THERMAL ANALYSIS OF SUGARCANE FIBER/POLYESTER ALUMINIUM HONEYCOMB PANEL FOR HOT HUMID CLIMATE APPLICATION

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Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor Of Mechanical Engineering Technology (Refrigeration and Air Conditioning System) with Honours

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DECLARATION

I declare that this Choose an item. entitled "Thermal Analysis of Sugarcane Fiber/Polyester Aluminium Honeycomb Panel For Hot Humid Climate Application " is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Name	:	Mohamad Irfan Indrawaty
Date	:	11/01/2023

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 Mechanical Engineering Technology (Refrigeration and Air Conditioning System) with Honours.

Signature : ....

Supervisor Name : Dr Muhammad Zulkarnain

Date : 11/01/2023

DEDICATION

This thesis is dedicated to my father, Indrawaty Bin Usman, told me that the finest form of knowledge to acquire is that which is learned for its own reason. It's also dedicated to my mother, Yulianis Binti Dahlan, who showed me that even the most difficult endeavour can be completed if approached in little steps. Both of them have supported me throughout the process, and their encouragement has ensured that I give it everything I have to finish what I have begun.

ABSTRACT

The climate in Malaysia is humid throughout the year. The average daily temperature in Malaysia is between 21°C to 32°C. Typically, winds from the Indian Ocean (Southwest Monsoon, May to September) and the South China Sea impact Malaysia's climate (North-Eastern Monsoon - November to March). It receives around 80 percent of its annual precipitation, which varies from 2000 to 2500 millimetres. According to the Malaysian Meteorological Department, Malaysia has been experiencing the south-west monsoon, which has resulted in a hot and dry climate between July and mid-September, with temperatures reaching 35°C to 40°C Malay mail (2021, July 21). Frequently occurring natural disasters in Malaysia are flash floods caused by heavy rainfall. According to the Agensi Pengurusan Bencana (NADMA) of Peninsular Malaysia, 33 districts in eight states have been impacted by flooding (Perak, Selangor, Kuala Lumpur, Negeri Sembilan, Melaka, Kelantan, Terengganu, and Pahang). During a natural catastrophe, hundreds of roads and highways remain closed, resulting in unplanned water and power outages. In neighbourhoods with low-cost housing, residents in single-story connected residences are unable to shift themselves and their possessions to the upper floors, so aggravating the issue. There have been medical evacuations due to a lack of food, water, electricity, and medicine for the elderly and other chronically ill individuals. Using a boat, Fire Rescue and Malaysia Civil Department are assisting in the relocation of refunge to a new shelter. Heavy rain that occurs in Malaysia from September to December will cause flash floods in Malaysia. Besides that, landslide also occur during a heavy rain in a certain location. Many people losing their family member and properties such as house during the natural disaster phenomenon. Generally, the victim shelted at the high building such as school or community hall that far away from the natural disaster. We can use the waste of sugarcane fiber combine with polyester Aluminum Honeycomb Panel to produce a cheaper shelter for teh victim or natural disaster instead of placing them together with crowded people in the community hall. Sometimes the community hall is closed for land activity such as a sport activity and wedding ceremony. We can create a shelter by using a sugarcane fiber and polyester Aluminum Honeycomb Panel in open space. The main aim of this research is to elobrate an innovation idea by using a waste sugarcane fiber or natural material to produce a cheaper shelter during natural disaster.To indentify the thermal conductivity and thermal resistance of combination of material polysester aluminium honeycomb panel and sugarcane fiber. Thermal conductivity commonly represented by (k) is the intrinsic capacity of a substance to transfer or conduct heat. It is one of three heat transmission techniques, the other two being convection and radiation. This heat transfer mode's rate equation is based on Fourier's law of heat conduction. However, Thermal resistance is defined as the ratio of a material's temperature difference between its two sides to its rate of heat flow per unit area. The thermal resistance of a textile material influences its heat insulation ability. The greater the thermal resistance, the less heat is lost. The sample 1 with 0 with % fiber has the highest number of the thermal conductivity and the lowest number of thermal resistance. However the sample 6 12 with % of fiber recorded the lowest thermal conductivity and the highest thermal resistance. So that the best sample for produce shelter hot humid is sample 6 because it has the lower thermal conductivity and the highest thermal resistance.

ABSTRAK

Iklim di Malaysia adalah lembap sepanjang tahun. Purata suhu harian di Malaysia adalah antara 21°C hingga 32°C. Lazimnya, angin dari Lautan Hindi (Monsun Barat Daya, Mei hingga September) dan Laut China Selatan memberi kesan kepada iklim Malaysia (Monsun Utara-Timur - November hingga Mac). Ia menerima sekitar 80 peratus daripada kerpasan tahunannya, yang berbeza dari 2000 hingga 2500 milimeter. Menurut Jabatan Meteorologi Malaysia, Malaysia telah mengalami monsun barat daya, yang mengakibatkan iklim panas dan kering antara Julai dan pertengahan September, dengan suhu mencecah 35°C hingga 40°C Malay mail (2021, 21 Julai). Bencana alam yang kerap berlaku di Malaysia ialah banjir kilat yang disebabkan oleh hujan lebat. Menurut Agensi Pengurusan Bencana (NADMA) Semenanjung Malaysia, 33 daerah di lapan negeri telah terjejas akibat banjir (Perak, Selangor, Kuala Lumpur, Negeri Sembilan, Melaka, Kelantan, Terengganu, dan Pahang). Semasa malapetaka semula jadi, beratus-ratus jalan dan lebuh raya kekal ditutup, mengakibatkan bekalan air dan bekalan elektrik terputus. Di kawasan kejiranan dengan perumahan kos rendah, penduduk di kediaman bersambung satu tingkat tidak dapat mengalihkan diri dan harta benda mereka ke tingkat atas, jadi memburukkan lagi isu. Terdapat pemindahan perubatan kerana kekurangan makanan, air, elektrik, dan ubat-ubatan untuk warga emas dan individu lain yang sakit kronik. Menggunakan bot, Bomba Penyelamat dan Jabatan Awam Malaysia membantu dalam penempatan semula tempat perlindungan ke pusat perlindungan baharu. Hujan lebat yang berlaku di Malaysia dari September hingga Disember akan menyebabkan banjir kilat di Malaysia. Selain itu, tanah runtuh juga berlaku semasa hujan lebat di lokasi tertentu. Ramai orang kehilangan ahli keluarga dan harta benda seperti rumah semasa fenomena bencana alam. Secara amnya, mangsa berteduh di bangunan tinggi seperti sekolah atau balai raya yang jauh dari bencana alam. Kita boleh menggunakan sisa gentian tebu yang digabungkan dengan Panel Sarang Lebah Aluminium poliester untuk menghasilkan tempat perlindungan yang lebih murah untuk mangsa atau bencana alam dan bukannya meletakkannya bersama orang ramai di balai raya. Kita boleh mencipta tempat perlindungan dengan menggunakan gentian tebu dan Panel Sarang Lebah Aluminium poliester di kawasan lapang. Matlamat utama penyelidikan ini adalah untuk mengembangkan idea inovasi dengan menggunakan sisa gentian tebu atau bahan semula jadi untuk menghasilkan tempat perlindungan yang lebih murah semasa bencana alam. Untuk mengenal pasti kekonduksian terma dan rintangan haba gabungan bahan polysester aluminium panel sarang lebah dan gentian tebu. Kekonduksian terma yang biasanya diwakili oleh (k) ialah kapasiti intrinsik bahan untuk memindahkan atau mengalirkan haba. Ia adalah salah satu daripada tiga teknik penghantaran haba, dua lagi ialah perolakan dan sinaran. Persamaan kadar mod pemindahan haba ini adalah berdasarkan hukum pengaliran haba Fourier. Rintangan haba bahan tekstil mempengaruhi keupayaan penebat habanya. Semakin besar rintangan haba, semakin sedikit haba yang hilang. Sampel 1 dengan 0 dengan gentian % mempunyai bilangan kekonduksian terma tertinggi dan bilangan rintangan haba terendah. Bagaimanapun sampel 6 12 dengan % gentian merekodkan kekonduksian haba yang paling rendah dan rintangan haba tertinggi. Sampel terbaik untuk menghasilkan tempat perlindungan lembap panas adalah sampel 6 kerana ia mempunyai kekonduksian haba yang lebih rendah dan rintangan haba yang paling tinggi.

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In the Name of Allah, the Most Gracious, the Most Merciful

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I would also like to thank my beloved parents for their endless support, love, and prayers. Finally, thank you to all the individuals who have provided me with the assistance, support, and inspiration to embark on my studies.

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LIST OF SYMBOLS AND ABBREVIATIONS

CO_2	-	Carbon dioxide
DTG	-	Derivative thermogravimetric
DSC	-	Differential scanning calorimeter
TG	-	Thermogravimetric
M^2	-	Meter square
W	-	watt
g	-	Grams
°c	-	Celcius
M^3	-	Meter cubic
kg	-	Kilogram
kJ	-	Kilojoules
cm	-	centimeter
NaOH	-	Sodium Hydroxide
Cm^3	-	Centimeter cubic
L	-	litres
Rpm	-	Rate per minutes
mPa	-	megapascal
s	-	second

CHAPTER 1

INTRODUCTION

1.1 Background

The climate in Malaysia is humid throughout the year. The average daily temperature in Malaysia is between 21°C to 32°C. Typically, winds from the Indian Ocean (Southwest Monsoon, May to September) and the South China Sea impact Malaysia's climate (North-Eastern Monsoon - November to March). It receives around 80 percent of its annual precipitation, which varies from 2000 to 2500 millimetres. According to the Malaysian Meteorological Department, Malaysia has been experiencing the south-west monsoon, which has resulted in a hot and dry climate between July and mid-September, with temperatures reaching 35°C to 40°C Malay mail (2021, July 21).

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Rescue and Malaysia Civil Department are assisting in the relocation of refunge to a new shelter.

