composite has two main composition that is matrix and reinforcements. Fiber reinforced polymer (FRP) consist of one or more discontinuous phase which is withal kenned as reinforcing material that is embedded to perpetual phase which is kenned as matrix (Bhaskar and Singh, 2013).

The role of reinforcing material is to sustain high tensile loads, while the matrix is in charge in rigidity to the composite. Loads are transfer by matrix, which is transfer from one to another fiber. However, FRP can be classified into two classes, that is thermosets and thermoplastic polymer. Thermosets are cured by a chemical reaction that is irreversible. The molecules in the polymer undergoes “cross-link” that is usually ionic or covalent bond (Karthikeyan and Udhayasankar, 2015).

2.3 Matrix of composite

Matrices is divided into three that is polymer, metal and ceramic. In a composite, the matrix functions as to transfer load to and between fibers by holding or “glues” the fibers together by cohesive and adhesive characteristics. Other than that, the matrix also protects fibers from environmental effect and abrasion (Karthikeyan and Udhayasankar, 2015). The matrix in composite binds the fibre together by its cohesive and adhesive characteristics. Since lignocellulosic fibre shows poor mechanical properties, hence alkaline treatment was implemented to increase interfacial adhesion between reinforcement and matrix. Moreover, the matrix contributes in resistance crack propagation and damage tolerance owing to the plastic flow at crack tips (Schwartz M.M, 1992). The type of matrix is major importance since the matrix determines the characteristic of the composite.

The type of matrix is divided into polymeric, metallic, carbon and ceramic. Polymer resin is classified into thermosetting and thermoplastics which is identified by the type of matrix (Taj et al, 2007). The matrix acts as material that gives body and holds the reinforcement of the composite together.

2.3.1 Introduction to polypropylene

Thanks to its durability, resilience and high melting point, polypropylene is used in a wide variety of films and multilayer film structures (J.-Ml. Charrier,1990). In addition, polypropylene (PP) resins can demonstrate excellent processability when formulated with the correct additive packs. The chemical structure of the homopolymer is quite simple, a methyl group located on each other unit of methylene. Figure 2.1 shows the polypropylene monomer unit

.

During polymerization, the placement of this methyl group around the stereocenter creates different tacticities. Methyl groups consistently placed on one side of the polymer chain produce isotactic polypropylene. The polymer is referred to as syndiotactic when these methyl groups alternate from one side to the other.

An atactic polymer is formed by random ordering of the methyl groups. The tacticity of the polymer partially determines the properties of the polymer. The polymer properties are also characterized by molecular weight distribution, degree of crystallinity and the method of polymerization. Further chemical modifications build an even more extensive library of physical properties for specific applications by copolymerization of monomeric units such as ethylene and butylenes.

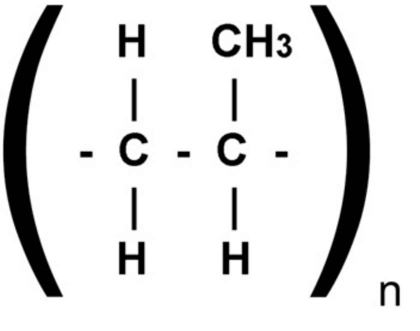


Figure 2.1 The polypropylene monomer unit

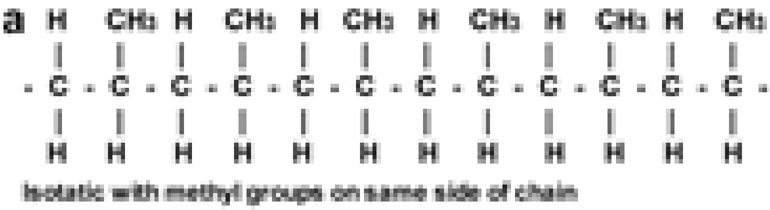


Figure 2.2 Schematic of polypropylene tacticities isotactic with all methyl groups on the same side of the chain

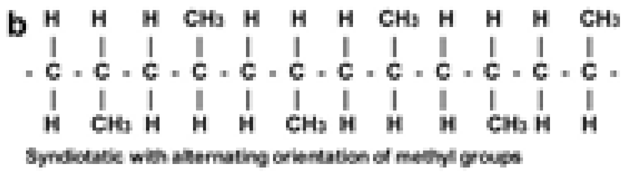


Figure 2.3 Schematic of polypropylene tacticities syndiotactic with methyl groups alternating above and below the chain

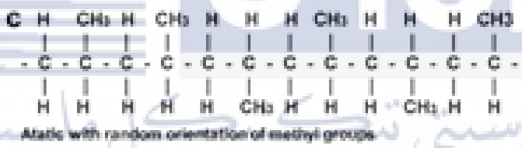


Figure 2.4 Schematic of polypropylene tacticities atactic with methyl groups in a random orientation.

2.4 General introduction to natural fiber

Increasing environmental awareness and community interest, new environmental legislation, and excessive fuel use, led to thinking about using environmentally friendly products. Natural fiber is considered one of the environmentally friendly materials with good properties in comparison with synthetic fiber (A. May-Pa, 2013).

Simply defined, natural fibers are fibers that are not man-made or synthetic. They that derive from plants or animals (A. Ticoalu, 2010). The use of natural fiber for the manufacture of composite materials, both renewable and non-renewable, such as oil palm, sisal, flax, and jute, has so far gained significant attention in recent decades. The plants that produce cellulose fibers can be categorized into bast fibers (jute, flax, ramie, hemp, and kenaf), seed fibers (cotton, coir, and kapok), leaf fibers (sisal, pineapple, and abaca), grass and reed fibers (rice, maize, and wheat), and core fibers (hemp, kenaf, and jute) as well as all other forms (wood and roots) (O.Faruk,2010). The most common and commercially natural fibers in the world and world production have are shown in Table 1.1.

Table 2.1 Natural fibers in the world and their world production

Fiber source	World production (10^3 ton)
Bamboo	30.000
Sugar cane bagasse	75.000
Jute	2300
Kenaf	970
Flax	830
Grass	700
Sisal	375
Hemp	214
Coir	100
Ramie	100
Abaca	70

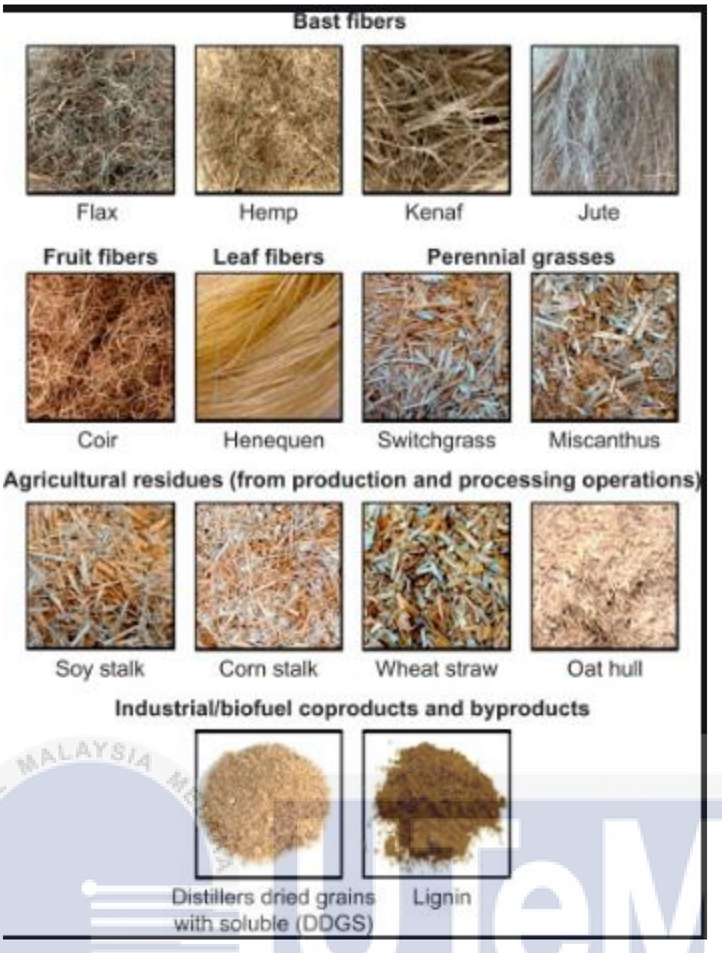


Figure 2.5 Examples of natural fibers

2.4.1 Application of natural fibers

Natural fiber is widely used in a wide range of industries. In the textile industry, for example, fabric based on one or more yarn types, such as flax, hemp, nettle, cotton, sisal and jute can be used to produce materials such as tarpaulin, geotextiles, bags, carpet or furniture. In transport networks, knotted nets have found applications. Fleeces and needle felts made of hemp or flax are used by the upholstery by the thermal insulating industry and in geotextiles. Neeedle felts made from fiber can be used as an impact sound insulator in buildings (Nina Graupner, 2010).

Insulating materials made from natural fibers have good properties for summer accumulation and winter heat insulation, as well as sound absorption from goos. These insulating materials have a high sorption ability that provides a weather equilibrium between living space and surrounding area (Brandhorst et al., 2006).

2.5 Paddy husk as fiber reinforcement.

In the recent years several scientists have documented comparative studies on composites based on various fibers. For instance, Premalal et al. (2002) compared two PP composite forms of fillers (PHP and talc). The processability and mechanical properties of the composites have been studied with regard to the form of filler and filler material. Talc composites are found to be easier to process than polymer composites packed with PHP. They reported that Young's modulus and flexural modulus improved in terms of mechanical properties, while yield strength and elongation at break decreased in both types of composites as filler material increased.They found a lower yield capacity of the PP / PHP composites, Young's modulus, flexural unit, and a higher break elongation than PP / talc composites.

Figure 2.6 Paddy husk

2.5.1 Paddy Husk/Polypropylene Composites.

PP is a chemical synthesized addition of polymer from the monomer propylene .It is a polymer used primarily in food container, laboratory equipment, vehicle parts, yogurt bottles, and more. It is suitable for a variety of applications due to its simplicity and resistance to heat and contaminants. PP manufacturing can be accomplished by molding and extrusion. Table 2.2 shows experimental results from different researches in terms of mechanical properties of RH composites by employing PP as matrix material. (Reza Arjmandi et al., 2015).

