A COMPARATIVE STUDY OF MECHANICAL AND THERMAL CONDUCTIVITY PROPERTIES OF AN INSULATION PARTICLEBOARD

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DECLARATION

I declare that this project report entitled "A Comparative Study of Mechanical and Thermal Conductivity Properties of an Insulation Particleboard" is the result of my own except as cited in the references.

Signature	:	....
Name	:	....
Date	:	....

APPROVAL

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

Signature : ....

Name : ....

Date : ....

DEDICATION

To my beloved, mother and father.

ABSTRACT

In the last few ten years, many researchers have tried to find new material that would be used in the industry with better properties and friendly environmental. Nowadays, as the earth in a critical condition with much pollutions, green energy technology has been introduced as a way to save the planet. Because of the pressure on slow-growing and save trees, many studies have been carried out to evaluate new, environmentally friendly raw materials for the production of particleboards. In this situation, agricultural waste has shown remarkable potential as a particleboard raw material, since the chemical composition of such waste is similar to that wood. Sugarcane bagasse is a potentially exciting substitute for wood in particleboards manufacturing because it has a similar composition than wood but in different proportions composition approximately 32–34% cellulose, 19–24% hemicellulose, 25–32% lignin, 6–12% extractives, and 2–6% ash. Sugarcane bagasse also has great tensile strength and hardness. Thus, it has the potential to be used as reinforcement in composites. This study aims to fabricate new particleboard insulation composites with low thermal conductivity coefficients using bio-based waste materials. Using wasted material such as sugarcane bagasse would be more green energy and save the environment. The percentage of fiber and polypropylene content use is 10%:90%, 20%:80% and 30%:70%. The result of testing is then compared to the previous research. From the result, sugarcane fiber composite is suitable for making low thermal conductivity particleboard.

ABSTRAK

Dalam beberapa tahun kebelakangan ini, banyak penyelidik telah berusaha mencari bahan baru yang akan digunakan dalam industri dengan sifat yang lebih baik dan persekitaran yang aman. Pada masa kini, sebagai bumi dalam keadaan kritikal dengan banyak pencemaran, teknologi tenaga hijau telah diperkenalkan sebagai cara untuk menyelamatkan planet ini. Oleh kerana tekanan pada pokok tumbuh perlahan dan menyelamatkan, banyak kajian telah dilakukan untuk menilai bahan mentah baru yang mesra alam untuk pengeluaran papan partikel. Dalam keadaan ini, sisa pertanian telah menunjukkan potensi yang luar biasa sebagai bahan mentah papan zarah, kerana komposisi kimia sisa tersebut serupa dengan kayu itu. Tebu tebu adalah pengganti yang berpotensi menarik untuk kayu dalam pembuatan papan partikel kerana mempunyai komposisi yang serupa dengan kayu tetapi dalam komposisi perkadaran yang berbeza kira-kira 32–34% selulosa, 19–24% hemiselulosa, 25–32% lignin, 6–12% ekstrak, dan 2–6% abu. Tebu juga mempunyai kekuatan tegangan dan kekerasan yang hebat. Oleh itu, ia berpotensi untuk digunakan sebagai penguat dalam komposit. Kajian ini bertujuan untuk membuat komposit penebat papan partikel baru dengan pekali kekonduksian terma yang rendah menggunakan bahan buangan berasaskan bio. Menggunakan bahan terbuang seperti tebu akan menjadi lebih banyak tenaga hijau dan menyelamatkan alam sekitar. Peratusan penggunaan kandungan serat dan polipropilena ialah 10%: 90%, 20%: 80% dan 30%: 70%. Hasil pengujian kemudian dibandingkan dengan kajian sebelumnya. Dari hasilnya, komposit serat tebu sesuai untuk membuat papan partikel kekonduksian terma rendah.

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UHMWPE	Ultra High Molecular Weight Polyethylene
ISO	International Organization for Standardization
MPa	Mega Pascal
GPa	Giga Pascal
℃	Degrees Celsius
%	Percentage
k	Thermal Conductivity
Q	Heat Flow
L	Length
ΔT	Temperature difference
T2	Final Temperature
T3	Heated section Low Temperature
T6	Cooled section High Temperature
T7	Cooled section Mid Temperature

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

In the last few decades, many researchers have tried to find new material used in the industry with better properties and friendly environmental. Nowadays, as the earth is in a critical condition with much pollution, green energy technology has been introduced to save the planet. Therefore, citizens are increasingly worried about the use of green materials for the industry to preserve the environment. Many research projects have currently been undertaken to find the latest alternative to current industrial materials.