Figure 1.1 shows flash flood at Shah Alam

Thermal analysis techniques are experimental procedures that study the relationship between the qualities of a material and its temperature. It is possible to acquire parameters such as enthalpy, thermal capacity, mass changes, and heat expansion coefficient. In the realm of materials science, thermal analysis is a crucial analytical and characterisation method. This technique may be utilised to determine the thermal characteristics of synthetic polymers and biomaterials with distinct phases and morphologies. Differential scanning calorimetry (DSC), thermogravimetric analysis, thermomechanical analysis, and dynamic mechanics analysis are long-established thermal analysis techniques.

DSC is the most essential of these techniques for thermal analysis. In addition to modulated-temperature DSC, quasi-isothermal DSC, and rapid DSC, it was also manufactured into various varieties. The various DSC techniques and methods are utilised to determine how the temperatures, heats, and/or specific heat capacities of various materials, such as low-molecular-mass substances, amorphous and semicrystalline synthetic polymers, and biopolymers, change when they undergo various thermodynamic and kinetic changes. In addition, DSC can reveal how the structure of polymers alters as they are heated, cooled, and maintained at a constant temperature. In addition, the computation of reversing and nonreversing heat flow can assist in determining which transitions are occurring simultaneously.

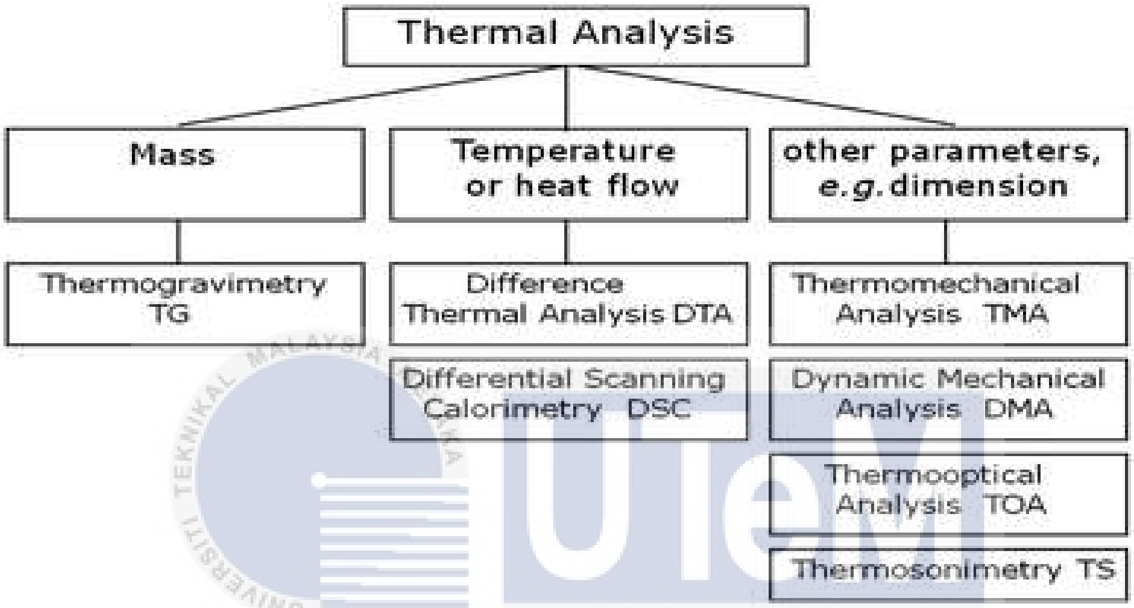


Figure 1.2 shows the method and parameter of thermal analysis.

1.2 Problem Statement

Heavy rain that occurs in Malaysia from September to December will cause flash floods in Malaysia. Besides that, landslide also occur during a heavy rain in a certain location. Many people losing their family member and properties such as house during the natural disaster phenomenon. They need to wait until the rescue team to transfer the victim to the confort zone. Generally, the victim shelted at the high building such as school or community hall that far away from the natural disaster.

We can use the waste of sugarcane fiber combine with polyester Aluminum Honeycomb Panel to produce a cheaper shelter for teh victim or natural disaster instead of placing them together with crowded people in the community hall. Sometimes the community hall is closed for land activity such as a sport activity and wedding ceremony. We can create a shelter by using a sugarcane fiber and polyester Aluminum Honeycomb Panel in open space.

1.3 Research Objective (Two or three objectives for study scope completed in two semesters)

The main aim of this research is to elobrate an innovation idea by using a waste sugarcane fiber or natural material to produce a cheaper shelter during natural disaster. Specifically, the objectives are as follows:

a) To study the thermal analysis of the sugarcane fiber and aluminium honeycomb panel and itself properties.
b) To indentify the thermal conductivity and thermal resistance of combination of material polysester aluminium honeycomb panel and sugarcane fiber.

1.4 Scope of Research

The scope of this study includes the following:

- The research analysis focuses on sugarcane fibre with polyester matrix as a composite sheet that adheres to honeycomb aluminium as a sandwich material.
- To get rid of the moisture in the Sugarcane fiber, they were dried in an oven at 105°C for 48 hours.

- During thermal analysis, the fibre lengths are altered, including chopped and long fibre sizes and randomly distributed procedures as a composite.
- By altering the volume percentage and treating fibres with chemicals such as NaOH and Acetone, thermal conductivity is measured.
- Differential scanning calorimetry (DSC) was used to analyse the thermal analysis of sugarcane fibre by measuring the energy transferred to or from a sample experiencing a physical or chemical change.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview

This section will describe the meaning of natural fibres and there are many types of fibres that can be collected on the earth's resources. Next, in order to make a good material composite of fiber, the selection of natural fibers is limited to low-cost fibers with high specific properties, low density, and eco-friendly to be considered. Meanwhile, the natural fiber will join with the aluminium honeycomb panel to create a shelter for the hot humid climate. Furthermore, the material preparation will show the step-by-step from the cleaning of natural fiber to the best type of aluminium honeycomb panel joining together. Last but not least, there are several testing materials that will be conducted on this final year project.

2.1 Natural Fibre

Natural fibres derived from plants and animal have been used by humans since the start of civilization (Ganguly et al., 2022). Since then, as human needs have evolved, these naturally occurring fibers have discovered new applications and functions. Due to their high specific strength, low density, and biocompatibility, these natural fibres are utilized as filler materials in 21st-century advanced composites.Due to its low energy usage, minimum material waste, and ease of fabrication of complex components, additive manufacturing has gained prominence as the future standard.

2.1.1 Type of Natural Plant Fiber

The manufacturing sector typically requires five types of natural plant fibres, including seed fibres, leaf fibres, fruit fibres, stalk fibres, and bast fibres.

I. seed fibres - The fibres extracted from the seeds of several plant species.

II. leaf fibres - The natural fibres that may be extracted from various plant leaves. examples: pineapple and banana leaf fibres.

III. Fruit fibres - The plant fibres extracted from the fruit of a plant (coconut fibre, sugarcane fibres).

IV. Stalk fibres - The natural fibres extracted from the stalks of several plant species. Wheat straws, bamboo fibres, rice and barley plant stem fibres, and straw are some examples.

V. Bast fibres - The natural fibres derived from the outermost layer of stem cells. Jute fibres, flax fibres, vine fibres, industrial hemp fibres, kenaf fibres, rattan fibres, and ramie fibres are examples of bast fibres. Due to the robust quality of these fibres, they are commonly utilised in textiles and packaging. Figure 2.1 depicts a picture of natural fibre, whereas Figure 2.2 compares the qualities of fibres

Figure 2.1 shows the image of natural fiber

	Physical Properties			Chemical Properties			Mechanical Properties		
Fiber	Density [gm/cm³]	Diameter [μm]	Length [mm]	Cellulose [wt.%]	Hemicellulose [wt.%]	Lignin [wt.%]	Tensile Strength [MPa]	Young's modulus [GPa]	Elongation [%]
Flax	1.4 – 1.5	40 – 600	5 – 900	70 – 75.2	8.6 – 20.6	2.2 – 5	345 – 900	27 – 80	1.2 - 1.6
Kenaf	1.2 – 1.45	12 - 37	4 - 110	45 - 57	21.5	8 – 13	295 - 930	53	1.6 – 6.9
Hemp	1.4 - 1.48	10 – 500	5 – 55	70 – 75.1	2 – 22.4	3.5 – 8	300 - 800	30 – 70	1.6
Jute	1.3 – 1.5	25 – 200	1.5 – 120	61 – 75.5	13.6 – 20.4	5 – 13	200 – 800	10 – 55	1.8
Sisal	1.2 – 1.5	8 – 200	900	47.6 – 78	10 – 17.8	8 – 14	100 – 800	9.4 – 28	2 - 3
Abaca	1.1 – 1.5	132 – 266	900	56-63.7	17.5	15.1	705 - 1041	9.8 – 14.8	3 - 12
Coir	1.1 – 1.46	10 - 460	20 – 150	32-43	<1	40 – 45	13 – 220	4 – 6	15 - 40

Figure 2.2 shows the fibres properties comparison.

2.1.2 The Application of Natural Fibres

In the construction industry, natural fibers, particularly certain glass fibers, are widely utilized in a variety of building materials. Several sectors, including the automobile and electronics industries, use cellulose fibre for a variety of purposes, including the automotive and electronic industries. These natural fibers can be utilized to create noise-absorbing panels and insulation. Moreover, natural fibres may have medical benefits because they can be used to produce biomaterials. Chitin, for instance, can be utilized to eliminate certain hazardous contaminants from industrial water outflow. There are many advantages and disadvantages to using natural fiber. Table 2.1 The advantage and disadvantage of using natural fibres

Table 2.1 The advantage and disadvantage of using natural fibres

Advantage of natural fibres	Disadvantage of natural fibres
Less specific weight results in higher specific strength and stiffness than glass	Lower strength, especially impact strenght
Renewable resource, little energy consumption, low CO2 emission	Change quality affected by weather
No tools wear, and no skin irritation were observed throughout processing	Insufficient moisture resistance, which promote fibre swelling.
Little cost production with low investment	Minimum permitted processing temperature
Excellent electrical resistance	Reduce durability
Excellent thermal and acoustic insulating	Lack fire resistance
Biodegradable	Low wetting with hydrophobic polymers

2.2 Material Composite for Natural Fibres

A composite material is a material made up of two or more materials, each of which has a different physical and chemical properties. These matrices are all good, but polymers have the finest features of them all. Low density, ease of molding into the proper shape, and low chemical resistance all play a role such as unsaturated polyester resin (Binti Mod Hafidz et al., 2022). Unsaturated polyesters are exceedingly diverse in terms of their properties and uses, and they have become a preferred thermoset matrix material for composites (Aziz et al., 2005). In comparison to other thermosetting resins, they have a number of advantages, including the ability to cure at room temperature, superior mechanical qualities,and transparency. As a result, they are frequently used in the industrial sector.