Figure 2.7 Paddy Husk-polypropylene composite

Table2.2 Experimental results from different researches in terms of mechanical properties of RH composites by employing PP as matrix material

Matrix	RH (wt %)	Coupling agent or compatibilizer (wt%)	Tensile strength (MPa) (%incr.)	Tensile modulus (GPa) (%incr.)	Flexural modulus (GPa) (%incr)
PP	30*	-	24 (-21)	21 (80)	-
PP	WRHA *40	-	23	1.18	-

PP	10	-	29 (-15)	-	-
PP	30	-	-	-	26
PP/NBRr (70/30)	10*	-	13 (-33)	1.1 (2)	-
PP	50	MAPP (4)	37.5 (5)	0.8 (78)	34 (143)

CHAPTER 3

METHODOLOGY

3.0 Experimental setup

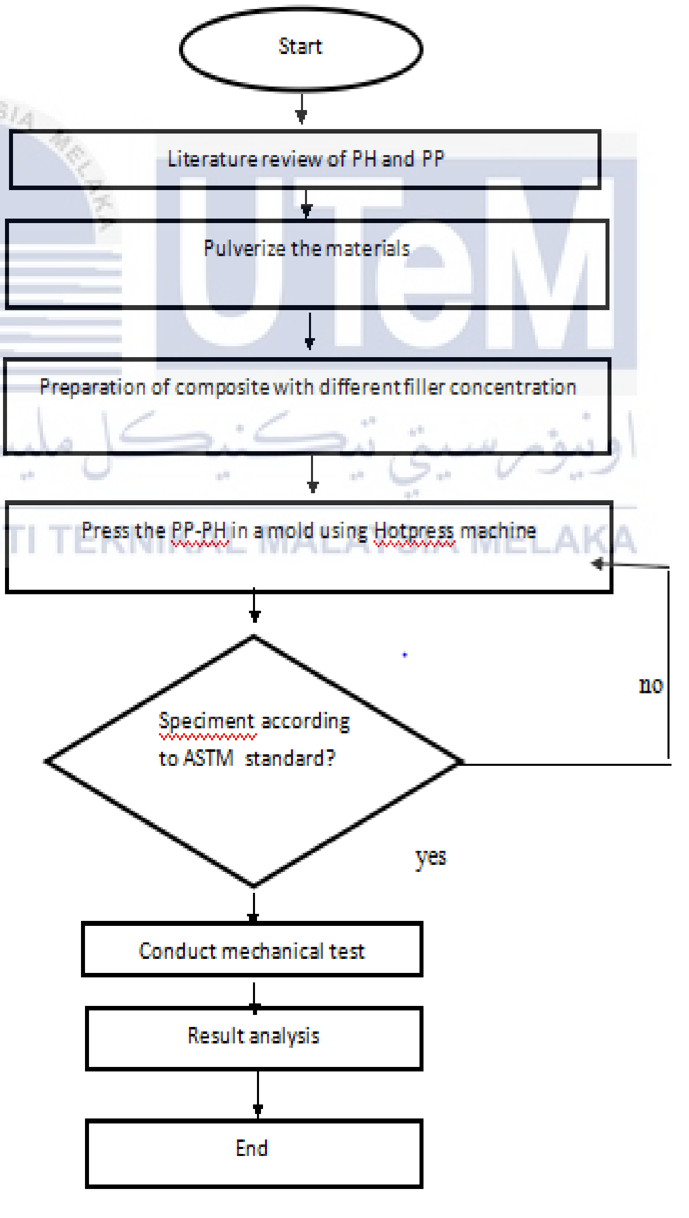


Figure 3.1 Flowchart of Project

3.1 Introduction

This chapter explains the system of methods used in this research. The workflow for this research is described in the flow chart as shown in Figure 3.1. It begins with a brief literature review on the materials in this research, which is natural fiber and polymer. After that, the material used for this study, which is paddy and polypropylene, is identified and then the sample was prepared.

3.1.1 Advantage of polypropylene

Polypropylene is suitable to be used in this experiment due to it's major advantages compared to the other polymers such as LDPE, HDPE, PVC and etc. Unmodified PP is very popular as a high-volume commodity plastic because of the low manufacturing cost (Devesh Tripathi, 2002). PP has higher stiffness at lower density and resistance to higher temperature when to subjected to mechanical stress. Moreover, PP has good chemical resistance, good environmental stress cracking resistance good fatigue resistance and good hardness. PP is also easy to process by injection molding and extrusion. Other mechanical advantages can be shown in table.

Table 3.1 the properties of unmodified PP are compared with other competitive thermoplastics

Table 1 Comparison of unmodified PP with other materials: Advantages [1]						
Property	PP	LDPE	HDPE	HIPS	PVC	ABS
Flexural modulus (GPa)	1.5	0.3	1.3	2.1	3.0	2.7
Tensile strength (MPa)	33	10	32	42	51	47
Specific density	0.905	0.92	0.96	1.08	1.4	1.05
Specific modulus (GPa)	1.66	0.33	1.35	1.94	2.14	2.57
HDT at 0.45 MPa. (°C)	105	50	75	85	70	98
Maximum continuous use temperature (°C)	100	50	55	50	50	70
Surface hardness	RR90	SD48	SD68	RM30	RR110	RR100
Cost (£/tonne)	660	730	660	875	905	1550
Modulus per unit cost (MPa/£)	2.27	0.41	1.97	2.4	3.31	1.74

ABS = acrylonitrile butadiene styrene
HIPS = high impact polystyrene
RR = Rockwell R
RM = Rockwell M
SD = Shore Durometer

3.1.2 Advantage of paddy husk

Paddy husk has the potential to replace man-made fiber in fiber-reinforced composites. Natural fiber has low cost, low density, recyclable and biodegradable which is good for the environment. According to Yang et al, who conduct an experiment on rice husk and polypropylene flour composite observed that tensile strength decrease while tensile module increase with the increase of degree of filling. Brittleness was shown in the composite at break at high testing rates and plastic deformation at higher temperature. Paddy husk can be used in building construction, automotive industries and insulation due to the low manufacturing cost and high availability.

3.2 Material preparation

The raw materials used in this experiment were paddy husk and polypropylene. An online retailer supplied the paddy husk in Figure 3.2 from Kedah. The polypropylene Figure 3.1 was supplied by Universiti Teknikal Malaysia Melaka (UTeM).

Figure 3.1 Polypropylene

Figure 3.2 Paddy husk

3.3 Calculating the density of the composite

Firstly, the density of composite must be determined to find the overall weight of the composite. It can be done by applying Law of Mixture. Firstly, the volume of specimen must acquired by using the formula length x width x thickness. Then this data will be inserted into the Rule of Mixture.

Volume of specimen mould = length x width x thichness

= 24.4 cm x 24.4 cm x 0.3 cm

= 178.608 cm^3

Density of PH, $\rho_f = 0.09\ g/cm^3$

Density of PP, $\rho_m = 0.946\ g/cm^3$

$$\rho_c = \rho_f \left({}^{V_f}/{}_{V_c}\right) + \rho_m \left({}^{V_m}/{}_{V_c}\right)$$

$$= \rho_f\, v_f + \rho_m v_m$$

$= (0.09 \times 0.1) + (0.946 \times 0.9)$

$= 0.8604\ g/cm^3$

$m = \rho \times v$

$= 0.8604\ g/cm^3 \times 178.608\ cm^3$

$= 143.96\ g$

3.4 Weighing and pulverizing the Paddy husk

The first step in specimen fabrication is to weigh the paddy husk (PH) and polypropylene (PP) based on the previous calculations using an electronic scale. The PH was then pulverized into paddy husk powder (PHP) using a Standard Blender in Figure 3.3. In this experiment, the spice grinder in Figure 3.4 was used instead of the plastic component.

This is because the blade in the spice grinder is design to crush hard objects. The paddy husk was pulverized into a powder consistency. This step is crucial to move on to the next step. PHP was then transferred into the Vibratory Sieve Shaker to sieve the pulverized PHP. In order to make sure the PHP has the same particle size, a mesh size of 150 was used to produce particle size of 0.105mm or 105µm. This to avoid error during testing and also very crucial for the next step.

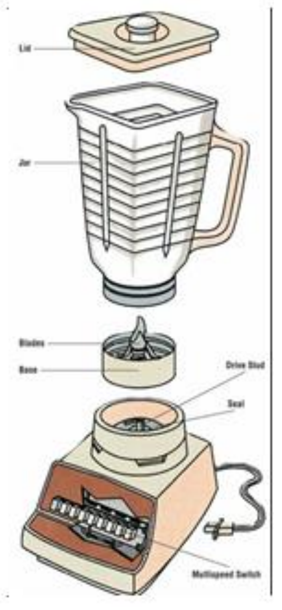


Figure 3.3 Schematic diagram of a standard blender

Figure 3.4 Spice grinder and standard blender

3.5 Sample formulation process

In this section, the formulation of PH-PP composite will be discussed in detail. The process starts with weight calculation to determine the weight of PHP and PP before mixing them into the internal mixer. The product is then transferred to the crushing machine to be crush into granules. The granules is then transferred to the hot press machine in a mould to be pressed into standard test specimen.

3.5.1 Weight calculation for PHP and PP

After obtaining uniform PHP particle size which 0.105mm or 105µm , the PHP was then mixed with PP in the internal mixer. PHP and PP were weigh beforehand using a digital weighing machine before inserted into the internal mixer. The Internal Mixer can only fit 50g per batch, so PHP were divided according 10%, 20%, 30% and 40% fiber filler.

Calculations:

$$\frac{\%PH}{100} \times 50g = W_{PH}$$

$$W_{PP} = 50g - W_{PH}$$

Table 3.2 Weight of distribution of PP and PHP

No.	Percentage of Paddy Husk powder (%)	Weight of PHP (g)	Weight of PP (g)
2	20	10	40
3	30	15	35
4	40	20	30

Figure 3.5 Digital weighing machine

3.5.2 Mixing using internal mixer

For the mixing process of PHP and PP, an internal mixer in Figure 3.7 was used to mix the two elements together. The maximum capacity of the internal mixer is 50g per batch and the required weight to fill a mould is 143.96 g of PHP-PP composite. The samples were divided into four batches to acquire 200g of PHP-PP composite per every percentage (20%, 30%, and 40%) of filler loading.

According to Hisham A. Maddah (2016), the melting point of PP IS 160-166 ^{o}C so for the first of 20% php, the internal mixer was set to a temperature of 175 ^{o}C with rotor speed of 50 rpm. PP was first inserted into the mixer and let run for 5 minutes. After 5 minutes, the PHP then added to the Internal Mixture and let mix with the PP for another 10 minutes. The overall mixing process took 15 minutes. This process was repeated four times to get 200g of samples.

For the 30% PHP, the internal mixer was set to 180 ^{o}C with rotor speed of 50rpm. PP was first inserted into the mixer and let run for 3 minutes. After the time is up, the PHP was then added to the Internal Mixer and let mix with the PP for another 12 minutes, the total process was 15 minutes. The process was repeated 4 times to get an adequate amount. When the mixing process s complete, the PHP-PP mixture was extracted from the mixer using a spatula provided and the leftover was scrapped off.

For the 40% php, the internal mixer was set to a temperature of 185oC with rotor speed of 50 rpm. PP was first inserted into the mixer and let run for 3 minutes. After the 3 minutes were up, the PHP was then added to the Internal Mixture and let mix with the PP for another 12 minutes. The overall mixing process also took 15 minutes. This process also was repeated four times. After each batch, when the mixing process was complete, the PHP-PP mixture was extracted form the mixer using a spatula provided and the leftover was scrapped off to minimize waste. The product of the mixing process has an irregular shape which is referred to as lumb shape in Figure 3.8 and 3.9.

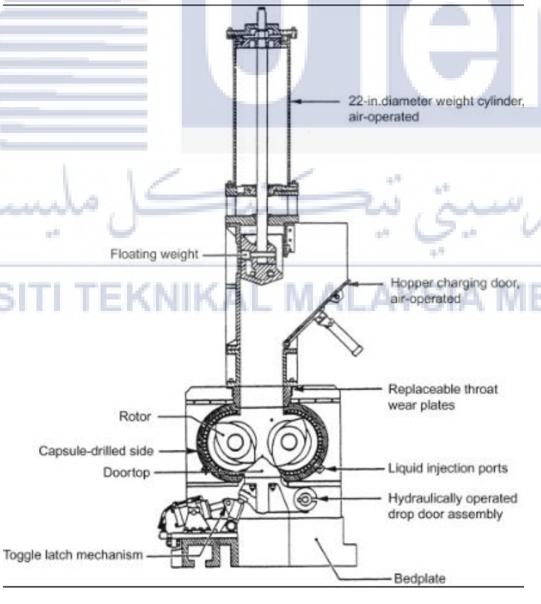


Figure 3.6 Schematic diagram of internal mixer

Figure 3.7 Internal mixer

Figure 3.8 PHP-PP in lumb shape

Figure 3.9 PHP-PP lumb separated and stored in a bag according to fiber content.

