UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF RICE HUSK REINFORCEMENT TO THE PROPERTIES OF POLYESTER BIO-COMPOSITE FOR ROOFING PRODUCT.

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Material) with Honours

by

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FACULTY OF MANUFACTURING ENGINEERING

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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APPROVAL

This PSM submitted to the senate of UTeM and has been as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design). The members of the supervisory committee are as follow:

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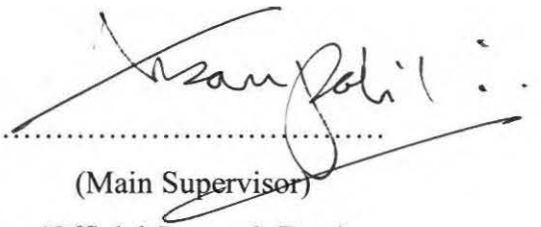

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ABSTRACT

There is a wide choice of materials used to roof a house, ranging from thatch - dried grass, to slate - pieces of stone. Modern products like plastic, thermoplastic, asbestos, fiberglass and concrete are available, and some innovative, energy-efficient homes are being roofed with sod. The rice husk will be a reinforcement that will be mix with Polyester as matrix in order to get the result of the study. Basically the natural fiber will be treated with the alkali treatment. The concentrations such as 2% NaOH with same soaking time which is 5 hours. For the manufacturing process, the rice husk / Polyester is prepared by using Hand Lay Up process with several equipments and tools. 3 pieces specimens of each testing were tested by using the different testing method. The tests that will be conducted are Tensile Test, Hardness Test, Impact Test, Flexural Test, Water Absorption, Thickness Swelling Test and Morphological Study. The results shows the ability of the rice husk become one of the possibility roofing materials. The effects of filler loading and surface modification of rice husks on the mechanical properties and water absorption of the composites were also investigated. The results show that tensile strength increases with increase in the composition and fiber percentage. However, after a certain composition, the tensile strength decreases again. From the tensile test, the results show that the specimen that consists of 15% composition of rice husk gives the higher value of tensile strength and its shows that the tensile strength of that composition much higher compared than asbestos. Water absorption test, shows that the specimen consists of rice husk have a lower % of water absorption, compared than asbestos specimen. This observation was well supported by the microstructure investigations of the fracture surfaces.

ABSTRAK

Berikut adalah berbagai pilihan bahan yang digunakan untuk atap rumah, bermula dari ilalang - rumput kering, untuk batu tulis - potongan-potongan batu. Modern produk seperti plastik, tremoplastik, asbestos, fiberglass dan konkrit yang sedia, dan beberapa inovatif, rumah hemat tenaga sedang beratap dengan tanah. Sekam padi ini akan menjadi penguat yang akan bercampur dengan Poliester sebagai matriks untuk mendapatkan hasil kajian. Pada dasarnya serat alami akan diperlakukan dengan perlakuan alkali. Konsentrasi seperti NaOH 2% dengan waktu perendaman yang sama iaitu 5 jam. Untuk proses manufaktur, sekam padi / Polyester disusun dengan menggunakan Hand Lay Up proses dengan beberapa peralatan dan perkakas-perkakas. 3 buah spesimen masing-masing ujian diuji dengan menggunakan kaedah ujian yang berbeza. Ujian yang akan dilakukan adalah Uji tarik, uji kekerasan, Kesan Uji, Uji lentur, Water Absorption, Ketebalan Swelling Test dan morfologi kajian. Keputusan menunjukkan kemampuan sekam padi menjadi salah satu kemungkinan bahan atap. Pengaruh filler loading dan pengubahsuaian permukaan sekam padi pada sifat mekanik dan penyerapan air dari komposit juga boleh diselidiki. Keputusan kajian menunjukkan bahawa kekuatan tarik meningkat dengan meningkatnya komposisi dan peratusan serat. Namun, setelah komposisi tertentu, kekuatan tarik menurun lagi. Dari ujian tarik, keputusan menunjukkan bahawa spesimen yang terdiri daripada komposisi 15% dari sekam padi memberikan nilai yang lebih tinggi kekuatan tarik dan menunjukkan bahawa kekuatan tarik komposisi yang jauh lebih tinggi berbanding asbestos. Ujian penyerapan air, menunjukkan bahawa spesimen yang terdiri daripada serkam padi mempunyai % lebih rendah penyerapan air, berbanding spesimen asbestos. Kajian ini disokong dgn gambarajah permukaan yang telah diperolehi daripada kajian morphological.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