Next, the composite of fibres such as hybrid composites are created by combining multiple reinforcing agents in a single polymer matrix to improve the composite qualities (Haris et al., 2022). By combining multiple reinforcing elements, it is possible to achieve either a synergistic or antagonistic impact. The features can also be modified by balancing the favorable characteristics of one material with the negative characteristics of another. The inclusion of numerous reinforcements into a matrix provides a greater range of qualities that are inaccessible in composites with a single fiber reinforcement. Synthetic fibers have been used to make high-performance polymer matrix composite products such as fiber reinforced plastic tanks, airplane components, car parts, and building panels.

In addition, the novel high-performance phenolic thermoset polybenzoxazine resin has enhanced strength, remarkable resilience, a high glass transition temperature (Tg), robust thermal stability, great flame retardancy, and low dielectric characteristics. It has a low water absorption rate and is corrosion resistant (Ramdani et al., 2022). Natural fibres, ceramics, and metal fillers have all been used to improve the processability and filler ratios of polybenzoxazine composites. This is owing to the low A-stage viscosity and broad processing window of the materials. On the basis of these materials, it is anticipated that reinforced polybenzoxazine systems would exhibit enhanced thermal and mechanical capabilities, as well as enhanced corrosion resistance. Figure 2.3 depicts the composite matrix material.

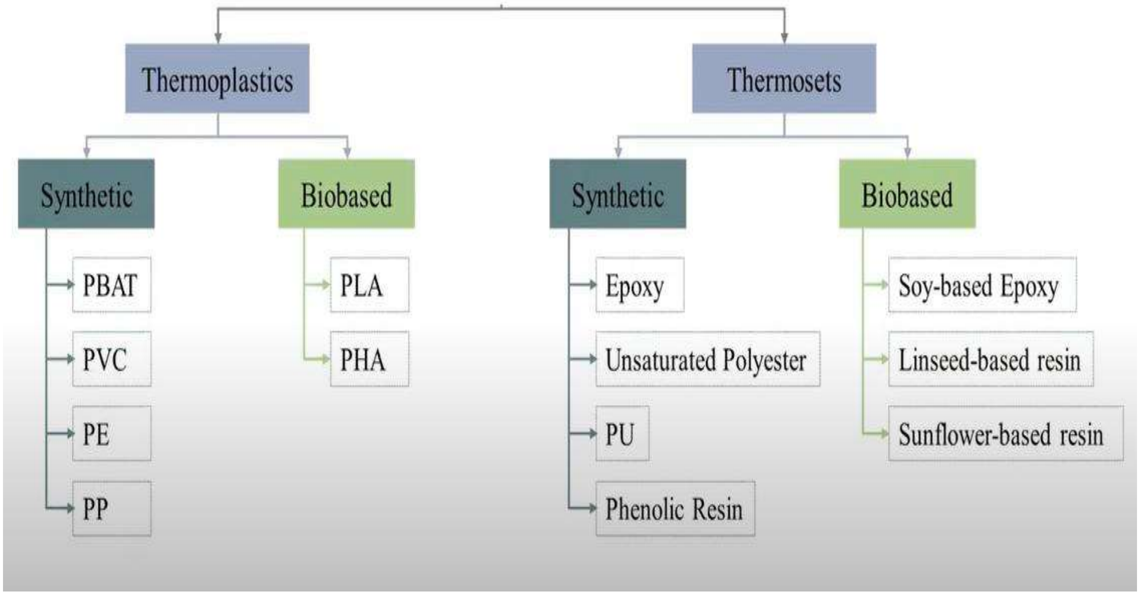


Figure 2.3 shows the matrix material composite

2.3 Honeycomb Sandwhich

A common biomimetic shape that is both lightweight and sturdy is a honeycomb sandwich construction. The honeycomb structure is either natural or artificial and has the shape of a honeycomb to decrease the amount of used material to achieve minimum material cost and minimal weight (Ramiz, 2020). Honeycombs and honeycomb materials are used in the fabrication of sandwich panels with a honeycomb core that has exceptional compression strength. Using paper, thermoplastics, or fabric as core material permits the fabrication of lightweight honeycomb structures with considerable structural strength independent of the strength of the building components.

2.3.1 The type of sandwich honeycomb panel

Four types of honeycomb panels are manufactured today: aluminium honeycomb, nomex honeycomb, thermoplastic honeycomb, and stainless steel honeycomb. Aluminum honeycombs provide the greatest strength-to-weight ratio and a wide range of geometric cell shapes; their properties are determined by foil thickness and cell size. These panels have various cell sizes and shapes that are mathematically related to the thickness and size of the foil. As honeycomb panels, the aluminium components are solid blocks that have not been stretched into sheets. Panels made of aluminium honeycomb offer the benefits of being durable and flexible. Aluminum honeycomb panels are corrosion-resistant, perform well at high temperatures, and are noncombustible. These panels do not absorb moisture and are resistant to fungus as a result. Aluminum honeycomb panels may be readily machined and formed. Table 2.2 show images of honeycomb

Nomex honeycombs are constructed with Nomex paper, which is formed from Kevlar fibres. These honeycomb cores have both high strength and fire resistance. This paper is manufactured from thermosetting phenolic-impregnated meta-aramid sheets. Nomex honeycomb panels provide high durability and fire resistance. These panels are often utilised in the interiors of aeroplanes. The Nomex panels have a low density, great mechanical strength, and strong stability. They provide good thermal insulation and have a high strength-to-weight ratio. They are beneficial in that they may be shaped into three-dimensional forms.

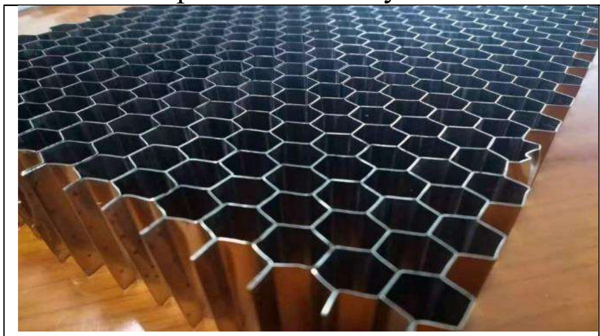
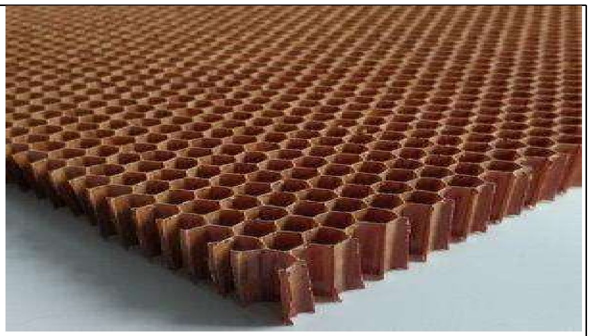
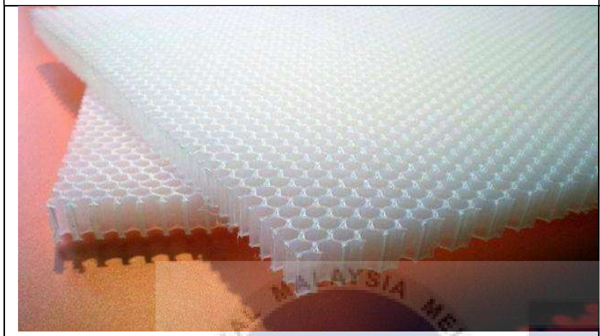
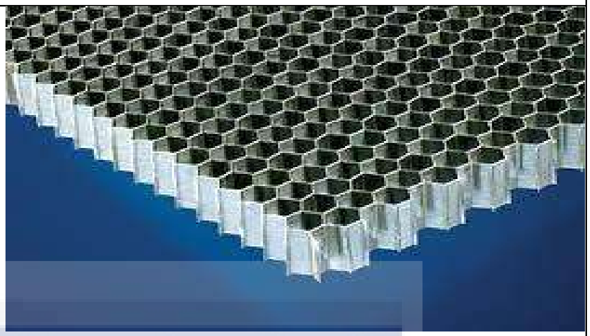
These thermoplastic honeycomb cores are readily recyclable and lightweight, and they are available in several shapes, such as:

- ABS provides surface hardness, tenacity, rigidity, dimension stability, and impact resistance.
- Polycarbonate provides superior light transmission, UV resistance, self-extinguishing qualities, and heat resistance.
- Polypropylene has high chemical resistance and is a cost-effective material for general-purpose cores.