In the 19th century, modern plywood was invented as the first alternative to natural wood. Plywood is made from thin wood and bonded together with an adhesive. By the end of the 1940s, the particleboard was introduced as a new popular alternative because of the lack of timber available to manufacture plywood affordably (S. A. Abdulkareem, Raji, & Adeniyi, 2017).

Particleboard has been the common building material used in almost all types of construction projects. It was commonly used because it’s made from the combination of waste materials and glued together with formaldehyde-based adhesive and synthetic resin and then compressed under hot pressure (Ibe Kevin et al., 2018). Some typical applications of these materials include indoor and outdoor use such as floors, walls, ceilings and office splitters. Conventionally, fibers and wood particles are the most commonly used raw materials in the particleboard industry. Due to slow-growing pressures and the protection of trees, many studies were carried out to determine new eco-friendly raw materials for the production of particleboards.

In this situation, agricultural waste has also shown a huge potential as a particleboard raw material, as the chemical composition of such waste has been close to that of wood. Among the wastes used for producing particleboards are corn cob, coconut husks and sugarcane. A large number of such waste are generated worldwide annually, which are mostly poorly recycled into products of added value.

In Malaysia, 1 tonne of sugarcane has produced for instance, which generally generates around 280 kg of bagasse for one cycle (Daud, Salleh, Salleh, & Straw, 2007). The fibrous are remaining by-product after extracted from sugarcane. Roughly 54 million dry tons of bags are produced annually around the world (Aminudin et al., 2017). Sugarcane bagasse is a potentially exciting substitute for wood in particleboards manufacturing because it has a similar composition than wood but in different proportions composition approximately 32–34% cellulose, 19–24% hemicellulose, 25–32% lignin, 6–12% extractives, and 2–6% ash (Haghdan, Renneckar, & Smith, 2015). Sugarcane bagasse has also a satisfactory modulus and tensile strength. Thus it has the potential to be used as reinforcement in composites.

In this technological era, the industrial factory fields are the source of human quality life. The environment problem like heat pollution also occurs because of this factor. Many researchers have attempted to reduce this kind of pollution. It based on the use of insulator materials such as porous materials like wool and fiber. Agriculture also wastes some of the insulator materials, and these materials called green materials. Many types of materials have been manufactured, such as rice straw, hemp, coconut coir and sugarcane.

1.2 PROBLEM STATEMENT

Insulation particleboards are widely used among people in many sectors. However, the existing insulation particleboards usually are entirely made with wood as the primary source. The rapid growth of particleboard in the market has made the demands of wood increasing. Therefore the cost to produce wood particleboard is increasing. The wood itself as resources is limited to obtain due to the massive destruction of trees done by illegal logging activities. The rising temperature also happens because of the illegal logging activities.

Due to this, people living with an unbearable situation with the heat surrounding environment and less privacy of their conversation. Therefore, the world needs to look for alternatives replacing wood for insulated particleboard that made from wasted agriculture such as sugarcane bagasse.

This study aims to fabricate new particleboard insulation composites using bio-based waste materials with low thermal conductivity coefficients. Using wasted material such as sugarcane bagasse is more green energy and save the environment.

1.3 OBJECTIVE

The objective of this project are:

I. To produce a new insulation particleboard with a low heat transfer coefficient.

II. To compare the mechanical performance and thermal insulation this particleboard with previous study.

1.4 SCOPE OF PROJECT

The scope of this study are:

I. Preparation of sugarcane bagasse as raw material for the fabrication of particleboard.

II. The fabrication of particleboard will be conducted with using 10%, 20% and 30% of sugarcane bagasse fiber.

III. The polypropylene will use as binder.

IV. The particleboard will be fabricated using hot press machine.

V. The particleboard will be test on

- Mechanical properties on its tensile strength and hardness
- Thermal insulation conductivity.

VI. The result will be compare with the previous studies of particleboard.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

In this chapter, the literature review is focused on the objective and scope of the project. The purpose of this chapter is to study from past researchers. This chapter contains five main topics, which are the thermal insulation, composite properties, type of binders, the use of natural fiber, and the experimental test.