3.5.3 Crush lumb into granules using Crushing Machine

The next step is to crush the lumb into smaller pieces using the Crushing Machine in Figure 3.10. A smaller size is required to fit the sample into the assigned mould later. The lumbs were crushed with pressure from the Crushing Machine. The product of the crushing process is called granules. The particle size of the granules must be 2mm x 2mm, this is important in order for the sample to be pressed into a board evenly.

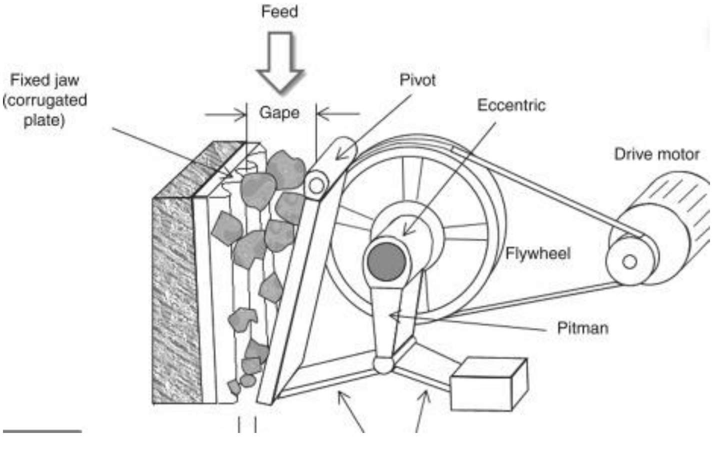


Figure 3.10 Schematic drawing of Crushing machine

Figure 3.11 Crushing machine

Figure 3.12 PHP-PP granules

3.5.4 Mould process

After crushing the samples and producing granules, the sample was then inserted into a mould. The mould has a rectangular shape with the dimension of 24.4 cm x 24.4 cm x 0.3 cm. The granules were weigh before inserting into the mould, the granule must weigh 200g based on the mould. This is because:

Calculation:

$$\rho = mv$$

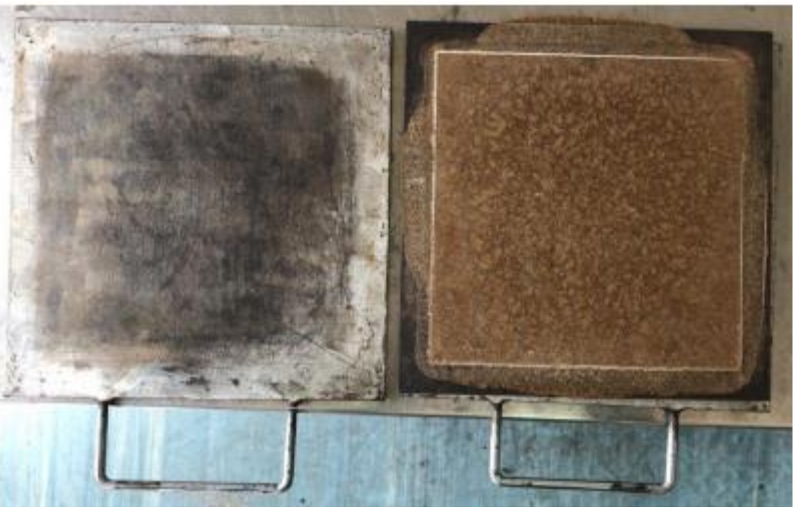


Figure 3.14 Mould

3.5.5 Hot press machine

Next, before the granules were pressed, 100% PP was used as reference to test the parameter. After testing, the parameter was set to pressure at 10 kg/cm2 and temperature of 185oC. The hot press machine was first preheated for 15-20 minutes. The mould is sandwiched between two flat plates and packed with 170g of granules.

The function of the Hot Pressed Machine is to pressed melt the PP-PHP granules according to the shape of the mould to produce an even board with a dimension of 24.4cm x 24.4cm x 0.3cm. The Hot Press Machine was set to a temperature of pressed at 10 kg/cm2, 185oC and water flowrate 900 ml/10.2 sec. First, the machine was pre-heat 10-15 minutes and the mould was placed on the machine.

A light pressure was first applied to melt the granule before pressing the mould to get the desired shape for 10 minutes. The product is then run through cold water to speed up the cooling process before proceeding to testing. The excess edges due to overflow was trimmed to get a clean line. This process was repeated with 20%,30% and 40% php.

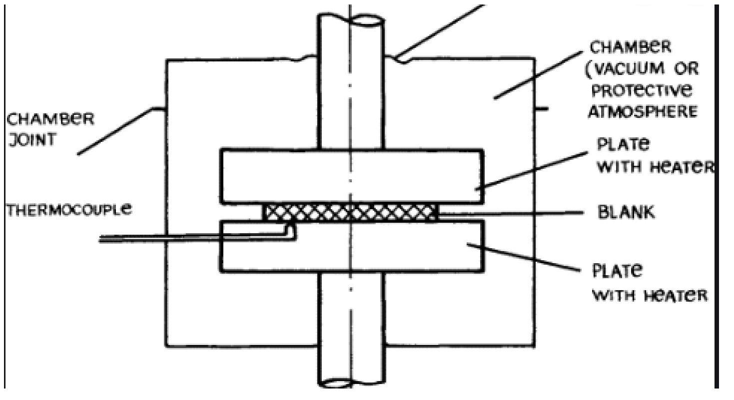


Figure 3.15 schematic diagram of a hot-press machine

3.16 Figure Hot press machine

Figure3.17 Hot pressing process carried out

Figure 3.18 pressed samples (100%, 20%,30%,40% php-pp)

3.5.6 Cutting the sample

After the sample are left to cool, the next step of the process was cutting. The sample was cut into shapes and full specification of the sample was provided in Table Table 3.3. An automatic cutting machine in Figure 3.21 provided by the faculty was used to cut the sample into their respective dimensions according to their respective standard.

Table 3.3 Dimension of each sample according to their respective test standard

Types of tests	**Dimension** **(length x width x thickness)**

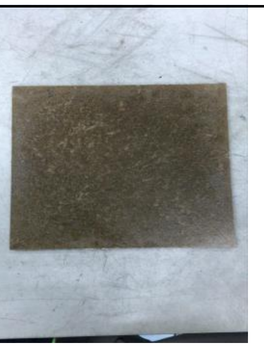
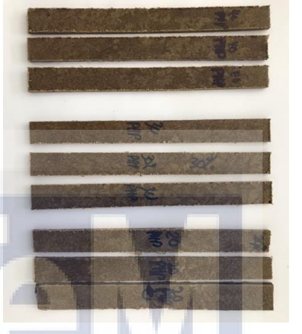
Hardness test (ASTM D2240)	 Figure 3.18 Hardness test sample 24.4 cm x 24.4 cm x 0.3 cm
Tensile test (ASTM D3039)	 Figure 3.19 Tnesile test sample 165 x 19 x 3 mm
Flexural test (ASTM D790)	 Figure 3.20 Flexural test sample 150mm x 25mm x 3mm

Figure 3.21 Cutting process of the sample

3.6 Testing

After the composite formulation, a few tests were carried out to investigate the mechanical properties of the Paddy husk-polypropylene composite. Based on the objective two test were conducted, which are:

1) Hardness test (ASTM D2240)
2) Tensile test (ASTM D3039)
3) Flexural test (ASTM D790)

3.7 Hardness Test (ASTM D2240)

Hardness test (ASTM D2240) is performed to determine the extent of the sample indentation, and empirical hardness can be obtained. To perform this test, analog scale "D" type Durometer based on the standard ASTM D2240 as shown in Figure 3.22 is used. The sample layer must be smooth and 3.0 mm thick to achieve this examination.

Figure 3.22 Analog scale "D" type Durometer

Figure 3.23 harrdness test carried out

Table 3.4 Specification of Analog scale "D" type Durometer

Specification	Description
Measuring a range of graduation	0~100 HD
Indentor	0~2.5 mm
Indntor press on telos	A, C type 0.55-8.06N, D type 0-44.5N
Power supply	1 SR44 button cell battery
Size	87x56x25mm (L x W x D) (3.43x2.2x0.98 inch)

Sharp cone point	SR 0.1mm
Included angle	30°

3.7.1 Procedure of hardness test

The first step was to place the sample on a smooth and hard horizontal surface to make that the sample help is optimum for the hardness test. The durometer was first held at a point, which does not impact the surface of the material by the tip of the indenter. Besides that, the presser's foot was placed at a distance from the sample 's edge to prevent any error. The presser foot then was applied to the sample gently.

Then, the presser foot was placed straight onto the sample, then gently pressed onto the sample to prevent the pressure foot from impacting and dropping. In fact, the vertical orientation of the presser foot will remove any lateral pressure that could exist if the durometer were bent a little and even not the longitudinal orientation to the sample surface. The amount of pressure applied to the sample was added enough to maintain a strong contact between the presser foot and the sample.

The durometer readings were reported for further study as the durometer reading stabilized. After recording the reading of the durometer, it is sufficient to rotate the anticlockwise red pointer to reset the reading of the durometer to 0. For one experiment reading was tested three times for reading accuracy. In fact, the foot of the presser will be directed away from the sample edge to avoid errors.

3.8 Tensile Test (ASTM D3039)

Tensile test is to indicate the material's ability to withstand the forces that pull it apart to an extent before material stretch and breaks. The tensile method is used to achieve the stress-strain diagram to determine the mechanical properties and overall behaviour. When the tensile test starts the specimen elongates as the specimen's resistance decreases and a load cell detects it. This load value is registered before a specimen breakage occurs. Mechanical properties that can be calculated by tensile tests are the tensile property, for example the tensile stress and the Young Modulus

Tensile test (ASTM D3039) is conducted to see the force required to break the composite sample and to see the material extend. The experiment is performed to determine whether sample remains or extends to the breakage point. The machine used in this experiment was the Instron Universal Testing Machine (UTM) 5585 in Figure 3.24, the specifications are stated in Table 3.5.

Table 3.5 Specification for Instron UTM 5585

Specification	Description
Accreditation – CE approval	Class B
Max. power (VA)	2950
Frequency	47 to 63 Hz
Max distance from a power source	2.44 m (8 ft) measured from the right side of the load frame
Standby or low speed	55
Maximum rate speed	74
Weight of load frame	952 kg (2100 Ib)

Figure 3.24 Instron Universal Testing Machine

3.8.1 Procedure of tensile test

To carry out this test, PH-PP composite was cut to the required length of 165 mm, width of 19 mm and thickness of 3 mm as per Figure 3.25. The specimen is placed in the grip of the Instron UTM 5585 as shown in Figure 3.24 operated by Bluehill 2 code with a constant head speed test of 2 mm / min. From the stress-strain curve diagram, information such as tensile stress, Young modulus and maximum load can be obtained.

The sample is clamped as per Figure 3.25, carefully to insure it is symmetrical to preserve a clear distribution of the pressure or stress. When the sample is not symmetrically clamped, the clamp was reset, and the sample appropriately corrected to ensure it is symmetrical. Then the tool is worked until two different pieces are removed from the sample.

The tensile test results were reported in the correct chart, and the experiment was completed. When all the data is collected, the clamps were removed, and the sample is extracted. The clamps are placed on another sample and the analysis is performed using the same method and specifications.