Stainless steel honeycombs are among the most durable honeycomb panels on the market, making them perfect for harsh settings and eye-catching facades. Where its application is located

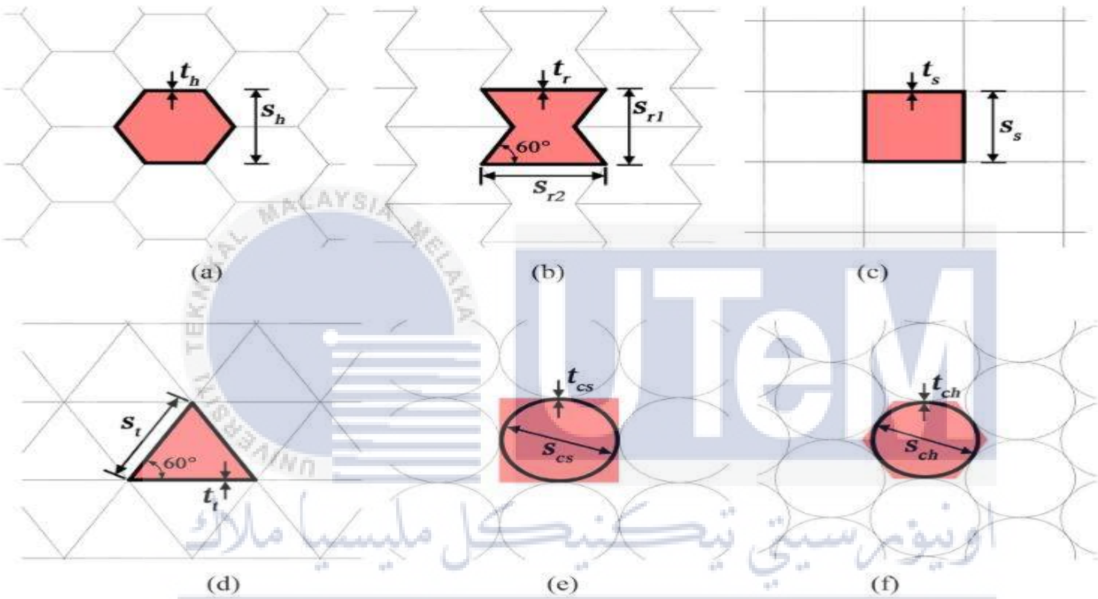
- Jet planes and rocket structure
- In the fictitiousization of light, water, fluids, and air.
- In electric shielding enclosures and wind turbine blades, conductive materials are used.
- In architectural outside curtain wall and clean room panels.
- In the rail sector, these protective structures absorb energy and are also utilised to make doors, flooring, energy absorbers/bumpers, and furniture.

Table 2.2 The pictures of honeycomb

 Aluminium honeycomb	 Nomex honeycomb
 Thermoplastic honeycomb	 Stainless steel honeycomb

2.3.2 The Type of Shape Sandwich Honeycomb

The most frequent kind of impact protection and energy absorption is hexagonal honeycomb. In addition, square, triangular, circular, and auxetic honeycombs have good impact resistance. Therefore, six kinds of honeycomb structures with identical mass and thickness will be manufactured and modelled (Wang et al., 2020). Each's relative density will be determined. To reduce the impact of the face sheets, just the honeycomb structure core will be examined. The most prevalent auxetic honeycomb is the reentrant hexagonal honeycomb, which exhibits apparent auxetic behaviour along in-plane directions and a distinctive synclastic curvature characteristic along out-of-plane directions, which may aid in enhancing energy absorption performance. It has been used for out-of-plane air blast impact investigations and has good impact resistance. In addition, honeycombs with triangular cells are more robust during in-plane dynamic crushing than honeycombs with square or hexagonal cells, resulting in larger plateau stresses. The complete out-of-plane study of triangular honeycomb has not yet been uncovered. Therefore, the kinds of square and equilateral triangles will also be compared to those of other triangle types. Figure 2.4 Cross-sectional image of one unit cell and structural parameters of (a) hexagonal honeycomb, (b) reentrant honeycomb, (c) square honeycomb, (d) triangular honeycomb, (e) circular honeycomb in square arrangement (CS type), and (f) circular honeycomb in hexagonal arrangement (CH type).



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2.4 Material Preparation of Natural Fiber

This section discusses the extraction and chemistry of natural fibres. The retting method and the mechanical decoricator will be explained as two ways of fibre extraction. Alkaline treatment, silane treatment, acetylation treatment, and benzoylation treatment are the last chemical treatments used to transport natural fibres.

2.4.1 Fibres Extraction Method

Retting and mechanical decortication are the two most used methods for removing natural fibres (Aravinth et al., 2022). The choice of extraction process depends on the kind of plant, such as bark, leaves, seeds, or roots. To extract plant fibres, the plant's chemical composition must be removed or dissolved, including pectin, hemicellulose, lignin, and any other waxes present. Depending on the extraction method, the recoverable fibre length might vary. Figure 2.4.1 shows the classification of fibres extraction

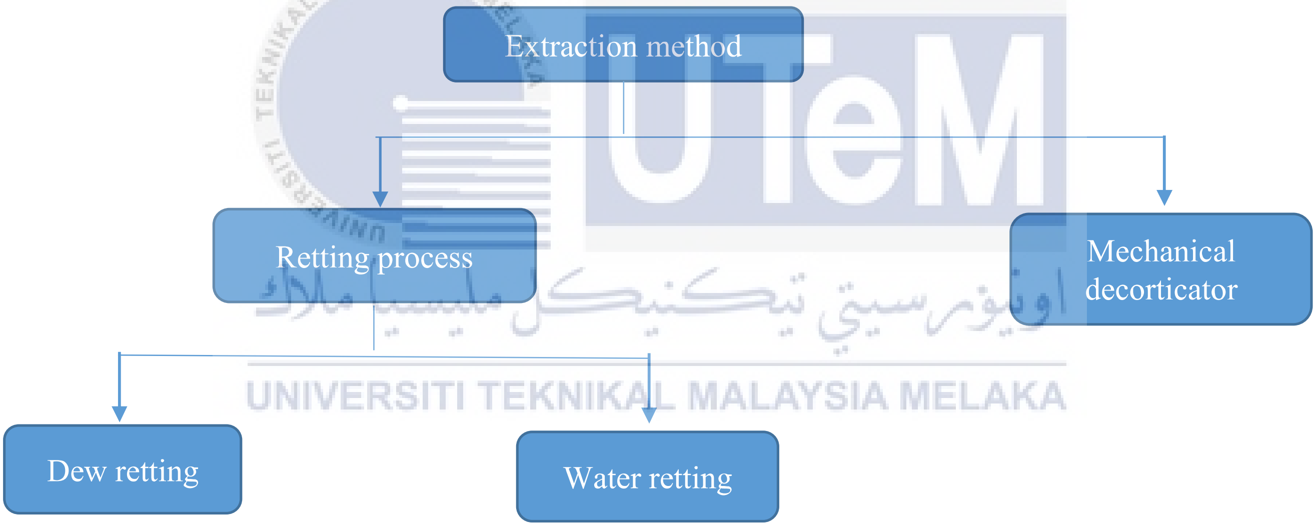


Figure 2.5 shows the classification of fibres extraction

1) Retting process

Retting is the process of extracting plant fibre by the natural degradation of pectin, hemicellulose, lignin, and any waxy or gelatinous components present. The time of retting ranges from 14 to 25 days, depending on the kind of plant. Microbes and water break down the plant's muscle tissue during the retting process, leaving behind the plant's fibre. Pectin, hemicellulose, lignin, and gelatinous substances are referred to as "muscle content" here. The quantity of fibre or yield is contingent on the effectiveness of the retting process. There are two ways to finish the Retting procedure: dew retting and water retting.

Dew retting refers to the breakdown of plant muscles that dew facilitates. In this technique, the plant's stem or stalk was exposed to the open air for two to four weeks. The plant's cellular muscles degrade when exposed to natural elements like as sunlight, air moisture, and dew, but the fibre remains intact. Depending on external variables, the duration of an operation may vary. Dew retting is used in regions where daytime temperatures should be warm and nocturnal dew levels should be high. This sort of environment creates high-quality fibres. However, dew-retted fibres are of lower quality than water-retted fibres and may be recognised by colour.

Fermentation assists in the breakdown of the plant's muscle tissue during water retting. The plant's stem or stalk is submerged in water for a period of time, and the fermentation process breaks down the plant's tissues, leaving behind the fibre content. Care must be exercised throughout this procedure to avoid injuring the fibres, which might result in a loss of mechanical strength. Maintain the appropriate time for high-quality fibre manufacturing. For water sources, stationary or moving water, such as ponds, rivers, tank water, etc., may be employed. The majority of stem and bast fibres, including jute, hemp, roselle, and bamboo, are removed by means of water and dew retting. The dew retting and water retting processes are both time-consuming; hence, the mechanical decorticator process may be used.

2) Mechanical

The name of this approach suggests that plant fibres were harvested via mechanical means. Using a succession of mechanical rollers, the plant was squeezed to remove the adhesive chemicals and outer layers. This results in the development of superior fibres. To achieve the desired quantity and quality of fibres, the plant was consistently fed and its superfluous muscles were eliminated. The fibers were then dried for several hours to eliminate any lingering moisture. Following the mechanical decortication of fibers, pectins, hemicellulose, and lignin will be present in the fiber, which may be eliminated by chemical treatment to improve the fiber's surface quality. Typically, a mechanical decorticator is used to extract fibres from leaf-based sources such as agave, pineapple, abaca, etc..

2.4.2 Chemical treatment of natural fibres

The presence of hydrophilic cellulose alters the interfacial adhesion of the polymer matrix and fibres due to the hydrophobic nature of the matrix (Sathish et al., 2021). One method for optimising the interaction between natural fibres and polymer matrix is to chemically treat the fibres. As it decreases the hydroxyl functional groups on the surface of the fibre and increases the surface roughness, it improves the matrix-fiber interface. By increasing the surface roughness of the fibre, its sensitivity to moisture is reduced, and the matrix and fibre are successfully interlocked. a number of chemical techniques may transform hydrophilic natural fibres into hydrophobic ones. Alkali treatment, silane treatment, acetylation, benzoylation treatment, potassium permanganate, stearic acid treatment, polymer coating, graft polymerization, isocyanate, maleated coupling agent, and peroxide treatment are among the most prevalent chemical treatments.