There is a wide choice of materials used to roof a house, ranging from dried grass, to slate - pieces of stone. Modern products like plastic, fiberglass and concrete are available, and some innovative, energy-efficient homes are being roofed with sod. New products are being developed to overcome the shortcomings of older roofing materials, meet the demands of modern building techniques, and conform to increasingly stringent building codes. What most homeowner's wish is a roof that's not too expensive, requires no maintenance, and lasts forever. But most roofs are replaced or at least repaired every ten years. When the right material are been choose for roofing material, you can reduce the cost of replacement. In the long run, you'll use less building material, fill up less landfill space with unnecessary material, and put less demand on our natural resources.

Nowadays, there are many studied have been made to composite material that reinforced by fibers. For example, rice husk as a fuel for bricks making in the Binh Duong Province of Vietnam. In this research, the researcher objective is to assess the possibility on the rice husk or rice husk briquette as an alternative to wood fuel in Binh Duong province (Nguyen, X.Q. 2000). According to a Philippine scientist, rice husks with less carbon and more silica can be used to produce better quality rice hull ash which can significantly improve the durability of concrete used in building material and substantially replace silica fume as an additive

Polyester were used a matrix materials and the rice husk (natural fiber) as the reinforcement. These materials also widely used for application to variety of structure such as automobile, athletics track, building material, knobs application and many other application. Therefore, in this study, it will be more focusing on rice husk as a natural fiber for roofing material and also the materials (rice husk) properties are describe and proposed the new material are highlighted.

Several testing such as impact testing, hardness testing, tensile testing, flexural testing, water absorption testing and thickness swelling testing will be conducted in order to determine the performance of these proposed material.

1.2 Problem Statements

Natural fibers can be produced in many types of reinforcement composites, such as continuous and discontinuous unidirectional fibers, random orientation of fibers, and so on. By taking the advantages from those types of reinforced composites such as produced good properties and reduced the fabrication cost, they had been used in the development of automotive, packaging and building materials.

From the existing research, roofing product is made from good materials which have a good quality and top class performance. Even though the good material using for roofing product nowadays, but there are still have a limitations. From this statement, research from waste material such as rice husk and matrix haven in Malaysia is doing.

1.3 Objectives of the Project:

The objectives of this project are:

a) To investigate and identify the processing and properties of rice husk reinforce the Polyester Bio-composite for roofing material.

b) Investigate the natural fiber (rice husk) performance in the manner of reinforce Polyester resin matrix.

c) Propose an alternative material using rice husk composite for the roofing material that will consider the ergonomic characteristics.

d) Test and analyze of the new material on tensile strength, elongation, hardness and impact strength.

1.4 Rational Research

a) Produce materials that environmental friendly, abundant source, low health risks, decreasing waste material and has or same mechanical properties like SBR, EPDM and PU.

b) Investigate natural fiber which is rice husk. It performance in the manner of reinforce nylon fiber matrix. Produce the composite material by using the proposed material to replace the existing material and components for roofing product.

c) To use the wasted material transform to valuable materials.

1.5 Scopes of the Project:

It is a project limitation or project area where this project will be focusing on which is to ensure that the project is not run out and still in project scopes and the most important is to ensure this thesis will complete in the specific time. Below are the scopes of the project:-

a) Recommend the new material based on ergonomic purpose for roofing product.

b) Developed and alternative material by using the rice husk composite.

c) The roofing material made by rice husk study will be focusing in Malaysia only.

d) The process method for sample preparation that will be implementing in this study is Hand Lay up Method.

1.6 Thesis Organization

Firstly the reports start with the introduction chapter. This chapter comprise the background of the study, problems statement, objectives, rational of the research, scopes of research, and organization of the report. For the Chapter Two it discussed about the literature review related on the topic of the research which is Study the Mechanical Properties on Bio-composites of Rice Husk and Application to Commercial Products Chapter two are included the introduction of material, mechanical properties of bio-composites materials, mechanical testing, material reparation and summary of the previous research. Than, it continue with the Chapter Three. This chapter was including the process flow chart to describe the overall flow of the research. This chapter further explain the method to manufacturing the product and the objectives stated for the research. After that Chapter Four represent the result that gathered after the testing and observation had been done. Finally, Chapter Five give a conclusion and future work recommendation for this research.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

A literature review is one of the research methods to review the earlier history in order to get the idea, project concept development, project methods and other. A literature review is one of the methods for our references to grab and get more information about some research or product or what else that has done by previous researcher. It viewed the scientific process and concept based on their experimental. Frequently, it comes out like journal, books, article and so on. The component of literature review is the actual research where they use the fact and logical concept that nobody can argue their research.