Figure 3.25 Tensile test samples

Figure 3.26 Tensile testing carried out

Figure 3.27 Sample break

3.9 Flexural test (ASTM D790)

The flexural strength is the material 's capacity to tolerate bending forces perpendicularly extended to the longitudinal axes. This is often referred to as the cross-breaking strength, where maximal tension produced as a bar-shaped test object is exposed to a bending force perpendicular to the wall, serving like a basic pole. Thanks to the flexural load this stress decreased is a mix of compressive and tensile tension. As defined in ASTM D790, use was made of three point loading system implemented on a supported base. This testing was conducted to determine flexural modulus, flexural. The machine used in this experiment was the Instron Universal Testing Machine (UTM) 5585 in Figure 3.28, the specifications are stated in Table 3.6.

Table 3.6 Specification for Instron UTM 5585

Specification	Description
Accreditation – CE approval	Class B
Max. power (VA)	2950
Frequency	47 to 63 Hz
Max distance from a power source	2.44 m (8 ft) measured from the right side of the load frame
Standby or low speed	55
Maximum rate speed	74
Weight of load frame	952 kg (2100 Ib)

Figure 3.28 Flexural testing set up

3.8.1 Procedure of flexural test

Universal Testing Machine Model 5585 was used to test the samples. A support span of 90 mm and with a constant cross-head motion of 2 mm/min was used in conducting the experiment. The flexural test was conducted at atmosphere of 24 ˚C and relative humidity of 50 percent. The dimension of the samples is 150mm x 25mm x 3mm as per Figure 3.29. The specimen was exposed to a bending force that acts perpendicular to the test piece.

On test piece, the constant load was then applied, and the deflection is recorded. The test was terminated until the average strain in the specimen's outer surface has exceeded the full strain or rupture occurs. In the flexural test, two essential parameters were defined, there is flexural power and tangent elasticity modulus in bending.

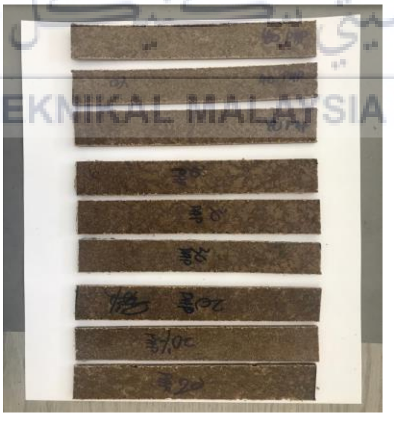


Figure 3.29 Flexural test samples

Figure 3.28 Flexural testing carried out

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, different mechanical testing was conducted onto the samples according to each specific ASTM mentioned in Chapter 3. The data and results of the experiments conducted were tabulated, analysed, and discussed in this chapter. As per clarified on the last chapter, there are three tests carried out to investigate the mechanical properties of the Paddy-husk polypropylene composite which are Hardness test (ASTM D2240), Tensile test (ASTM D638), and Flexural test (ASTM D790).

4.2 Hardness properties of Paddy-husk reinforced polypropylene composite

The average value obtained from using the durometer gauge to test the hardness of each composition weight percentage is tabulated and analysed. Theoretically, the trend should show that the hardness increases gradually as the weight percentage of sample increases.

Based on the figure and table below, it can be concluded that hardness decreases with filler loading. It can be observed that 20%, 30%,40% have hardness reading of 73.67, 67.33 and 46.67 respectively. It is shown that there is decrease of hardness of composite 27% from 20% to 40% weight percentage of filler.

PHP cellulose consists of three polar free hydroxyl groups and two glycosidic carbon groups, rendering it strongly polar in nature while PP methine is non-polar. The resulting polarity difference between PHP and PP leads to lower binding, and lower mixing ability to interact.

The results of the experiment are similar to an experiment carried out by Md. Mahfujul Islam et al. (2015), where they investigated the physio-mechanical properties of rice husk and polyester composite. From their finding it can be seen that the hardness decrease with the increase percentage of filler loading. This is due to the fact that the distribution of the PHP was not equal in each of the samples. Further investigation is needed to get the better results. The area of testing should be varying and the number of samples should be increased to get accurate results.

According to Rassiah and Ali (2016), the addiction of rice husk and clay into thermoplastic increase the hardness of the composite. Other studies by (Agunsosoye et al, 2012) and (Chanap R, 2012) where hardness of natural fiber composite increases as filler content increases. Both research uses treatment and binding agent that help the natural fiber and thermoplastic to mix well thus improving their physical and mechanical properties.

Table 4.1 Hardness test results using durometer on three different sample with different fiber composition

	20% PHP	30% PHP	40% PHP
Reading 1	75	69	49
Reading 2	72	68	48
Reading 3	74	65	43
Average	73.66666667	67.33333333	46.66666667

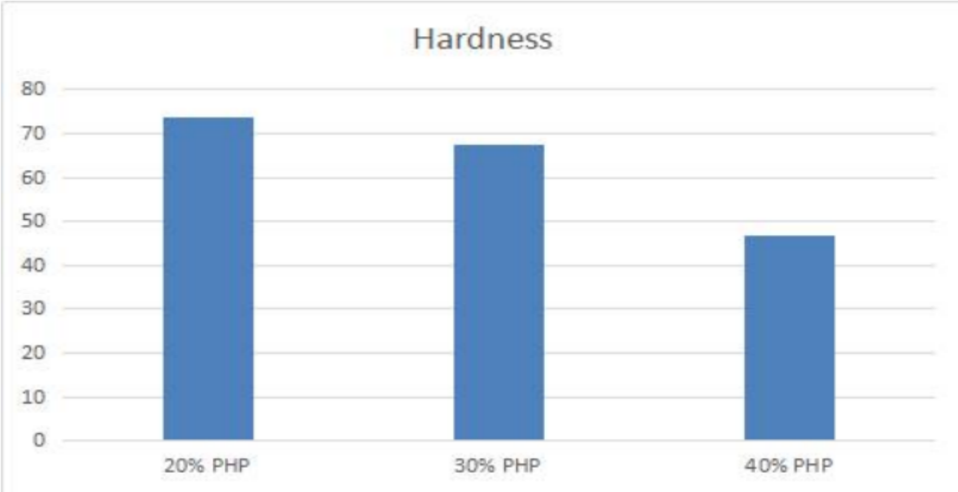


Figure 4.1 Hardness test results on 20%, 30%, and 40% PHP in PP

4.3 Tensile test properties of Paddy-husk reinforced polypropylene composite

This section discusses the tensile properties of composite PP reinforced with PH. From the stress-strain curve (referred to APPENDIX B) provided by the universal testing machine, tensile strength and Young modulus were measured after the test. At least three study groups were prepared with the same scale but with varying filler loads of 20%, 30% and 40% PHP. For the tensile test set up the samples were formulated and tested with length of 165 mm, width of 19 mm and thickness of 3 mm. Statistical research was carried out for each sample using data from three experiments. Table 4.1-4.4 indicates the average maximum load (N), tensile stress (MPa) and Young modulus (GPa) of all three samples groups PHP filler load. The tensile properties were summarized in Table 4.5, after evaluating each of the results.

Table 4.2 Average maximum load, tensile stress, and Young modulus of 20% of PHP-PP composite

SAMPLE ID	Max Load (N)	Tensile stress (MPa)	Young Modulus (GPa)	PHP(WT%)
A1	705.20	12.37	6.03	20.00
A2	555.62	9.75	5.20	20.00
A3	758.26	13.30	5.90	20.00
AVE	673.03	11.81	5.71	
STD	105.08	1.84	0.45	

Table 4.3 Average maximum load, tensile stress, and Young modulus of 30% of PHP-PP composite

SAMPLE ID	Max Load (N)	Tensile stress (MPa)	Young Modulus (GPa)	PHP(WT%)
B1	722.39	12.67	6.53	30.00
B2	556.78	9.77	6.36	30.00
B3	582.20	10.21	5.75	30.00
AVE	620.46	10.88	6.21	
STD	89.19	1.56	0.41	

Table 4.4 Average maximum load, tensile stress, and Young modulus of 40% of PHP-PP composite

SAMPLE ID	Max Load (N)	Tensile stress (MPa)	Young Modulus (GPa)	PHP(WT%)
C1	615.21	10.79	7.69	40.00
C2	749.39	13.14	8.06	40.00
C3	620.29	14.88	7.50	40.00
AVE	661.63	12.94	7.75	
STD	76.04	2.05	0.28	

Based on the summary of data in Table 4.5, the tensile stress for 20% PHP is 11.81 MPa with a standard deviation of 1.84. The tensile stress for 30% PHP is 10.88 MPa with a standard deviation of 1.56. as for 40% PHP the tensile stress is 12.94 MPa with a standard deviation of 2.05. This shows a trend where the tensile stress increased with the PHP filler loading as shown in Figure 4.2.

This trend was also shown in past research by Abdulrasoul Oromiehie (2009) where they investigate the physical-mechanical properties of polypropylene filled with wood fibre, rice-husk, bagasse. The tensile strength was tested on three different filler loading which were 40%,50% and 60% of fiber, and resulted in a declination of tensile strength. This is because when a certain concentration of fiber is achieved, the fiber adhesion to the matrix is not strong to transfer applied load through the interface. In addition, the interface region is also expanded, leading to weak interfacial bonding between the fiber and the matrix.

The Tensile modulus or also known as Young modulus can also be obtained form the summary in Table 4.5. The Young modulus for 20% PHP filler loading is 5.17 GPa with a standard deviation 0f 0.45. Next the Young modulus for 30% and 40% are 6.21 GPa ± 041 and 7.75 GPa±0.28 respectively. The standard deviation of the data is really small and almost insignificant, which mean the data is not dispersed and accurate. Young modulus increased as the filler loading increased as shown in Figure 4.3.

According to Dinh Vu et. al. (2018), It is expected that the increase of the Young's modulus and fexural properties will be due to the high fiber stifness relative to the PP matrix. Furthermore, Roshanak Khandanlou et. al..(2013) stated that partially segregated microspaces produced during tensile loading obstructed the distribution of stress between the fiber and PP matrix, thereby raising the degree of obstruction with increased fiber content, resulting in increased stifling

Table 4.5 The summary of tensile properties of PHP reinforced PP composite

PHP (wt%)	PP (wt%)	Tensile stress (MPa)	Young Modulus (GPa)
20	80	11.81±1.84	5.17±0.45
30	70	10.88±1.56	6.21±0.41
40	60	12.94±2.05	7.75±0.28

Moreover, there are a few studies that also study the tensile properties of different types of natural fibers such as wood fibers. A study carried out by Abdulrasoul (2010) in investigating the Physio-mechanical of wood fiber polypropylene composite. The research shows that wood fiber has a higher tensile property compared to PHP-PP composite. The test yielded a tensile strength of 46.3 0MPa for PP reinforced with 50% wood fiber.