Due to its simplicity and convenience of administration, alkali therapy is the most common chemical treatment, and its efficacy is somewhat higher than that of other therapies. The goal of this process is to remove the hydroxyl group from the fibre by treating it with solutions of sodium hydroxide, potassium hydroxide, or lithium hydroxide. During this procedure, non-cellulosic components such as hemicellulose, pectin, lignin, and other sticky compounds are eliminated, and the fibre's surface roughness is increased, which is advantageous at the fibre matrix interface.

The primary goal of silane treatment is to interlock the matrix and fibre. This is accomplished chemically by using the silane's two functional groups. The first component, silanol, combines with the hydroxyl group in the fibre, while the second group reacts with the matrix. This results in self-condensation and the formation of a hydrocarbon chain, which helps chemically bond the matrix and fibre. The handling of silane is primarily determined by hydrolysis time, a functional group present in silane, pH, and temperature. Triethoxy vinyl silane, vinyl trimethoxy silane, and aminopropyl triethoxy silane are the most often utilised silanes in silane treatment. These silanes are combined with an alcohol, such as methanol or ethanol, and water at a ratio of 60:40, and then allowed to rest for 30 to 60 minutes. The pH of the solution must be maintained at 4, and acetic acid may be added if required. The fibre may be steeped in the solution before being dried at 60 degrees Celsius. Due to the increased contact between matrix and fibre, the tensile strength of the composite increases.

The goal of acetylation is to enhance the fibre's surface. The fibre is steeped in an acetic anhydride solution for two to three hours, with acetic acid added as a catalyst to accelerate the process. This method includes an esterification reaction between the acetyl and hydroxyl groups of the fibre. This process yields acetic acid as a byproduct. Finally, the fibre's surface is refined and made smooth. Acetate ions are removed from the fibre using water. This treatment will reduce the moisture absorption of jute, hemp, and flax fibres by 50 to 65%, hence enhancing matrix and fibre interlocking.

During benzoylation, fibres are treated with benzoyl chloride. In this technique using sodium hydroxide solution for alkali treatment, the hydroxyl groups in the fibre were activated, and the lignin, waxes, and coating sticky material were eliminated. With benzoyl chloride, the activated hydroxyl group in the fibre was then reacted. This will remove the hyrdoxyl group by a chemical reaction that converts benzoyl chloride to benzoic acid, leaving chlorine that may be removed with water. The thermal and tensile qualities of sisal and sugar palm fibres are better.

2.5 Testing Material On The Natural Fiber

In the field of materials research, thermal analysis is an essential analytical and characterisation technique (Xue et al., 2020). This technique may be used to determine the thermal characteristics of biomaterials and synthetic polymers with different phases and morphologies. Traditional thermal analysis methods include differential scanning calorimetry, thermogravimetric analysis, thermomechanical analysis, and dynamic mechanic analysis (DMA). The DSC is the most important thermal analysis technique among those mentioned. This was followed by modulated-temperature DSC (MT-DSC), quasi-isothermal DSC, and quick DSC (F-DSC). Numerous DSC methods and techniques characterise the temperatures and heats and/or changes in specific heat capacity during thermodynamic and kinetic transitions of a variety of materials, including low-molecular-mass compounds, amorphous and semicrystalline synthetic polymers, and biopolymers.

Monitoring the structural changes of polymers during heating, cooling, and isothermal tests is also possible using DSC. Moreover, the calculation of reversing and nonreversing heat flow may help distinguish between separate transitions. DSC is a common technique for detecting thermally induced phase transitions and structural changes in natural fibres such silk, cellulose, chitin, and collagen. Physical transitions and chemical processes often entail the release or absorption of heat, allowing DSC to identify differences in heat flow rates between the sample and the reference. Variation in heat flow rates is caused by the sample's specific heat capacity. In nonisothermal crystallisation research, DSC can thus identify the glass transition temperature and the increase in heat capacity at the glass transition, the melting and boiling point, the heat of fusion and heat of vaporisation, and the crystallisation temperature. In addition, DSC is often used to assess the kind of nucleation and crystal development during isothermal crystallisation experiments.

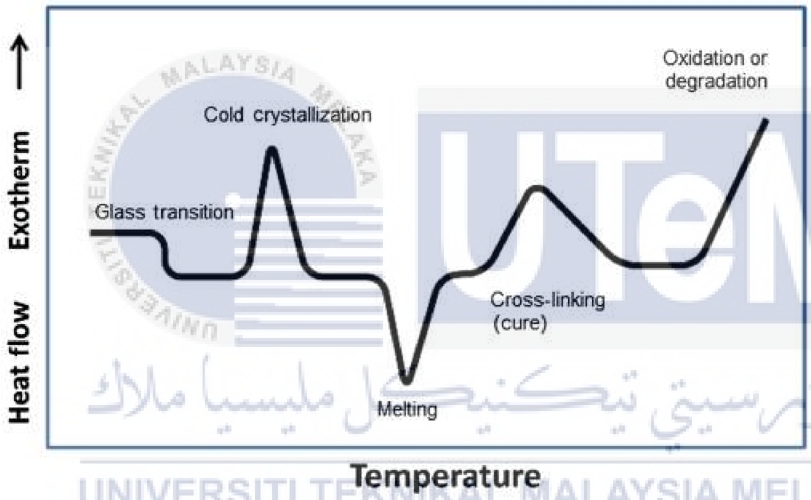


Figure 2.6 show an ideal DSC nonisothermal heating curve of a semicrystalline biopolymer material

In addition, the thermal degradation of the fibres was evaluated by recording TG/DTG and DTA thermograms of fibre samples with NETZSCH STA 2500, a thermal analyzer with flexible software for the temperature range of room temperature to 600 °C at a heating rate of 10 °C/min under ultrapure N2 and air (80/20, N2 /O2) atmospheres (Subramanian & Vijayakumar, 2021). The sample size ranged from 4 to 9 mg, the protective gas (N2) flow rate was 60 ml/min, and the purge gas flow rate was 40 ml/min (air or N2). Crucibles made of alumina were used as sample containers and as standards. The temperature was calibrated using In, Ag, Au, Cu, and Al metals of spectroscopic quality.

Calibration standards for enthalpy (H) were indium metal and calcium oxalate monohydrates. The estimated H values in J/g were determined by calculating the endothermic and exothermic peak regions enclosed by the peak and interpolated base line. Stacking and analysing the captured thermograms using the proteous software. Figures 2.6.1 through 2.6.3 show the TG/DTA and DTG thermograms of unprocessed, partially delignified, and bleached Allamanda Blanchetti Stem fibres and unprocessed cotton fibres recorded in N2 or air. The early weight loss up to 100 °C in TG and the endotherm at about 57–58 °C in difference thermal analysis are attributable to water loss. The moisture content of raw Allamanda Blanchetti, delignified/bleached Allamanda Blanchetti, and raw cotton fiber, as evaluated by weight loss at 100 °C, was 6.9%, 6.6%, and 5.3%, respectively. This showed that the moisture content of raw and delignified/bleached Allamanda Blanchetti fibers were equivalent, but higher than that of raw cotton.

It seemed that the moisture content of both untreated and treated Allamanda Blanchetti fibers was greater than that of untreated cotton and that the elimination of lignin had not enhanced the Allamanda Blanchetti fiber's capacity to absorb moisture. Due to the fact that a biocomposite's stability, dimensions, porosity formation, and tensile strength may deteriorate if it has a high moisture content, the fiber's moisture content was a crucial characteristic for composite applications. The equilibrium moisture content of treated Allamanda Blanchetti fiber was found to be lower than that of sisal, jute, flax, banana, nettle, hemp, and ramie fibers (8–22% by weight).

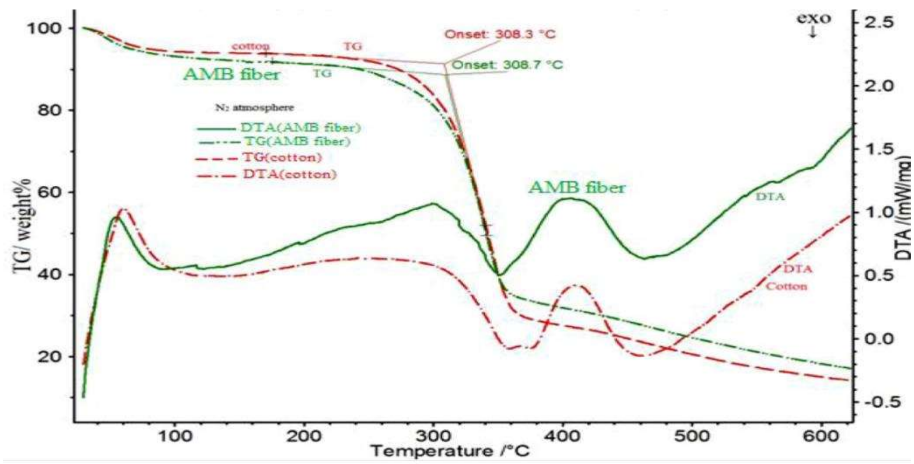


Figure 2.6.1 shows TG/DTA thermograms for raw Allamanda Blanchetti and cotton fibers under N_2

Raw Allamanda Blanchetti, raw cotton, and delignified/bleached Allamanda Blanchetti fibers started to disintegrate at 308,7 °C, 303,3 °C, and 343.2 °C, respectively, when exposed to nitrogen dioxide (Figure 2.6.1 and 2.6.2). This demonstrated that the thermal stability of the raw Allamanda Blanchetti and cotton fibers under N2 was almost same, and that the thermal stability of the Allamanda Blanchetti fiber enhanced after alkali treatment and bleaching. This is because layers such as wax, pectin, hemicellulose, etc., which disintegrate at lower temperatures than cellulose, are removed. The lower initial degradation temperature (331 °C) for delignified/bleached Allamanda Blanchetti fiber in air compared to N2 was due to oxidative degradation in air. Thermal decomposition of cellulose in an inert environment (N2) produced a DTG peak (Figure 2.6.3) associated with the creation of macromolecules with unsaturated ring structures. Unfortunately, this peak partly overlaps the exothermic mass loss peak associated with cellulose oxidation in air. Thus, the major DTG peak in air is lower in temperature than in N2. The disappearance of the shoulder peak of the DTG curve (Figure 2.5.2) between 230 and 260 °C indicates the loss of hemicellulose and pectin in the treated

Allamanda Blanchetti fiber. The residual mass at 600 °C for raw Allamanda Blanchetti and cotton fibers in N2 was 18.22 and 15.04 wt percent, respectively, with the greater mass residue in raw Allamanda Blanchetti fiber attributable to larger amounts of wax, pectin, protein, etc (Figure 2.5.1). Maximum mass loss (49 wt %) of raw Allamanda Blanchetti fiber in N2 was recorded at 340 °C, whereas the corresponding values for raw cotton fiber were 342.5 °C and 50.3 wt %, respectively.