2.1 Introduction to composites

A composite is any material made of more than one component. The composites materials were used a long time ago. The general classification of composite material is based on the nature of the constituent materials. Historically, the most common structural materials of organic nature are wood. In fact, most modern composites material imitates wood in that they consist of strong fibers embedded in softer supporting material. In addition to their weight advantage per unit volume, some composites provide batter stiffness and strength properties rather than metals (Brent, S.A., 2000). Reinforcement provides strength and rigidity, helping to support structural load. The properties of the area around the resin are much lower than the properties around the fiber (Callister, W. D., Jr., 2003). Composites are usually

classified by the type of material used for matrix. The four primary categories of composites are polymer matrix composite (PMCs), metal matrix composite (MMCs), ceramic matrix composite (CMCs) and carbon / carbon composite (CCCs). However, only the polymer matrix composite will be discuss in this section.

In their broadest form, composites are the result of embedding high-strength, high-stiffness fiber of one material in a surrounding matrix of another material. The fiber if interests for composites are generally in the form of their single fibers about the thickness of a human hair or multiple fibers twisted together in the form of a yarn or two. In forming fiber reinforcement, the assembly of fibers to make fiber forms for the fabrication of composite material can take the following forms as shown in figure 2.1.

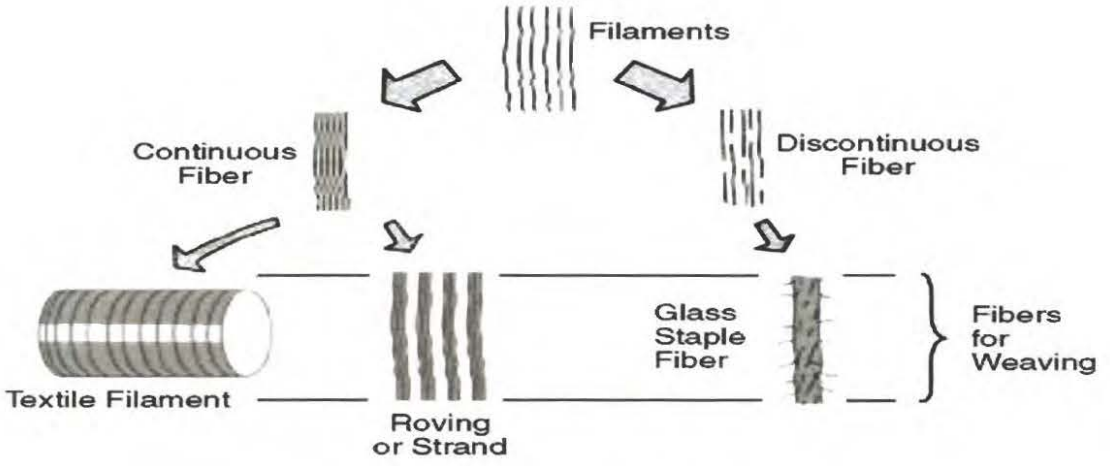

Figure 2.1: Different Fiber Form (Stephen, W.T, *et al.*, 2003).

2.1.1 Polymeric Matrix Composite (PMC)

Polymer Matrix Composite is frequently divided into two categories which is reinforced plastics and advanced composite. The similarity based on the level of mechanical properties. These materials consist of strong fibers embedded in a resilient plastic that holds them in place. The most common advanced composites are polymer matrix composites. These composites consist of a polymer resin as the matrix with fibers as the reinforcement medium (Callister, W. D., Jr., 2003).

The properties of the composite depend on the matrix, reinforcement and the boundary layer between two items called "intherphase". There are many variable to consider when designing the composite. The variables included are type of the matrix, type of the reinforcement, their relative proportions, and geometry of the reinforcement and the nature of the intherphase. These materials can be fashioned into a variety of shapes and sizes. PMC one of the low cost, high strength and simple manufacturing principles compared than other material.