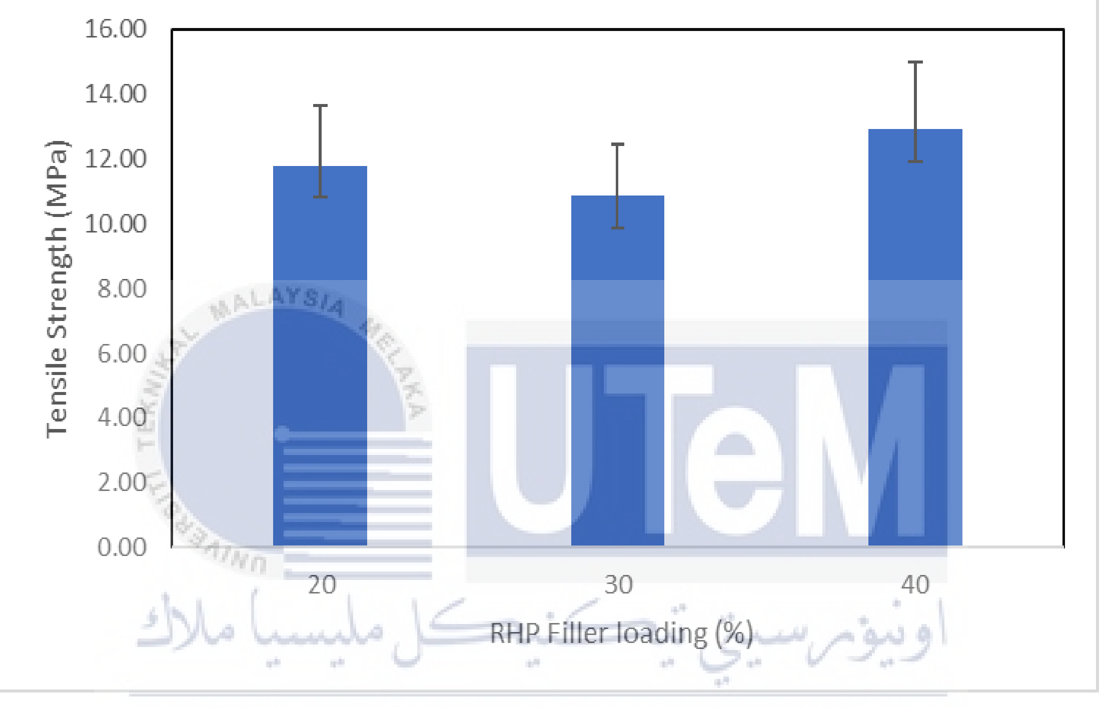


Figure 4.2 Tensile stress of different PHP filler loading

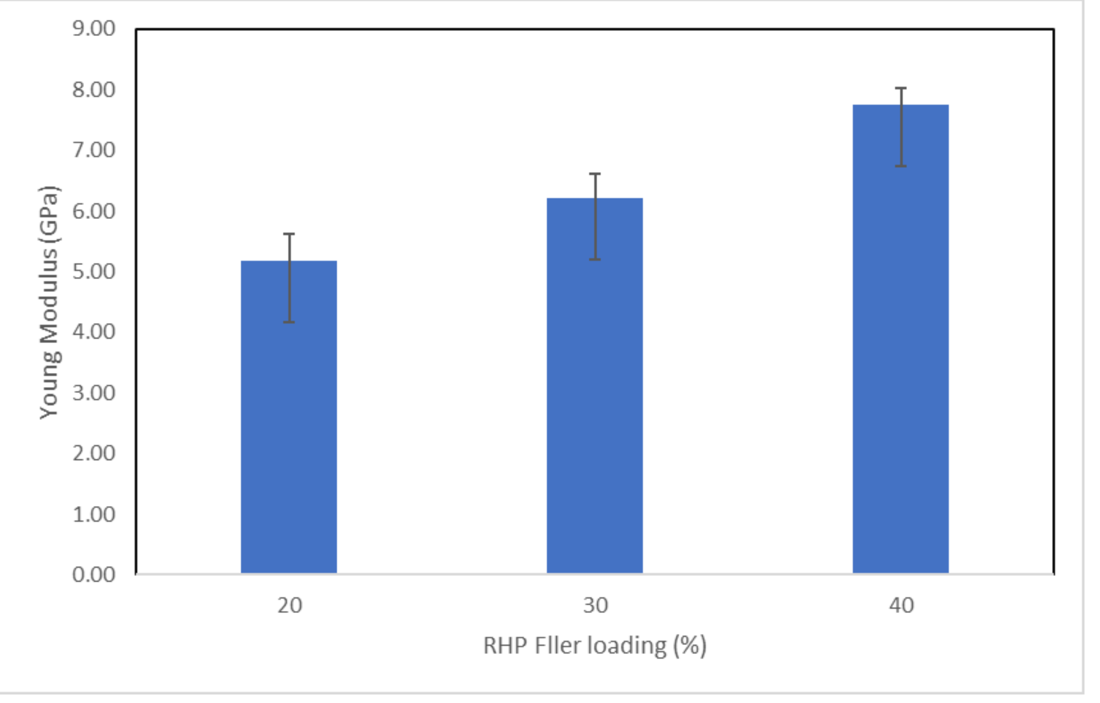


Figure 4.3 Young Modulus of different PHP filler loading

4.4 Flexural properties of Paddy-husk reinforced polypropylene composite.

According to W.D. Callister (2003), flexural strength which is also known as bending strength or rapture strength is defined as its ability to resist deformation under load. The samples were prepared according to ASTM D790, 3-point loading. To study the mechanical properties of the PHP-PP composite, flexural test was performed on three groups of samples with different filler loading which are 20%, 30% and 40% PHP. Flexural test was conducted on all the samples Each of the groups consist of three samples which are tested individually, and their readings were taken. The readings were then averaged, and standard deviation were taken and tabulated in Table 4.6-4.8. Results obtained from the flexural by the using the Universal Testing Machine is attached at APPENDIX C.

After obtaining the results, statistical analysis was carried out based on the data of three specimens of each group of samples. Table 4.6-4.8 shows the average maximum load (N), flexural strength (MPa), and flexural modulus (GPa) of 20%, 30%, and 40% PHP filler loading respectively. After analysing each of the data, the flexural properties were summarized in Table 4.5.

Based on the data on Table 4.2, the maximum loading for the 20% PHP filler is 49.16 N with a standard deviation of 4.26. However, based on table 4.3 and table 4.4, the maximum load decrease gradually from 42.28 N with a standard deviation of 3.09 to 36.19 N with a standard deviation of 2.18 as the filler percentage increased from 30% to 40% PHP. The PHP-PP composite can withstand a maximum load of 49.16 N.

From the summary of the flexural properties in Table 4.5, the flexural strength and flexural modulus were obtained.

Table 4.6 Average maximum load, flexural strength, and flexural modulus of 20% of PHP-PP composite

sample ID	Max Load (N)	Flexural stress (MPa)	Flexural Modulus (GPa)	RH
A1	44.62	26.77	1.36	20.00
A2	53.08	31.85	1.63	20.00
A3	49.77	29.86	1.52	20.00
AVE	49.16	29.49	1.50	
STD	4.26	2.56	0.14	
	49.16±4.26	29.56±2.56	1.50±0.14	

Table 4.7 Average maximum load, flexural strength, and flexural modulus of 30% of PHP-PP composite

sample ID	Max Load (N)	Flexural stress (MPa)	Flexural Modulus (GPa)	RH
B1	45.84	27.51	1.58	30.00
B2	40.48	24.29	1.50	30.00
B3	40.51	24.31	1.43	30.00
AVE	42.28	25.37	1.50	
STD	3.09	1.85	0.08	
	42.28±3.09	25.37±1.85	1.50±0.08	

Table 4.8 Average maximum load, flexural strength, and flexural modulus of 40% of PHP-PP composite

sample ID	Max Load (N)	Flexural stress (MPa)	Flexural Modulus (GPa)	RH
C1	38.69	23.22	1.50	40.00
C2	34.70	28.82	1.08	40.00
C3	35.18	21.11	1.30	40.00
AVE	36.19	24.38	1.29	
STD	2.18	3.98	0.21	
	36.19±2.18	24.38±3.98	1.29±0.21	

The flexural strength of 20% PHP filler loading is 29.56 MPa with a standard deviation of 2.56. For 30% PHP filler loading, the flexural strength is 25.37 MPa with a standard deviation of 1.85. The 40% PHP filler loading yielded a flexural strength of 24.38 with a standard deviation of 3.98. Standard deviation characterizes the usual distance of an occurrence from the centre of distribution or the mean value. When findings become more scattered so the variability will increase. A low standard deviation thus means less varriabilty, while the high standard deviation implies more data distribution, Mohini P. Barde and Prajakt J. Barde (2012). The data obtained has a relatively low standard deviation which means that the data has less variability and more accurate.

Based on the summary in Table 4.9 and Figure 4.4, it reveals that the flexural strength decreased gradually with the addition of PHP filler loading. The flexural strength indicates that the more concentrated the filler loading the more brittle the sample is going to be. This indicates that the increasing percentage of PHP supports more composite-formed interfaces and cavities and this may explain the decline in flexural strength, according to Md Mahfujul Islam (2015).

The decrease in strength of PHP polypropylene composites on increasing the volume fraction of PHP is due to PHP being weak in tension. Young's modulus and flexural modulus increased, whereas yield strength and elongation at break decreased with the increasing in filler contents for both types of composites.

From table 4.9, it can be concluded that the flexural modulus for 20% PHP is 1.50 GPa±0.14 For the 30% PHP is 1.50GPa±008 and for 40% PHP is 1.29±0.21. The flexural modulus of the PHP-PP composite decrease as the percentage of filler loading increase as Figure 4.5.

Table 4.9 The summary of flexural properties of PHP reinforced PP composite

PHP (wt%)	PP (wt%)	Max Load (N)	Flexural stress (MPa)	Flexural Modulus (GPa)
20	80	49.16±4.26	29.56±2.56	1.50±0.14
30	70	42.28±3.09	25.37±1.85	1.50±0.08
40	60	36.19±2.18	24.38±3.98	1.29±0.21

In addition, there are several studies that also study the tensile properties of various types of natural fibers, such as wood fibres, kenaf and baggase fibers. A analysis of the physio-mechanical of wood fiber polypropylene resin performed by Abdulrasoul (2010). Evidence reveals that wood fiber has a higher flexural modulus relative to composite

PHP-PP. Based on he experiment the bagasse fiber has a flexural strength of 58.51 MPa and a flexural modulus of 5.10 GPa which is higher than the RHP-PP composite.

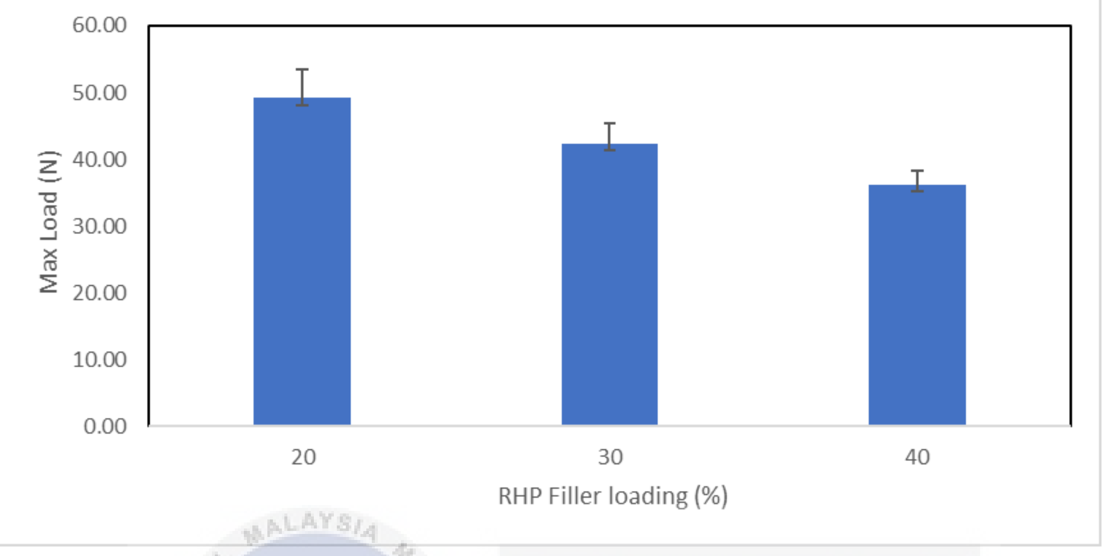


Figure 4.4 Graph of comparison on maximum loading between three different PHP filler loading