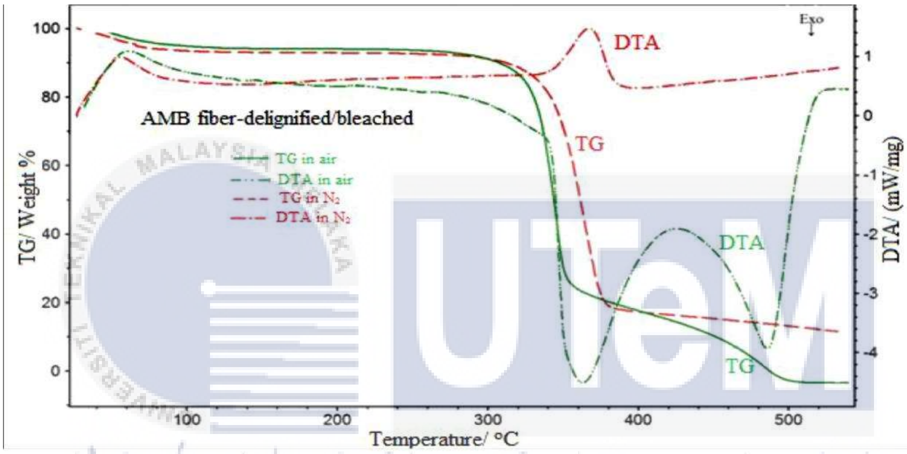


Figure 2.6.2 show TG and DTA traces for delignified/bleached Allamanda Blanchetti fiber in air and N_2

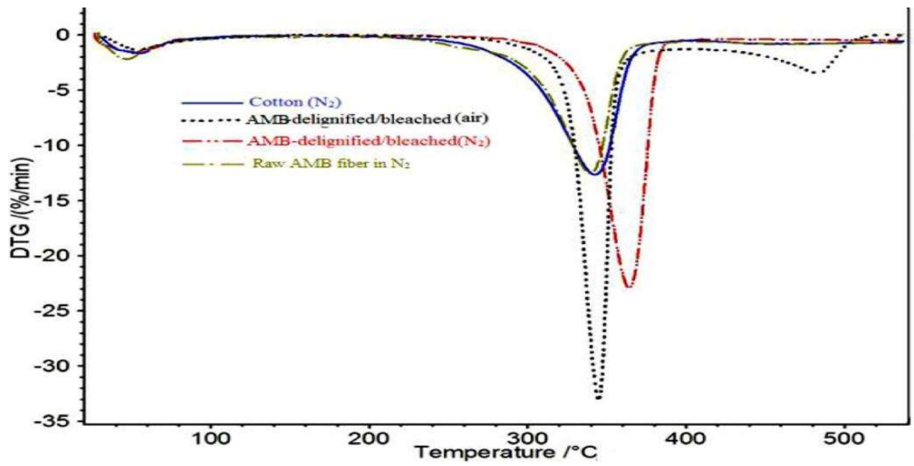


Figure 2.6.3 shows DTG thermograms of raw cotton, raw and treated Allamanda Blanchetti fibers in N_2 or air.

Again, this indicated that the thermal stability of the raw Allamanda Blanchetti fiber was equivalent to that of the raw cotton fiber. In contrast to N2, where the treated fiber degraded in a single step, it decomposed in two steps in air (Figure 2.6.2 and 2.6.3). The oxidative breakdown of the stable molecules created in the first stage is responsible for the two-phase deterioration in air. The greatest mass loss temperature and corresponding mass loss measured for the treated Allamanda Blanchetti fiber in air and N2 for the early degrading phases were 346.4 and 364 °C and 42 and 57 wt percent, respectively. The weight loss of treated Allamanda Blanchetti fiber up to the inflexion point (483 °C) in the second breakdown stage was approximately 98 wt percent in air and 86 wt percent under N2. At 495 °C, the treated Allamanda Blanchetti fiber in air completely disintegrated, leaving no remnant, but in N2 it deteriorated by 86 wt %.

The difference thermal analysis trace of raw FMB fiber in the presence of N2 demonstrated two exotherms at 361.6 and 463 °C with about 163.7 and 259.3 J/g change in enthalpy (H) at these temperatures, respectively (Figure 2.6.1). This was the outcome of hemicellulose decomposition. Raw cotton also had two exothermic reactions at 359 and 461.2 °C, with H values of 182.4 and 461.2 J/g, respectively. The lack of these exotherms in the difference thermal analysis trace of alkali-treated Allamanda Blanchetti fiber (Figure 2.6.2) was attributed to the removal of hemicellulose during alkali treatment. The treated Allamanda Blanchetti fiber displayed an endotherm (about H = + 141 J/g) at 367.4 °C in N2 due to heat degradation of the cellulose content (Figure 2.6.2). Due to oxidative decomposition, the treated Allamanda Blanchetti fiber degraded exothermically in air, with exothermic maxima at 363 and 485.6 °C and H values of approximately 932.2 and 803.1 J/g, respectively (Figure 2.6.2).

Thermal conductivity is an essential characteristic of thermal insulating materials used in constructions, and it varies among materials. The insulating characteristics of composite materials are affected by a number of parameters, including fiber type, fiber/adhesive interface structure, density, particle size, and porosity. All produced hybrid composites are used as building insulation since their values are within the defined ranges for thermal insulators for structures (Mawardi et al., 2022). There is a link between the high water absorption levels and the low thermal conductivity coefficients of these composites, since the foamy region of the oil palm trunk offers a substantial amount of empty space, hence lowering the thermal conductivity of composites. The high water absorption values of the samples were destined to be followed by low thermal conductivity.

Using the transient electro-thermal (TET) method and the steady-state electro-thermal (SET) technique from 320 K to 7 K, polyimide (PI) composite fibers (crystallinity less than 2% to 10%) were generated (Xiang et al., 2022). Subsequently, thermal conductivity tests utilising the ASTM C177-97 [33] technique were conducted at a constant temperature on all 150 mm x 150 mm x 10 mm samples of each kind of hybrid composites. Four thermocouples were used to measure two samples inside and outside the box, two samples inside and two samples outside.

2.6 Conclusion

In this chapter, we conduct a literature research on the previous products of the extraction and processing of natural fibers. Many natural fibers, like as sugarcane fibers, may be extracted from earthen sources without damaging the environment and used to create housing, clothing, and vehicle components such as bumpers and bodykits. Large quantities of sugarcane fibers are produced in Malaysia, but bagasse fibres are discarded after sugarcane juice extraction. Because bagasse fibers are a renewable resource that is also biodegradable, they may be used to make a hot, humid shelter. The natural fiber must be subjected to a chemical treatment in order to eliminate any undesired moisture or particles that may be present. We must choose the sandwich composite of sugarcane fiber and polyester aluminium honeycomb from the research journals since it is durable, inexpensive, and lightweight. The optimal method for analysing the thermal characteristics of natural fibers is differential scanning calorimetry. Differential scanning calorimetry techniques and methods explain the temperatures, heats, and/or changes in specific heat capacity during the thermodynamic and kinetic transitions of various materials, such as low-molecular-mass compounds, amorphous and semicrystalline synthetic polymers, and biopolymers.

CHAPTER 3

METHODOLOGY

3.0 Introduction

Through this chapter, we will explain the research design to develop the natural fiber of sugarcane fiber with a composite polyester aluminium panel for hot, humid climate shelter application based on the literature review in the previous chapter. The selection of material depends on the cost and suitability of material to fabricate the shelter by using the sugarcane fiber and the composite polyester resin aluminium honeycomb sandwich. In order to fabricate, the best equipment has to be considered, such as an oven, stirrer, mould, etc. Last but not least, the arrangement of the experiment setup should ensure it follows the machine procedure.

3.1 Flow Chart

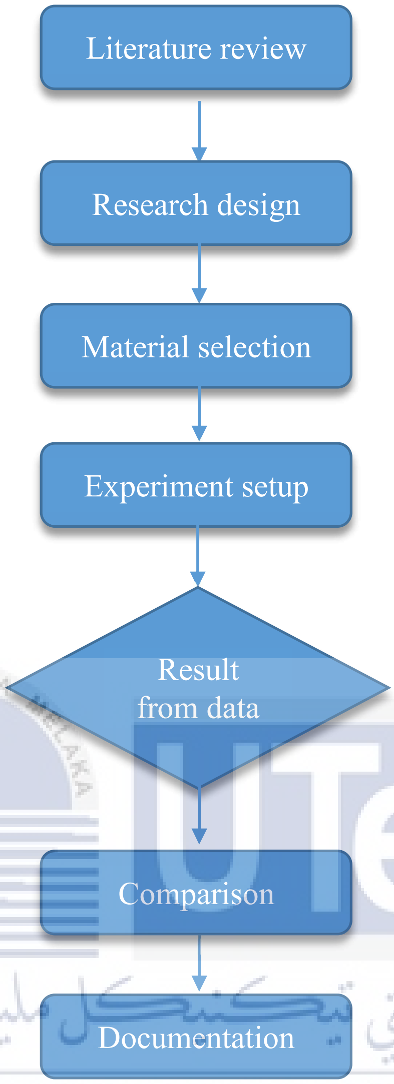


Figure 3.1 shows the flow chart of the experiment process

3.2 Research Design

This thesis presents a new combination of aluminium honeycomb and sugarcane waste. The selected combination is based on a thermal study of honeycomb, which has excellent thermal conductivity for hot-humid shelter applications and may be enhanced with polyester resin derived from sugarcane waste. The size of the honeycomb is either 1.5 mm or 2.5 mm. The fiber size is reduced to six millimetres and chemically processed. The experiment must be undertaken to identify which material must be used to construct a shelter for a hot and humid region.