2.2 Matrix

The matrix will affect a minor role in the tensile load-carrying capacity of a composite structure. But, selection of matrix has a major authority on inter laminar shear as well as on in-plane shear properties of the composite materials. Inter laminar shear strength is an important design consideration for structures under torsion loads. The matrix provides lateral support against the possibility of fiber buckling under compression loading, thus influencing to some extent the compressive strength of the composite materials. The interactions between the fibers with the matrix are very important in designing damage-tolerant structures.

The role of the matrix in a fiber-reinforces composite is:

a) To transfer stresses between the fibers
b) To provide a barrier against an adverse environment
c) To protect the surface of the fibers from mechanical abrasion

2.2.1 Type of Polymer

There are two types of polymers used using in industrial which is plastic and elastomer. There are two major classes of plastics; thermoplastic and thermoset. Thermosets are materials that undergo a curing process during part fabrication, after which they are rigid and cannot be reformed. Thermoplastics on the other hand, can

be repeatedly softened and reformed by application of heat. Thermoplastics are often subdivided into several types; amorphous, crystalline and liquid crystal. There are numerous types of polymers in both classes.

Polymer are an important class of material because they possess very wide range of application and properties such as mechanical, physical and chemical and very established of structure. Thermoset which are obtained by cross linking polymer chains, thermoset material cannot return to the original and do not become soft to any significant extent with increasing temperature. Table 2.1 is show that the comparison of typical ranges of property values for thermosets and thermoplastics and table 2.2 shown the Comparison Thermosets and Thermoplastics.

Table 2.1: Comparison of Typical Ranges of Property Values for Thermosets and Thermoplastics (Matthews and Rawlings (1999)).

Properties	Thermoset	Thermoplastic
Young's modulus (GPa)	1.3-6.0	1.0-4.8
Tensile strength (MPa)	20-180	40-190
K_{Ic} (MPa $m^{1/2}$)	0.5-1.0	1.5-6.0
G_{Ic} (kJ/m^2)	0.02-0.2	0.7-6.5
Maximum service temperature	50-450	25-230
Tensile Properties	Excellent	Excellent
Fatigue Resistant	Excellent	Good
Processing Pressure Mpa(psi)	0.59 – 0.69 (250 – 600)	1.38 – 2.07 (200 – 300)
Processing Temperature ^{0}C (^{0}F)	121-315 (85-100)	343- 427 (650-800)
Health / Safety	Excellent	Excellent

Table 2.2: Comparison Thermosets and Thermoplastics (Callister, W. D., 2007)

Material	Advantages	Disadvantages
Thermoset	• High thermal stability • High rigidly • High dimensional stability • High strength with hardness and stiffness • Good wetting and adhesion to reinforcement	• Cannot be reshape • Resins and composite materials must be refrigerated • Long process cycles • Reduced impact –toughness • Poor recycling capabilities
Thermoplastic	• Easy to process • Good corrosion resistant • Can return to the original shapes • Can withstand with a high temperature • They are easily molded	• Decreased durability • Becoming soft when heated

2.2.2 Thermosets

Thermosets are Polymers which do not melt when heated. Thermosets molecules are cross-linked by strong covalent intermolecular bonds, forming one giant molecule. Cross-linking is irreversible therefore thermosets can not be reprocessed (re-melt). Cross-linking is achieved in curing process initiated by heat, chemical agents or radiation. Before curing processing thermoset materials are stored in partially polymerized condition. Vulcanization (cross-linking, curing) results in sharp increase of strength, elasticity and stability of thermosets. Thermosets are stronger and stiffer than Thermoplastics. Stiffness of thermosets is even higher than some metals (aluminum). Thermosets also have higher thermal, chemical and creep resistance than thermoplastics. Thermoset materials may contain filler materials in form of powder or fibers, providing improvement of specific material properties (strength, stiffness, Modulus of Elasticity, thermal resistance, and lubricity). Common filler materials are glass in various forms, metal powders, graphite or molybdenum disulfide powder.