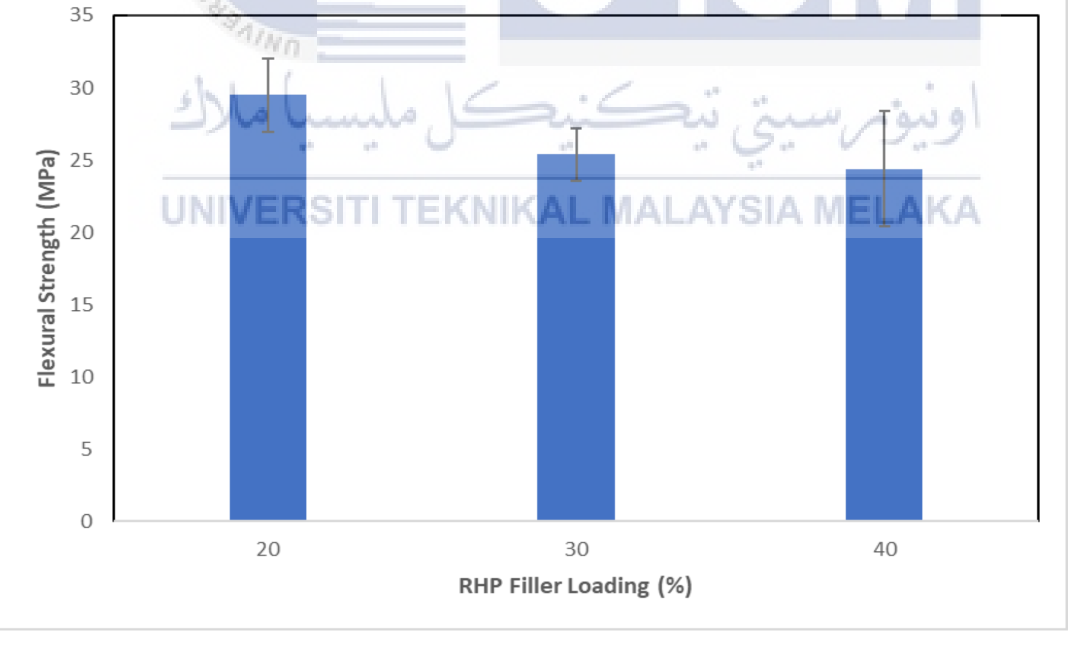


Figure 4.4 Graph of comparison on Flexural strength in MPa between three different PHP filler loading

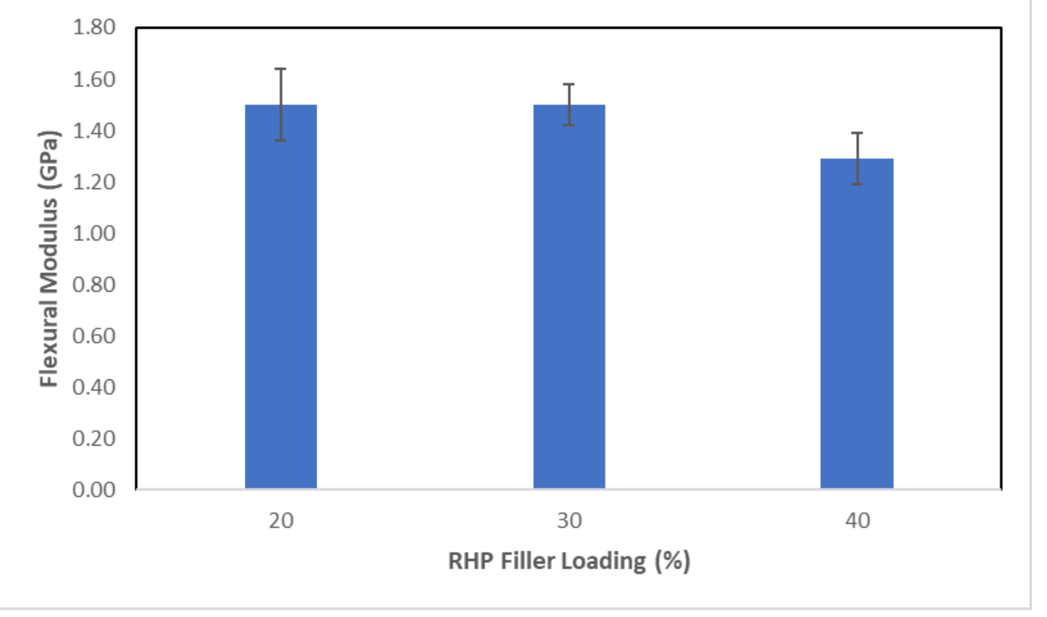


Figure 4.5 Graph of comparison on flexural modulus in (GPa) between three different PHP filler loading

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Characterization of Paddy-Husk Polyproplyene Composite

In summary, paddy husk was processed to produce a particle size powder of < 105 μm as a composite reinforcement material, while polypropylene as a matrix was prepared to produce composite samples for hardness testing, tensile testing and flexural testing according to the correct standard which are ASTM D2240, ASTM D3039 and ASTM D3039.

Based on the experiments carried out, it can be concluded that hardness decreases with filler loading. It can be observed that 20%, 30%,40% have hardness reading of 73.67, 67.33 and 46.67 respectively. It is shown that there is decrease of hardness of composite 27% from 20% to 40% weight percentage of filler

The tensile stress for 20% PHP is 11.81 MPa±1.84. The tensile stress for 30% PHP is 10.88 MPA± 1.56. as for 40% PHP the tensile stress is 12.94 MPa ± 2.05. This shows a trend where the tensile stress increased with the PHP filler loading. The Tensile modulus or also known as Young modulus can also be obtained form the summary. The Young modulus for 20% PHP filler loading is 5.17 GPa± 0.45. Next the Young modulus for 30% and 40% are 6.21 GPa ± 041 and 7.75 GPa±0.28 respectively. The standard deviation of the data is really small and almost insignificant, which mean the data is not dispersed and accurate. Young modulus increased as the filler loading increased.

The flexural strength of 20% PHP filler loading is 29.56 MPa ±2.56. For 30% PHP filler loading, the flexural strength is 25.37 MPa±1.85. The 40% PHP filler loading yielded a flexural strength of 24.38±3.98. The flexural strength decreased. It can be concluded that the flexural modulus for 20% PHP is 1.50 GPa±0.14 For the 30% PHP is 1.50GPa±008 and for 40% PHP is 1.29±0.21. The flexural modulus of the PHP-PP composite decrease as the percentage of filler loading increased.

5.2 Recommendation for future works

Apart from being climate safe, biocomposites provide other advantages. Significant improvement in the use of biocomposites was seen in numerous sectors like the automobile industry. Yet owing to some shortcomings in it the promise has not yet been thoroughly explored. Moisture, for example, influences the composite 's output itself by reducing its mechanical properties. Yet this can be fixed with rational changes that will allow biocomposite to enter new markets.

Paddy husk fibre has great potential that can be further explored in terms of chemical and thermal properties. With the aid of chemical treatment, the mechanical properties of paddy husk may be further improved to help reduce the inherent hydrophilic quality of natural fibres. Applying alkaline treatment involves soaking the fibers in NaOH solution for many hours in order to strengthen the elastic and binding properties of the fibers such that the matrix may connect them correctly. In addition, additives such as Ultraviolet (UV) stabilizers may be applied when treating the fiber as Ultraviolet stabilizers can improve the resistance of the composite to Azwa el moisture absorption. Al.(1993).

The addition of other filler such as silica and clay can also improve the mechanical properties of the composite. A hybrid composite can be further investigated, such as adding kenaf fiber to the pady husk composite to produce a more durable product.

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APPENDICES

APPENDIX A

Gant chart for PSM I and PSM II respectively

Task / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Research Title Selection	■	■												
Literature Review		■	■	■	■	■	■	■	■	■	■	■	■	■
Experiment Design				■	■	■	■							
Material Preparation								■	■	■	■	■		
Preliminary Data Analysis											■	■		
PSM I Report Writing											■	■		
PSM I Report Submission												■		
PSM I Seminar													■	■

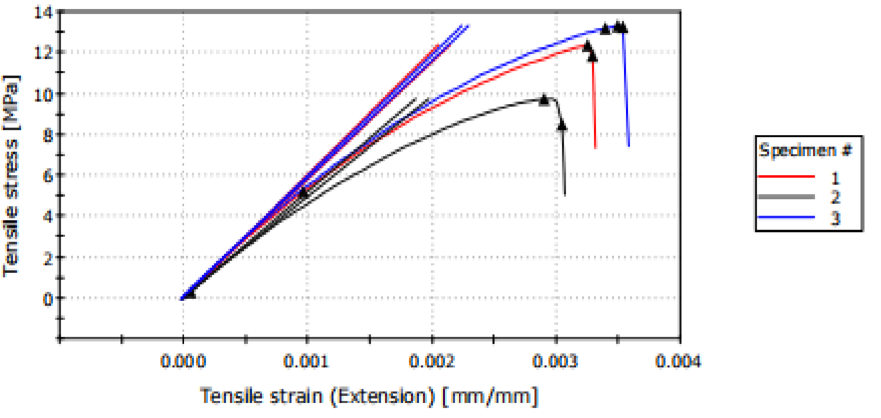
Figure

Task / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Material Review	■	■	■											
Experiment Design			■	■										
Experimental Work				■	■	■								
Sample Fabrication						■	■	■	■	■	■	■		
Mechanical Testing								■	■	■	■	■		
Analysis											■	■		
Results & Discussion												■	■	
PSM II Report Writing									■	■	■	■	■	■
PSM II Report Submission													■	■
PSM II Seminar														■

APPENDIX B

Results of Tensile test

20% PHP



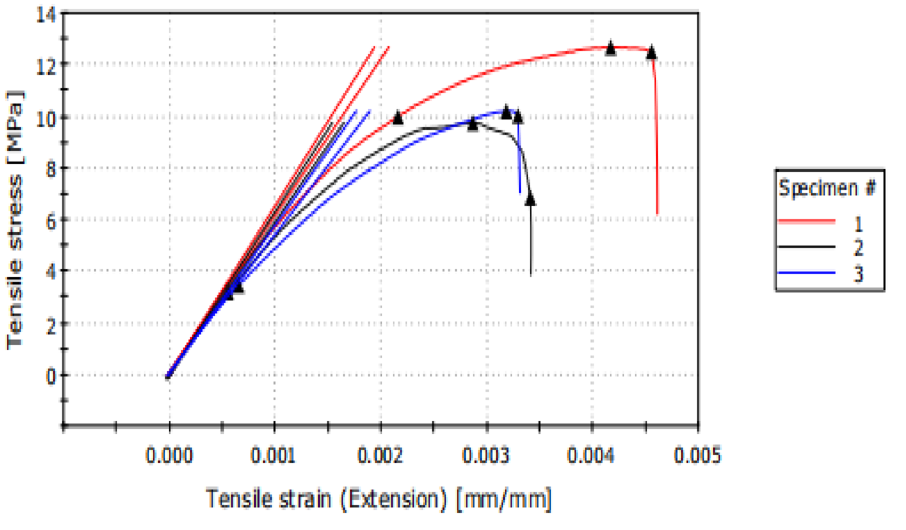
	Maximum Load [N]	Tensile stress at Maximum Load [MPa]	Tensile strain (Extension) at Maximum Load [mm/mm]
1	705.2023	12.3720	0.0032
2	555.6224	9.7478	0.0029
3	758.2560	13.3027	0.0035

	Load at Break (Standard) [kN]	Load at Yield (Offset 0.2 %) [N]	Tensile stress at Yield (Offset 0.2 %) [MPa]
1	0.6765	-----	-----
2	0.4848	-----	-----
3	0.7560	-----	-----

