RESEARCH AND DEVELOPMENT OF FIRE RETARDANT KENAF FIBER FOR HEAT AND FIRE INSULATOR APPLICATION

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DECLARATION

I declare that this thesis entitled “Research and Development of Fire Retardant Kenaf Fiber for Heat and Fire Insulator Application” 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 : Meryl

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Date : 18 JANUARY 2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours.

Signature : ----------

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DEDICATION

This study is wholeheartedly dedicated to my beloved parents Tomy Pangot and Pita Liran Erang who have been my source of inspiration and continually provide me moral, spiritual, emotional, and financial support. To my siblings, Miani, Walter, Margret and Mawarita, lectures, course mates and friends who shared their words of advice and encourage me to finish this research. Thank you so much.

ABSTRACT

Nowadays, awareness towards environmental issues increases significantly where people have learned the important of protecting environment for a better future. Thus, this study have explore the kenaf fiber embedded with fire retardant liquid by producing a heat and fire insulator application. The samples is 200 mm x 2000 mm x 40 mm in size, with fixed composition of kenaf fiber but different fire retardant ratios. The sample is prepared by combining 184g kenaf fiber with 5% of fire retardant and gradually increasing the amount of fire retardant until 25%. It take approximately one hour for the kenaf fiber and fire retardant mixture to completely mixed. The samples are then dried for 2 to 3 days at room temperature with good ventilation surrounding. Thermal testing, fire testing and acoustic testing have been performed as part of this study. The outcome of this study is that the performance of sample as a good insulator depends in the composition ratios of fire retardant and also the density of the sample. The use of kenaf fiber embedded with fire retardant is to produced an excellent performance of heat and fire insulators.As a result, sample S1 with the highest value of thermal conductivity which is 0.4472 W/mK and temperature different of 240°C, sample S6 with the higher percentage of non-burn fiber which is 98.103% and lastly, sample S3 which have reached the highest peak of 0.9104 coefficient at 1259 Hz and at 1600 Hz with coefficient of 0.9091 was obtained. This study suggest that this study sample have a potential to replace the current insulator used in industry.

ABSTRAK

Pada masa kini, kesedaran terhadap masalah alam sekitar meningkat dengan ketara, ramai telah mempelajari pentingnya melindungi alam sekitar untuk masa depan yang lebih baik. Oleh itu, kajian ini telah mengkaji serat kenaf yang disertakan dengan cecair tahan api untuk membuat aplikasi penebat haba dan api. Sampel berukuran 2000 mm x 200 mm, dengan nisbah serat kenaf yang sama tetapi berbeza nisbah cecair tahan api yang berbeza telah dihasilkan. Sampel disediakan dengan menggabungkan serat kenaf seberat 184 g dan 5% cecair tahan api dan secara beransur-ansur meningkatkan jumlah cecair tahan api sehingga menjadi 25%. Kira-kira satu jam diperlukan untuk campuran serat kenaf dan cecair tahan api sepenuhnya bercampur. Sampel kemudian dikeringkan selama 2 hingga 3 hari pada suhu bilik dengan pengudaraan yang baik di sekitarnya. Ujian terma, ujian api dan pengujian akustik dilakukan sebagai sebahagian daripada kajian ini. Hasil kajian ini ialah prestasi sampel sebagai penebat yang baik bergantung kepada nisbah komposisi kalis api dan juga ketumpatan sampel. Penggunaan cecair tahan api yang dicampur dengan serat kenaf diharapkan dapat menghasilkan kualiti penebat panas dan api yang baik.Hasilnya, sampel S1 dengan nilai kekonduksian terma tertinggi iaitu 0.4472 W/mK dan perbezaan suhu 240°C, sampel S6 dengan peratusan gentian tidak terbakar yang lebih tinggi iaitu 98.103% dan terakhir, sampel S3 yang telah mencapai puncak tertinggi iaitu pekali 0.9104 pada 1259Hz dan pada 1600Hz dengan pekali 0.9091 telah diperolehi. Kajian ini mencadangkan sampel kajian ini berpotensi untuk menggantikan penebat semasa yang digunakan dalam industri.

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LIST OF SYMBOLS

d	-	Diameter
ρ	-	Density
λ	-	Thermal Conductivity
θ_{mean}	-	Mean Temperature
mm	-	Millimeter
kg	-	Kilogram
˚C	-	Degree Celcius
W/m.K	-	Watts per meter-Kelvin
m^3	-	Cubic meter
Hz	-	Hertz
K	-	Kelvin
N	-	Newton

LIST OF ABBREVIATIONS

NS	-	Nylon
PU	-	Polyurethane
FR	-	Fire Retardant
TRMS	-	Thermo Reflective Multilayer
SEM	-	Scanning Electron Microscope
LKTN	-	Lembaga Kenaf dan Tembakau Negara
PVC	-	Polyvinyl Chloride
ASTM	-	American Standard Testing Material

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CHAPTER 1

INTRODUCTION

This chapter will explain and clarify about background, characteristic and behaviour of kenaf fiber and fire retardant for fire and heat insulator application. This research is an idea that consists of fundamental theory on past research, book, journal and online sources. Hence, the information and issue are gathered to identify the improvement needed for this research.