2.2.3 Matrix Material

Although thermoplastic and thermoset materials can be reinforced, a composite with very short fibers tends to have thermoplastic as matrix elements (Strong, 2006). For this study, we use Polyester resins are the simplest, most economical resin systems that are easiest to use and show good chemical resistance. Almost one half million tons of this material is used annually in the United States. Unsaturated polyesters consist of unsaturated material, such as malefic anhydride or fumaric acid that is dissolved in a reactive monomer, such as styrene. Polyester resins have long been considered the least toxic thermoset to personnel, although recent scrutiny of styrene emissions in the workplace has led to the development of alternate formulations. Most polyester is air inhibited and will not cure when exposed to air. Typically, paraffin is added to the resin formulation, which has the effect of sealing the surface during the cure process. However, the wax film on the surface presents a problem for secondary bonding or finishing and must be physically removed. Non-air inhibited

resins do not present this problem and are therefore, more widely accepted in the marine industry (Matthews et al., 1994).

The two basic polyester resins used in the marine industry are orthophthalic and isophthalic. The ortho resins were the original group of polyesters developed and are still in widespread use. They have somewhat limited thermal stability, chemical resistance, and processability characteristics. The iso resins generally have better mechanical properties and show better chemical resistance. Their increased resistance to water permeation has prompted many builders to use this resin as a gel coat or barrier coat in marine laminates.

The rigidity of polyester resins can be lessened by increasing the ratio of saturated to unsaturated acids. Flexible resins may be advantageous for increased impact resistance; however, this comes at the expense of overall hull girder stiffness. Nonstructural laminate plies, such as gel coats and barrier veils, are sometimes formulated with more flexible resins to resist local cracking. On the other end of the spectrum are the low-profile resins that are designed to minimize reinforcement print-through (Matthews et al., 1994).

Typically, ultimate elongation values are reduced for these types of resins, which are represented by DCPD. Curing of polyester without the addition of heat is accomplished by adding accelerator along with the catalyst. Gel times can be carefully controlled by modifying formulations to match ambient temperature conditions and laminate thickness (Matthews et al., 1994).

Table 2.3: Mechanical Properties for selected material (CES EDU pack – Material Selection Software)

No	Material / Properties	Teflon (PTFE)	Nylon 6,6	Nylon 6,10	ABS	Polyester
1	Density (g/cc)	0.700 – 2.30	1.02 – 1.49	1.02 – 3.80	0.350 – 1.26	1.8e3-2.2e3
2	Yield strength (Mpa)	15.00 – 27.6	11.0 – 135	50 – 393	40.0 -95.1	50.4-110
3	Tensile strength (Mpa)	10.00 – 45.0	20.7 – 170	30.0- 237	20.0 – 65.0	63-138
4	Compressive strength (Mpa)	1.5 – 23.5	7.00 – 90.0	68.9 – 179	30 – 55	103-207
5	Hardness – Rockwell	Shore D50 – D65	93.0 – 123	111- 122	90.0 -121	56-62
6	Young Modulus (Gpa)	0.4 – 0.552	-	0.8 – 44.2	-	7.9-17.2
7	Thermal Expansion ($10^{-4}/^{0}C$)	25	20	23	24 – 33	10.8-54
8	Resistance to heat (^{0}C)	287	80- 150	80 – 120	60 – 98	-
9	Water absorption %	0.000 – 0.100	0.420 – 9.00	0.100 – 1.5	0.2 – 0.45	0.01-0.25
10	Shear Strength (Mpa)	9.31 – 25.5	50.0 – 73.8	65.5 – 79.0	-	-

Table 2.4: Advantages and Disadvantages for Selected Material (Engineering Material, 2007).

Material	Advantages	Disadvantages
Nylon	Tough, strong and impact resistant Low coefficient of friction Abrasion resistance High temperature resistance Process able by thermoplastic method Good solvent resistance Resistant to bases	High moisture absorption with related dimensional instability Subject to attack by strong acids and oxidizing agents Requires ultraviolet stabilization High shrinkage in molded sections
Polyester	Water (fresh) Excellent Water (salt) Excellent Weak acids Acceptable Weak alkalis Unacceptable Strong alkalis Organic solvents UV radiation (sunlight) Oxidation at 500C	Cannot recycle
ABS	High impact resistance with toughness and rigidity Good electrical properties Excellent adhesion by metal coatings Fairly good weather resistance and high gloss	Poor solvents resistance Subject to crack by organic materials of low molecular mass Low dielectric strength Only low elongation available