3.3 Material Selection

3.3.1 Sugarcane Fiber and It Chemical Treatment

Sugarcane is the greatest crop in the world and it can be produce in asian country such as malaysia, india, and indonesia. The natural sugarcane fiber uses in this investigation was sourced locally. According to previous research, the typical fiber length was between 0.1 cm and 0.8 cm (depending on your fiber). The leftover components, which are typically referred to as bagasse, are generated as byproduct after the sugar canes are compressed. Bagasse is a lignocellulosic substance made up of 45–55 percent cellulose, 25–30 percent hemicellulose, and 18–24 percent lignin. Three main components make up a sugarcane stem where the fibers (73%), pith (5%) and rind (22%). Both the pith and the rind's outer layer have been investigated as potential fiber sources. Compared to the rind which has a density of 550 kg/m^3, the pith has a significantly lower density (220 kg/m^3) and is made up of coarse fiber and numerous big cavities. Figure 3.2 the sugarcane baggase fiber. The natural sugarcane fiber was submerged in water for 24 hours to remove impurities, such as oil or sugar, that could hinder mechanical performance. Next, the sugarcane residue is exposed to the sun to evaporate any remaining moisture. Table 3.2 Procedure cleaning sugarcane fiber

Figure 3.2 the sugarcane baggase fiber

The alkaline treatment also known as mercerization, is a chemical process in which natural fibers are submerged for a predetermined amount of time and at a predetermined temperature in a solution of sodium hydroxide (NaOH). An amount of the lignin, hemicellulose, wax, and oils that normally coat the outside surface of natural fibers are removed during the alkaline treatment, which changes the fibers' surface. Figure 3.3 the sodium hydroxide and Table 3.1 sodium hydroxide properties.

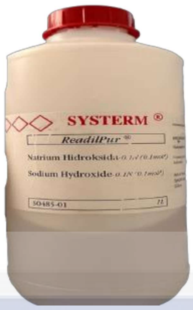


Figure 3.3 the Sodium Hydroxide.

Table 3.1 Sodium Hydroxide Properties.

Contain per litre at 20'C	4.000g/L NaOH
Indicater	Phenolphthalein
Actual normality	0.1003N
Specific density (20'C)	1.00g/cm^3
Colour	Clear,colourless

Table 3.2 Procedure cleaning sugarcane fiber.

Bil	Step	Figure
1	by using the sucargane machine extractor the sugar was seperated into the container and the fiber were left behind	

2	To esure the fiber was cleaned from dirt, it soaked with sodium hydroxide (NaOH) for 30 minutes and water is used to remove excess NaOH solution	
3	Drying the wett sugarcane fiber at 100’c for 6 hours using Oven	
4	The fiber was blend to remove cotton	
5	Filtered unwated cotton on the sugarcane fiber	

3.3.2 Material For Sugarcane Fiber Composite

Polyester resin is a viscous liquid resin and it made from a glycol and an unsaturated dibasic acid condensated. This polymer is distinguished by its transparent, pale yellow tint and a double bond between its carbon atoms (C=C). Figure 3.4 the nordsodyne polyester resin and and it hardener Figure 3.5 the butanox m-50. Table 3.3 the norsodyne polyester resin properties.

Figure 3.4 the Norsodyne polyester resin

Figure 3.5 the butanox m-50

Table 3.3 The Norsodyne polyester resin properties.

Specific weight at 20°C	1,10 g/cm³
Brookfield viscosity at 23°C, sp 2 rpm 50	450 – 650 mPa.s
Solid content	56 – 60 %
Exothermic peak	90 – 110 ‘C

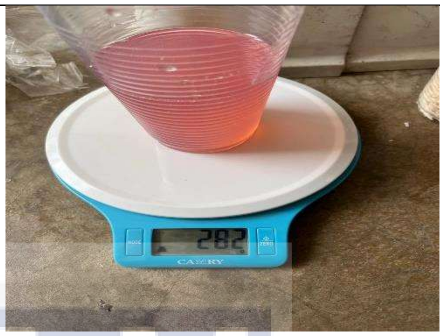
Aluminum honeycombs possess the highest strength-to-weight ratio of any structural materials. The thickness of the foil and the size of the cells determine the range of geometric cell formations and properties that are present. The resultant honeycomb is stretched to create a sheet from a block that has not been expanded. In particular applications, such as maritime construction, honeycombs made of aluminium are susceptible to corrosion. When a cored laminate meets this type of honeycomb, it irreversibly deforms. So, for this experiment, aluminium is the appropriate material to employ. To increase the mechanical qualities of honeycomb panels, polyester resin can be used with honeycomb panels. In addition, the polyester resin will be combined with its hardener in a 4% of the unsaturated polyester resin. Vaseline was utilised in the inquiry to lubricate the polyester resin mould. Table 3.4 The composite ratio for polyester resin and harderner. Figure 3.6 below shows vaseline. Table 3.5 procedure composite norsodyne polyester resin aluminium panel and sugarcane fiber.

Table 3.4 The composite ratio for polyester resin and hardener.

Polymer (g)	Hardener (g)	Fiber (g)	Weight Total (g)	Weight (%)	Hardener
294.00	6.00	0.00	300	0%	4%
284.16	11.84	4.00	300	1.33%	4%
282.24	11.76	6.00	300	2%	4%
280.32	11.68	8.00	300	2.67%	4%
278.40	11.60	10.00	300	3.33%	4%
276.48	11.52	12.00	300	4%	4%

Figure 3.6 show the vaseline

Table 3.5 Procedure composite norsodyne polyester resin aluminium panel and sugarcane fiber

Prepare the first sample of fiber 4g and continues with the last sample 12g	
Measure the weight of norsodyne polyester resin follow by the ratio of 96:4 harderner	
Measure the weight butanox m-50 before it mix with their unsaturated resin	
Pouring the unsaturated Polyester Resin into Butanox M-50 (hardener) to created the best composite and stirred in order to get a good mixture.	
Rub the vaseline on the surface area of the mould to avoid the fiber stick on the mould.	

Pouring the thermoset composite with sugarcane fiber in mould and hold it until 2-3 hours in to get a solid composite.	
Finally take out the finished composite from the mould and clean the mould from any dirt or dust.	

3.4 Preparation for sampel size

This experiment would explores the concepts of thermal conductivity and linear heat conduction with an experiment. The heat transfer experiments base unit, fits onto. The linear conduction experiment are consist of cylinder bar, cylinder specimen, thermocouple, heater and water hose. The diameter of cylinder specimen size is 6.2 cm and the length is 1.8 cm. Table 3.6 show the measurement of specimen and Table 3.7 procedure for sample size.

Table 3.6 The measurement of specimen

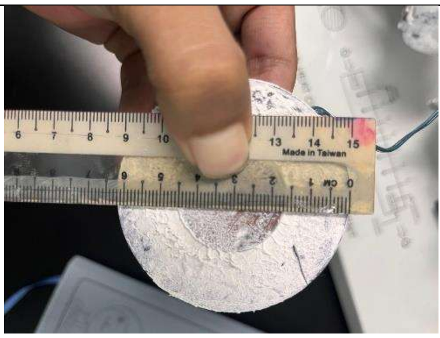
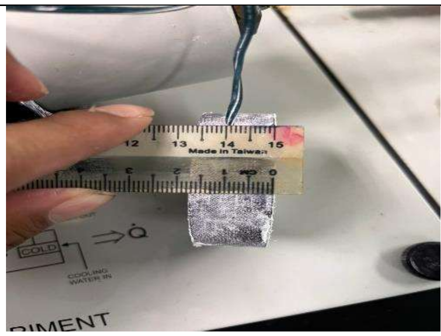
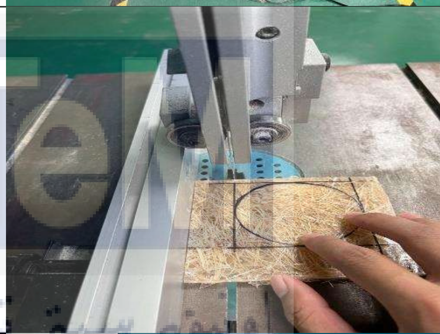
 The diameter of specimen size is 6.2 cm	 The specimen length is 1.8 cm

Table 3.7 Procedure for sampel size

Draw the square with the lenght of 6.2cm x 6.2cm width	
Switch on the power supply of makita saw machine	
Adjust the ruler bar parallel to specimen in order create a straight cut.	
Pull the trigger to move the cutting tool saw	
Cut the specimen and after finished switch of the machine. Clean the machine from dusk	

Cut the aluminium honeycomb panel size 6.2cm x 6.2cm by using cutter	
Prepare the polyester resin and hardener as well as applying glue to honeycomb panel between sugarcane fiber on combine it.	
Let the sample fully dried on 1 to 2 hours	
In order to minimize heat loss,the surface material was rolled by insulation and applying heat sink compound	

3.5 Equipment

Table 3.8 Shows equipment use in this experiment.