2.1 THERMAL INSULATION

Thermal insulation is a technology that helps to slow down the rate of heat transfer by reducing the mechanism of heat convection, conduction, and radiation. The thermal insulation function is to maintain the temperature within the building by delaying the heat transfer. By using this method on the building, the energy consumption by the human can be conserved. This statement is supported by Lucero-álvarez, Rodríguez-Muñoz, & Martín-Domínguez, (2016) that said, that thermal insulation can reduce the energy consumption in the buildings. By applying this method in walls and roofs, the uses of daily air conditioning can be reduced.

2.1.1 APPLICATION OF THERMAL INSULATION

Other than the building, the thermal insulation system also appropriates in the automotive sectors. Thermal insulation particleboard can be mounted both on the roof and on the armrest of the door panel. This technology will help improve the thermal comfort of the car and provide passengers with a smoother ride. The lightweight of the composite thermal insulation system installed in a vehicle is assumed can reduce the car's fuel consumption.

According to the present study by Al-Oqla & Sapuan, (2014), the uses of fiber in the automotive industry could already be found in the 1960s when coconut coir being used to make the car seats and polypropylene composites used as substrates for the interior of the car.

2.2 COMPOSITE

2.2.1 Definition of Composite

The composites are each of them retains its characteristics but absorbed into other components to enhance their properties (Florea & Manea, 2019). In the process of producing the composite material, the right types of binders need to be consider. It is supported by Binici, Aksogan, & Demirhan, (2016) that said, strong kind of adhesive or resin, the size, and reinforcement method can influence the product's mechanical properties.

The researchers have done a lot of studies on composite itself. Usually, most studies are carried out to find the mechanical or physical properties of the composite material. Particleboard or panel form product has set as the sample for applying this application. Liao, R., Xu, J & Umemura, (2016), fabricated low density particleboard that contains a composition of sugarcane bagasse, water, citric acid, and sucrose were done with different percentage of densities which is 0.30, 0.35, 0.40, 0.50 g/cm^3. Sucrose and citric acid were initially mixed and diluted into water using the mixer machine under a ratio of 1:1. The concentration of the solution was 30 gram citric acid and 30 gram sucrose per 100 gram solution. The solid additives nitric and sucrose accounted for 10%, 20%, 30%, and 40% of the oven-dried particle was used as an adhesive and then sprinkled onto the particles. The process proceeds by placing homogeneous single-layered into 320 × 320 mm mold. The mold was then hot-pressed at a temperature of 170 °C at 2 MPa for 8 minutes. The board thickness was regulated by 7 mm-thick distance bars. After that, the mold is left to be cooled at room temperature.

2.2.2 Hybrid composition

Hybrid composition materials are defined as the combination of two or more different types of fibers in the same binder. It is possible to obtain new properties or characteristics from a hybrid composite material that is not in a single type of reinforcement. Usually, the hybrid composites material was used to reinforce one material with the other's material to increase the physical and mechanical properties of their combination. Not many researchers study hybrid composite using a source from natural fibers to combine as filler. In hybrid composites, they usually use one natural fiber and one non-natural fiber (glass) combined with a binder.

Zhang & Hu (2014) has done studied hybrid composite using natural fibers as filler. The study used rice straw particles and coir fibers as the filler to reinforce with polypropylene to find the behavior of the hybrid composites. Table 2.1 shows the composition of weighted PP samples, rice straws, and coir fibers corresponding to the fiber content. The composition is prepared by combining it with an internal mixer at 60 rpm speed and 180 °C temperature for 8 minutes. The composite material is then ground to achieve the structural fibers' granular form using a pilot-scale grinder. After that, the granule is dried on a vacuum oven at 130 ℃ for 3 hours. Then the sample is fabricated using a compression molding machine with a pressure of 20 MPa at 190℃. The tested samples are left at room temperature for at least two days before testing.

Table 2.1: Composition of the studied (wt %)

(Source: Zhang & Hu, 2014)

TYPE	Polypropylene content (% by wt)	Rice husk content (% by wt)	Coir fibers content (% by wt)
A	60	30	10
B	60	20	20
C	60	10	30
D	50	30	20
E	50	20	30