1.1 Background

In the past years, green building materials, particularly insulating materials made from renewable resources, are in high demand. As a result of the growing need to conserve energy, the use of natural materials has become increasingly important (Korjenic et al., 2011). Fiore et al. (2020) identifies that the natural fibre is divided into three types which are vegetable, mineral and protein fibre. For vegetable type, it can be obtained from plants which are the seed, stem, leaves and fruit. While for protein type, it can be obtain from animal which are the hair, fur and secretions. In another study, Florea and Manea (2019) mentioned that the developments of natural fiber are an important opportunity to produce materials from renewable sources in order to construct sustainable buildings. Furthermore, they also state that natural fibers are qualified because it has a low impact on the environment that use local raw materials, thus achieving the lowest impact and if possible positive on human life.

According to Takagi (2019), natural fiber-reinforced polymers composites have many unique functional properties, such as thermal insulation, biodegradability, and vibration damping capacity, in addition to acceptable mechanical properties. It was also mentioned that

the functionalities of natural plant fibres are derived from both chemical and microstructural characteristics. Therefore, the natural fibre used as reinforcement must be carefully chosen in order to achieve acceptable functional results. Muthukumar et al. (2020) have investigated the analysis of thermal conductivity and thermal resistance of natural fibre composites made of banana, pineapple, and jute. They discovered that combining natural fibres has a significant impact on thermal properties such as thermal resistance and thermal conductivity in this study.

In the past year, Zach et al. (2013) noted that natural fibre has gotten a lot of attention as an insulation material, especially in the construction and reconstruction of existing buildings to implement effective energy-saving measures. A research study by Bozsaky (2019) also found that because heating our building consumes 30 % of total energy consumption, reducing energy consumption has become a priority for engineers. In addition, it was also investigate the thermal conductivity of some thermal insulation based natural fiber where the author found that bamboo fiber has the highest thermal conductivity which is 0.080 to 0.340 W/mK followed by coconut fiber 0.040 to 0.050 W/mK, palm fiber of 0.041 W/mK. However, there are some negative characteristic of material based on natural fiber where it has high wettability (Atmakuri et al., 2020), high water absorption (Väisänen et al., 2017) and poor response to fire (Kim et al., 2018).

In conclusion, many intriguing findings demonstrating the utility of natural fibre in insulation applications have been reported. However, the majority of studies in the open literature did not look into the potential of kenaf fibre embedded with a fire retardant for use as a heat and fire insulator. As a result, this study will look into the potential of kenaf fiber embedded with fire retardant for use as a heat and fire insulator.

1.2 Problem Statement

In 2019, Abu-jdayil observes that because they are constantly exposed to weathering and stresses, thermal insulation materials must meet certain standards. As a result, they must be extremely durable and maintain their thermal insulation properties. Ramasubbu and Madasamy (2020) mentioned that natural fiber has been proved to be the best material for thermal insulation as it bearing advantages includes low density, high strength and resistance to breakage during processing. This study also highlight that natural fiber has a low energy content and recyclability and has been used in transportation, building and construction industries. However, natural fiber can withstand the heat at a temperature of less than 750 °C (Spinnler et al., 2004). Therefore, more research is needed to improve the natural fiber's performance.

In this study, the kenaf plant was chosen because of its rapid growth, high productivity or land ratio, high photosynthesis rate and suitability for planting in Malaysia's climate (Lee et al., 2021). Unfortunately, kenaf plantations in Malaysia face a number of challenges, including a scarcity of skilled workers and a low profit margin as a function of land area. The researcher also added that woven kenaf has been used in automotive structural components because of its high impact resistance. However, the kenaf material's slow development led to its failure as a pioneer in automotive green materials.

Study by Mohd (2014) found that the findings of kenaf research are relevant to tropical countries in general, but there is a scarcity of published Malaysian kenaf research and its international accessibility. Therefore, Ashori (2014) have investigate chemical (organic and inorganic) and morphological characteristics of kenaf fractions (bast, core, and whole stem) from Malaysia cultivars. Because of their weakness in terms of moisture resistance, which leads to high water absorption, alkaline treatment has been used with sodium hydroxide (NaOH) solutions to mercerize the fiber's hydrophilic effect (Ikhwan et al., 2018).