	Tensile strain (Extension) at Yield (Offset 0.2 %) [mm/mm]	Modulus (Automatic) [GPa]	Modulus (Automatic Young's) [MPa]
1	-----	5.7396	6032.83298
2	-----	4.8940	5196.09742
3	-----	5.7413	5896.42821

	Modulus (E-modulus) [GPa]
1	-----
2	-----
3	-----

30% PHP



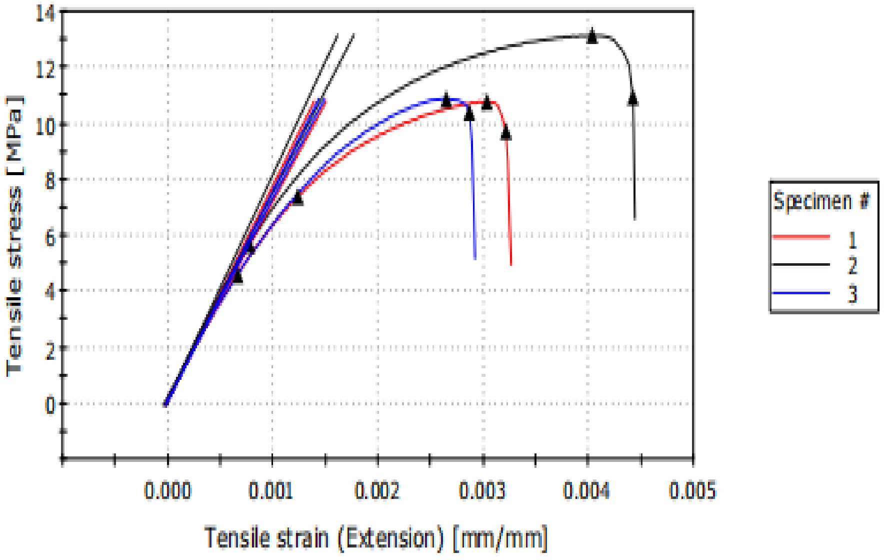
	Maximum Load [N]	Tensile stress at Maximum Load [MPa]	Tensile strain (Extension) at Maximum Load [mm/mm]
1	722.3879	12.6735	0.0042
2	556.7805	9.7681	0.0029
3	582.2026	10.2141	0.0032

	Load at Break (Standard) [kN]	Load at Yield (Offset 0.2 %) [N]	Tensile stress at Yield (Offset 0.2 %) [MPa]
1	0.7130	-----	-----
2	0.3916	-----	-----
3	0.5724	-----	-----

	Tensile strain (Extension) at Yield (Offset 0.2 %) [mm/mm]	Modulus (Automatic) [GPa]	Modulus (Automatic Young's) [MPa]
1	-----	6.0486	6526.40362
2	-----	5.8894	6356.45921
3	-----	5.3300	5751.84578

	Modulus (E-modulus) [GPa]
1	-----
2	-----
3	-----

40% PHP



	Maximum Load [N]	Tensile stress at Maximum Load [MPa]	Tensile strain (Extension) at Maximum Load [mm/mm]
1	615.2073	10.7931	0.0030
2	749.3933	13.1473	0.0040
3	620.2855	10.8822	0.0026

	Load at Break (Standard) [kN]	Load at Yield (Offset 0.2 %) [N]	Tensile stress at Yield (Offset 0.2 %) [MPa]
1	0.5553	-----	-----
2	0.6248	-----	-----
3	0.5939	-----	-----

	Tensile strain (Extension) at Yield (Offset 0.2 %) [mm/mm]	Modulus (Automatic) [GPa]	Modulus (Automatic Young's) [MPa]
1	-----	7.0349	7685.61204
2	-----	7.2783	8056.24629
3	-----	7.1982	7503.78789

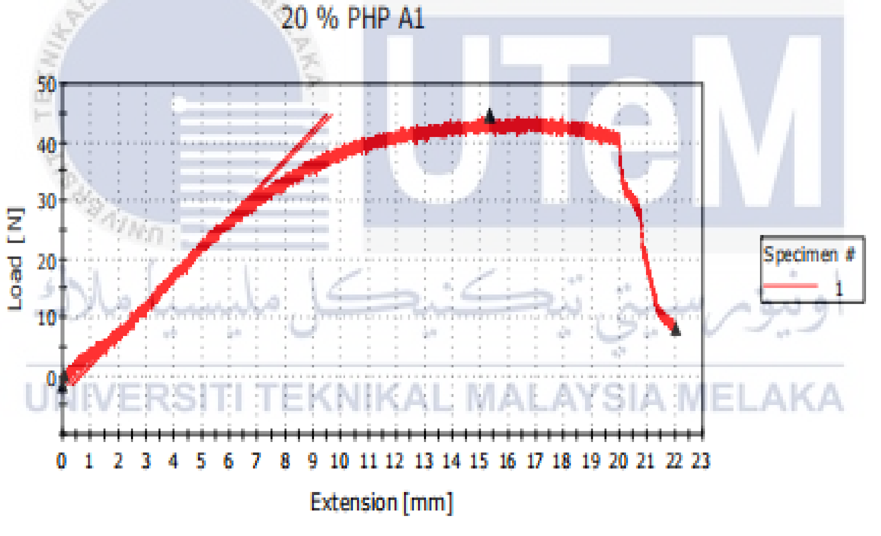
	Modulus (E-modulus) [GPa]
1	-----
2	-----
3	-----

APPENDIX C

Results for Flexural test

Paddy husk PP Composite

Paddy husk PP Composite



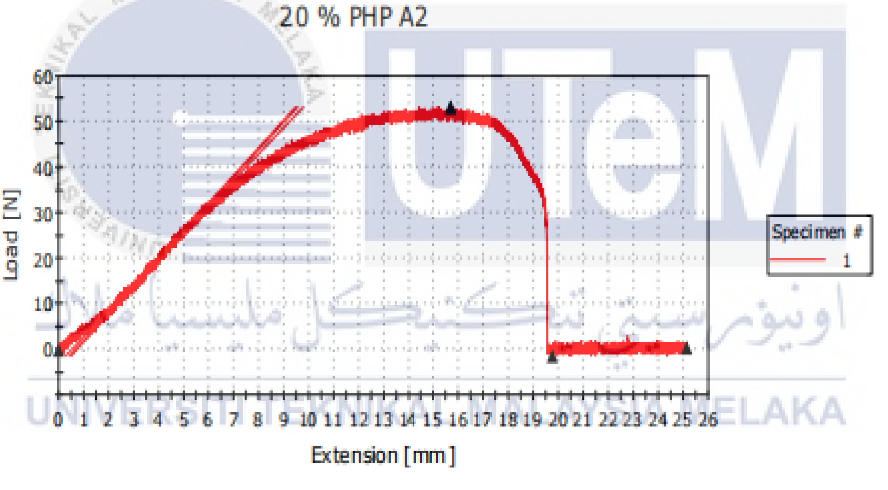
	Maximum Load [N]	Flexure stress at Maximum Load [MPa]	Extension at Maximum Load [mm]	Flexure strain (Extension) at Maximum Load [mm/mm]
1	44.618	26.771	15.333	0.034

	Load at Yield (Zero slope) [N]	Flexure stress at Yield (Zero slope) [MPa]	Flexure strain (Extension) at Yield (Zero slope) [mm/mm]	Flexure extension at Yield (Zero slope) [mm]
1	44.618	26.771	0.034	15.333

	Modulus (Automatic) [MPa]	Modulus (Automatic Young's) [MPa]	Modulus (E-modulus) [MPa]
1	1359.219	1362.013	1308.576

Paddy husk PP Composite

Paddy husk PP Composite



	Maximum Load [N]	Flexure stress at Maximum Load [MPa]	Extension at Maximum Load [mm]	Flexure strain (Extension) at Maximum Load [mm/mm]
1	53.080	31.848	15.680	0.035

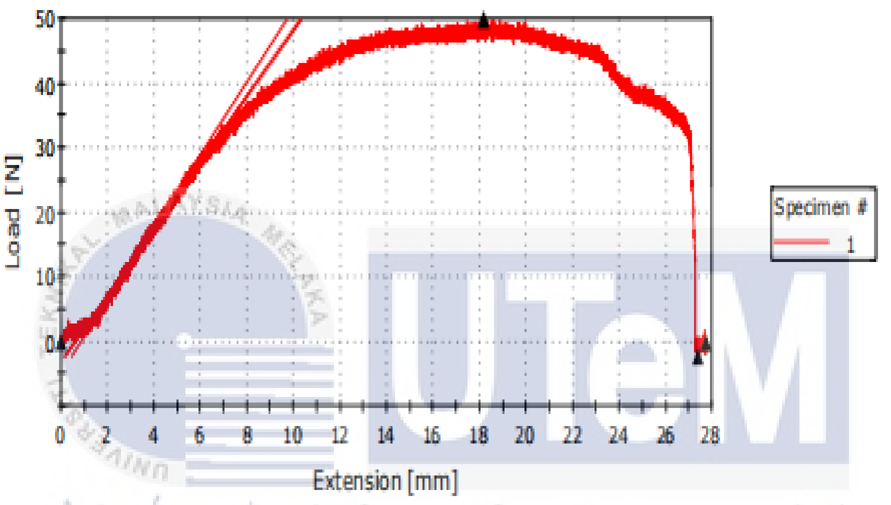
	Load at Yield (Zero slope) [N]	Flexure stress at Yield (Zero slope) [MPa]	Flexure strain (Extension) at Yield (Zero slope) [mm/mm]	Flexure extension at Yield (Zero slope) [mm]
1	53.080	31.848	0.035	15.680

	Modulus (Automatic) [MPa]	Modulus (Automatic Young's) [MPa]	Modulus (E-modulus) [MPa]
1	1615.203	1633.839	1546.899

Paddy husk PP Composite

Paddy husk PP Composite

20 % PHP A3



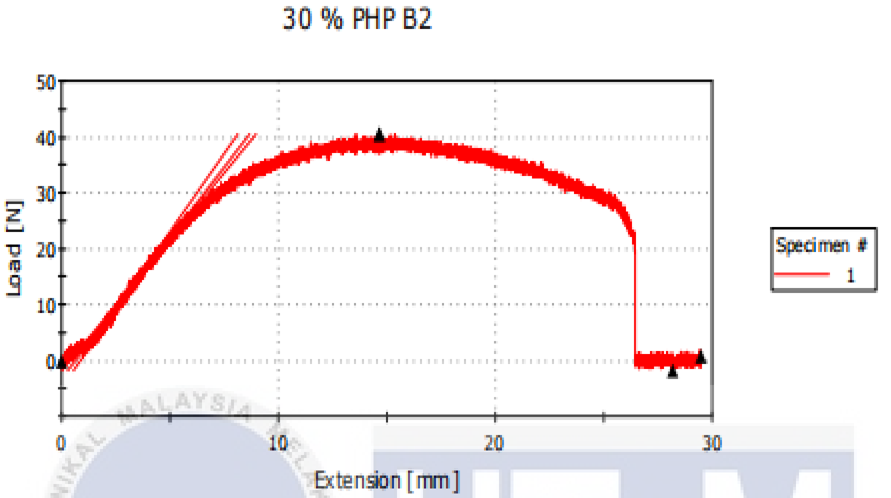
	Maximum Load [N]	Flexure stress at Maximum Load [MPa]	Extension at Maximum Load [mm]	Flexure strain (Extension) at Maximum Load [mm/mm]
1	49.768	29.861	18.147	0.040

	Load at Yield (Zero slope) [N]	Flexure stress at Yield (Zero slope) [MPa]	Flexure strain (Extension) at Yield (Zero slope) [mm/mm]	Flexure extension at Yield (Zero slope) [mm]
1	49.768	29.861	0.040	18.147

	Modulus (Automatic) [MPa]	Modulus (Automatic Young's) [MPa]	Modulus (E-modulus) [MPa]
1	1391.675	1516.112	1374.309

Paddy husk PP Composite

Paddy husk PP Composite



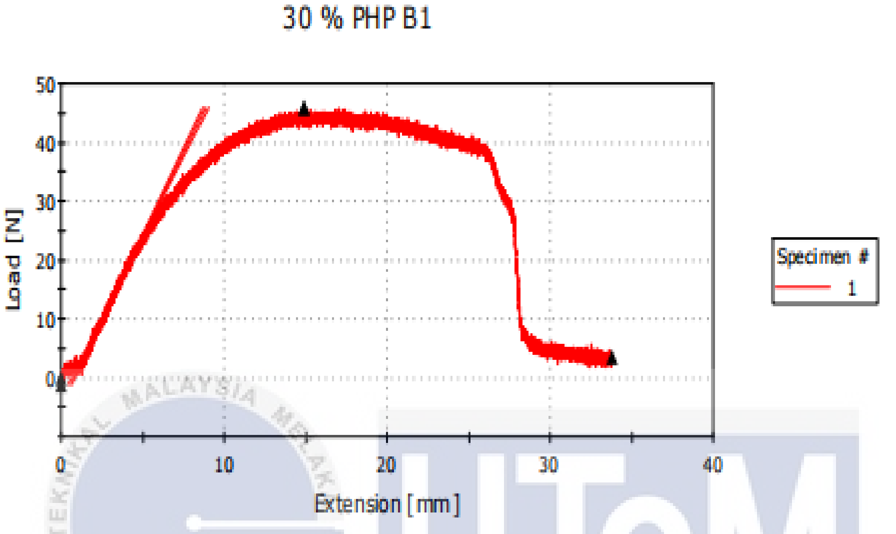
	Maximum Load [N]	Flexure stress at Maximum Load [MPa]	Extension at Maximum Load [mm]	Flexure strain (Extension) at Maximum Load [mm/mm]
1	40.481	24.289	14.633	0.033

	Load at Yield (Zero slope) [N]	Flexure stress at Yield (Zero slope) [MPa]	Flexure strain (Extension) at Yield (Zero slope) [mm/mm]	Flexure extension at Yield (Zero slope) [mm]
1	40.481	24.289	0.033	14.633

	Modulus (Automatic) [MPa]	Modulus (Automatic Young's) [MPa]	Modulus (E-modulus) [MPa]
1	1356.651	1499.681	1269.070

Paddy husk PP Composite

Paddy husk PP Composite

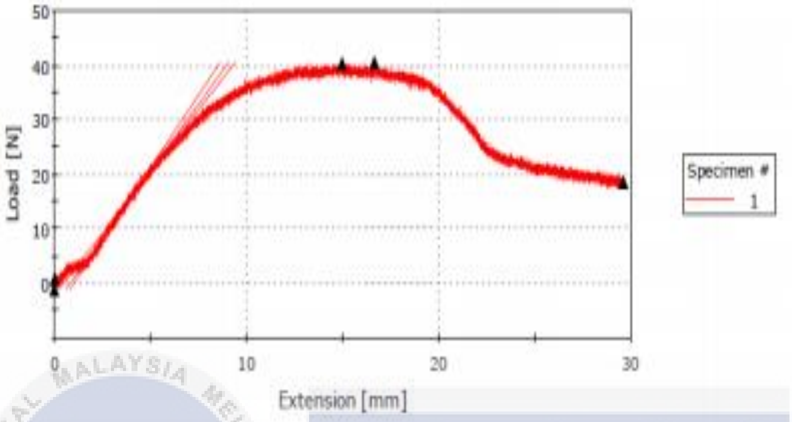


	Maximum Load [N]	Flexure stress at Maximum Load [MPa]	Extension at Maximum Load [mm]	Flexure strain (Extension) at Maximum Load [mm/mm]
1	45.841	27.505	14.877	0.033

	Load at Yield (Zero slope) [N]	Flexure stress at Yield (Zero slope) [MPa]	Flexure strain (Extension) at Yield (Zero slope) [mm/mm]	Flexure extension at Yield (Zero slope) [mm]
1	45.841	27.505	0.033	14.877

	Modulus (Automatic) [MPa]	Modulus (Automatic Young's) [MPa]	Modulus (E-modulus) [MPa]
1	1531.294	1575.856	1468.885

Paddy husk PP Composite

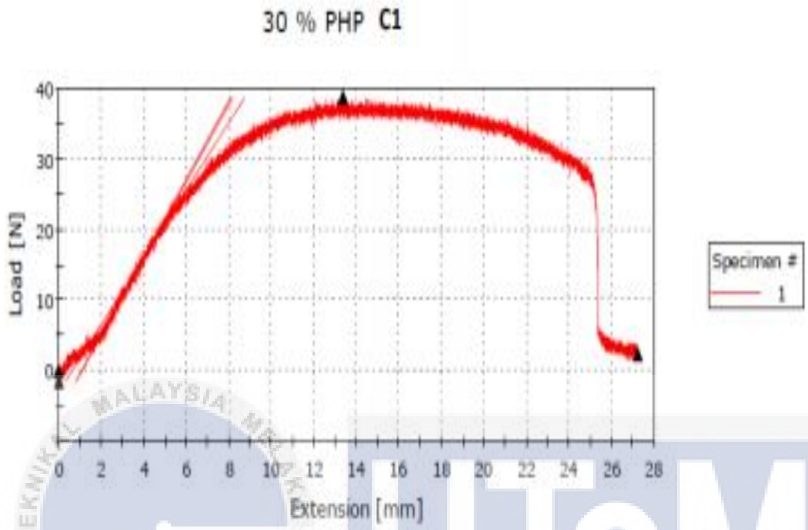


	Maximum Load [N]	Flexure stress at Maximum Load [MPa]	Extension at Maximum Load [mm]	Flexure strain (Extension) at Maximum Load [mm/mm]
1	40.509	24.305	16.643	0.037

	Load at Yield (Zero slope) [N]	Flexure stress at Yield (Zero slope) [MPa]	Flexure strain (Extension) at Yield (Zero slope) [mm/mm]	Flexure extension at Yield (Zero slope) [mm]
1	40.352	24.211	0.033	14.967

	Modulus (Automatic) [MPa]	Modulus (Automatic Young's) [MPa]	Modulus (E-modulus) [MPa]
1	1321.743	1432.480	1220.655

Paddy husk PP Composite



	Maximum Load [N]	Flexure stress at Maximum Load [MPa]	Extension at Maximum Load [mm]	Flexure strain (Extension) at Maximum Load [mm/mm]
1	38.691	23.215	13.360	0.030

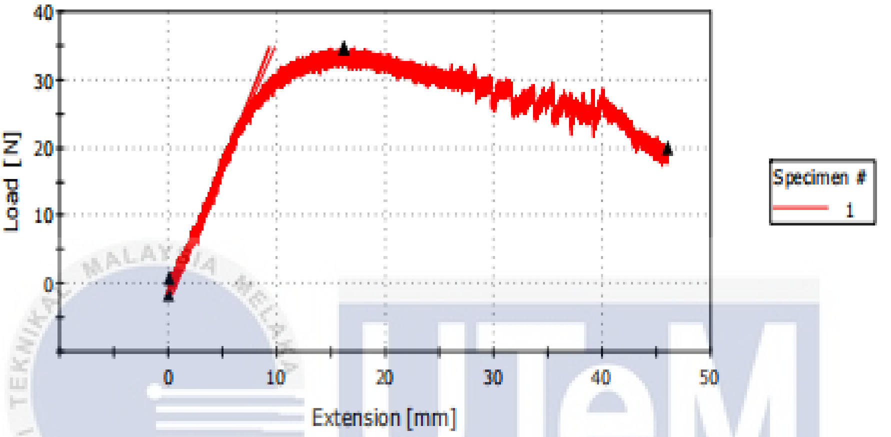
	Load at Yield (Zero slope) [N]	Flexure stress at Yield (Zero slope) [MPa]	Flexure strain (Extension) at Yield (Zero slope) [mm/mm]	Flexure extension at Yield (Zero slope) [mm]
1	38.691	23.215	0.030	13.360

	Modulus (Automatic) [MPa]	Modulus (Automatic Young's) [MPa]	Modulus (E-modulus) [MPa]
1	1461.382	1494.321	1283.056

Paddy husk PP Composite

Paddy husk PP Composite

40 % PHP C2



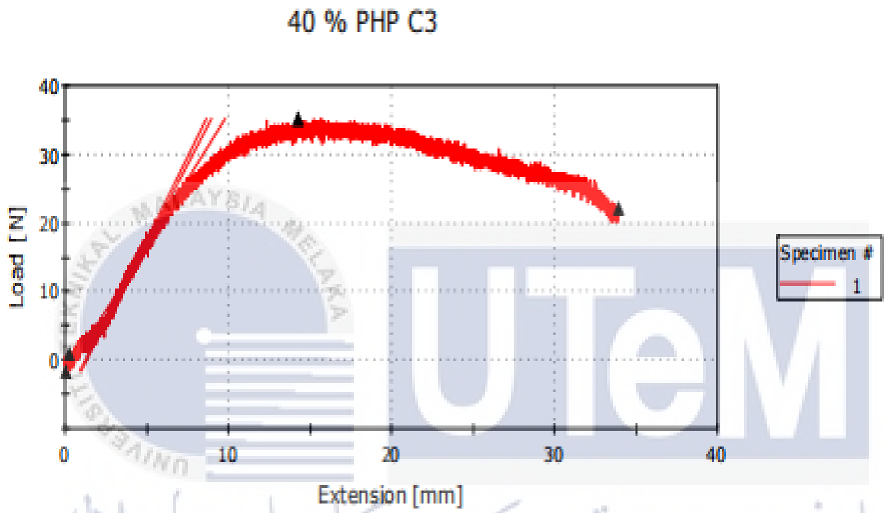
	Maximum Load [N]	Flexure stress at Maximum Load [MPa]	Extension at Maximum Load [mm]	Flexure strain (Extension) at Maximum Load [mm/mm]
1	34.697	20.818	16.140	0.036

	Load at Yield (Zero slope) [N]	Flexure stress at Yield (Zero slope) [MPa]	Flexure strain (Extension) at Yield (Zero slope) [mm/mm]	Flexure extension at Yield (Zero slope) [mm]
1	34.697	20.818	0.036	16.140

	Modulus (Automatic) [MPa]	Modulus (Automatic Young's) [MPa]	Modulus (E-modulus) [MPa]
1	1101.692	1086.014	976.912

Paddy husk PP Composite

Paddy husk PP Composite



	Maximum Load [N]	Flexure stress at Maximum Load [MPa]	Extension at Maximum Load [mm]	Flexure strain (Extension) at Maximum Load [mm/mm]
1	35.177	21.106	14.253	0.032

	Load at Yield (Zero slope) [N]	Flexure stress at Yield (Zero slope) [MPa]	Flexure strain (Extension) at Yield (Zero slope) [mm/mm]	Flexure extension at Yield (Zero slope) [mm]
1	35.177	21.106	0.032	14.253

	Modulus (Automatic) [MPa]	Modulus (Automatic Young's) [MPa]	Modulus (E-modulus) [MPa]
1	1226.353	1295.871	1033.655