Equipment	Explanation
 Electronic balancing	A sub-milligram analytical balance is a type of balance used to measure extremely small masses. The measuring pan of an analytical balance (0.1 mg or better) is contained in a glass cage with doors to keep out dust and prevent air currents from affecting the functioning of the balance.
 Stirrer	A stirrer's primary role is to agitate liquids in order to speed up processes or improve mixes. In this experiment stirrer is use to stir the mixture of polyester resin and the sugarcane residue
 Oven	An *oven* is a tool which is used to expose materials to a hot environment.
 Mold	When poring the polyester resin mold will keep the shape and keep the polyester resin from flowing out.
 TD1002A Linear Heat Conduction Experiment	Explores the concepts of thermal conductivity and linear heat conduction with an experiment. The heat transfer experiments base unit, fits onto.

3.6 Testing Method

The sandwich sugarcane fiber with polyester resin and aluminium honeycomb panel would place to the linear conduction experiment. The 0% fiber, 4% fiber, 6% fiber, 8% fiber, 10% fiber and 12% fiber were prepared as sample composite with aluminium honeycomb panel. Figure 3.7 show the diagram of linear conduction experiment.

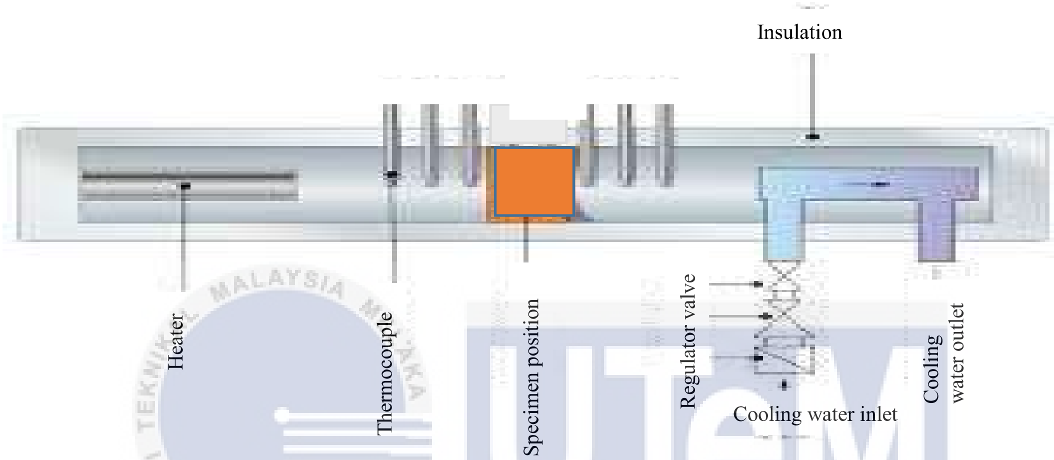


Figure 3.7 the diagram of linear conduction experiment

The water supply were pipe connected and the valve were in open position to allow the water supply in the entire system. Ensure the there are no water leak in the system. Each sample of fiber has been rolled by insulation and the surface contact applied heat sink compound. Figure 3.8 the heat sink compound.

Figure 3.8 the heat sink compound

Hence the check leak and connection wire are in the good position. Place the first sample 0% fiber at specimen position according to Figure 3.7 above.

3.7 Validation

In this case, the thermal conductivity of the numerical method was validated through the TD1002 Heat Transfer Experiment , which measured the linear conductivity of sugarcane fiber and aluminium honeycomb panel composite. From the past lab experiment, the value of copper were calculated 314.97 W/m°C. According J. Carvill, in Mechanical Engineer's Data Handbook, 1993 the value of copper is 386 W/m°C. The differentiate from this result concluded that finite element analysis is accurate with the error only 18.4% from experimental method. The calculation of error percentage shows below:

Error = (experimental – actual) / actual x 100%

= (314.97-386)/386 x 100%

= 18.6%

3.8 Summary of Material Used

The overall materials used in the production of this project were listed. This is important to ensure that all the needed material is prepared accordingly. Table 3.9 the summary of material used.

Table 3.9 show summary of material used

Bill	Material	Quantity
1	Sugarcane fiber	40 gram
2	Norsodyne polyester resin	1 698.6gram
3	Butanox M-50	64.4gram
4	Vaseline	80ml
5	Heat sink compound	10g

CHAPTER 4

4.0 Introduction

This report shows the results of an experiment conducted to study the optimization of many types of parameters. In this study, tables and graphs are used to explain the temperature of the specimen, thermal conductivity, and specific heat capacity. In addition, statistical analysis is carried out and reported in order to gain a better understanding of the elements that influence the thermal analysis of sugarcane residue reinforced with polyester resin.

4.1 Thermal Conductivity & Resistance

Thermal conductivity commonly represented by (k) is the intrinsic capacity of a substance to transfer or conduct heat. It is one of three heat transmission techniques, the other two being convection and radiation. Heat transfer processes can be quantified using suitable rate equations. This heat transfer mode's rate equation is based on Fourier's law of heat conduction. It is also described as the amount of heat that can be carried per unit time per unit area through a plate of a certain material of unit thickness, with the faces of the plate ranging in temperature by one unit. Figure 4.1 show the equation of thermal conductivity. However, Thermal resistance is defined as the ratio of a material's temperature difference between its two sides to its rate of heat flow per unit area. The thermal resistance of a textile material influences its heat insulation ability. The greater the thermal resistance, the less heat is lost. Figure 4.2 shows the equation of the thermal equation.

$$k = Q * L / A(T2 - T1)$$

Where:

Q = heat flow (W)

L = length or thickness of the material (m)

A = surface area of material (m^2)

$T2 - T1$ = temperature gradient (K)

Figure 4.1 show the equation of thermal conductivity

$$R_t = \frac{L}{kA}$$

where

k is the materials conductivity [$W.m^{-1}.K^{-1}$]

L is the plane thickness [m]

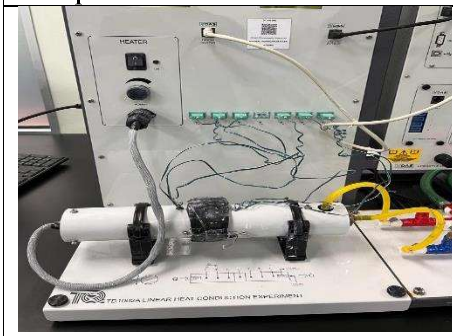
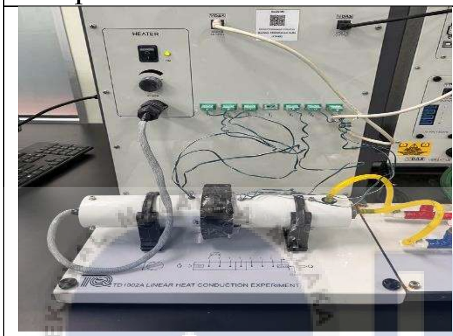
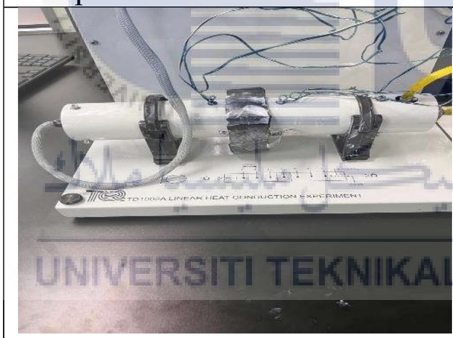
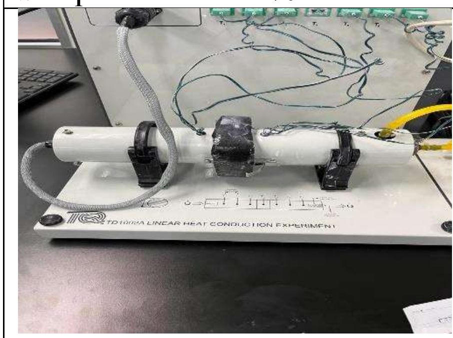
A is the plane area [m^2]

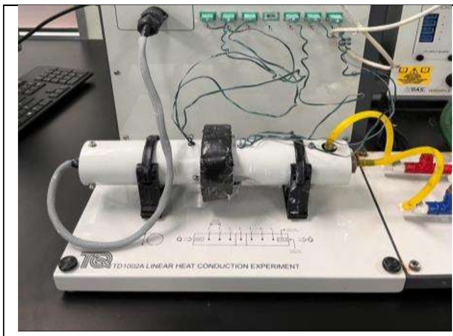
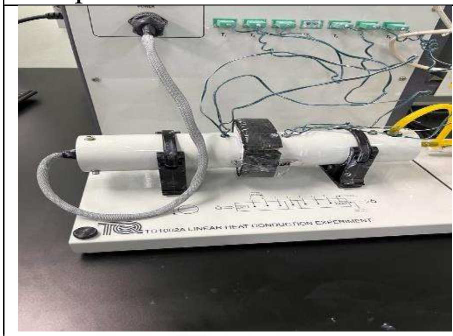
Figure 4.2 show the equation of the thermal resistance.

4.2 Linear Conduction Experiment

The electric heater and thermocouples are connected to sockets on the Heat Transfer Experiments Base Unit, which also serves as the heat sink's cold water supply and drain. Turn on the cooling water flow and experiment with the heater power. Then take temperature readings as the heat passes along the bar. Insulation surrounding the specimen minimises heat loss by convection and radiation, therefore the findings should be close to theory only for simple linear conduction. Table 4.1 show the experiment conduct.

Table 4.1 show the experiment conduct

Sampel	T initial	T final	T_{In} - T_F
 Sampel 1 of 0 with % fiber	40.0'C	28.8'C	11.2'C
 Sampel 2 of 4 with % fiber	60.4'C	26.5'C	33.9'C
 Sampel 3 of 6 with % fiber	69.2'C	24.9'C	44.3'C
 Sampel 4 of 8 with % fiber	78.0'C	23.5'C	54.5'C

 Sampel 5 of 10 with % fiber	88.5’C	22.8’C	65.7’C
 Sampel 6 of 12 with % fiber	94.1’C	22.2’C	71.9’C

From the Table 4.1, the value of thermal conductivity can be determined by using the Fourier's law of heat conduction. By referring Figure 4.1 we need to calculate the surface area of specimen which length x width and the thickness of the sample in unit meter. The power used in this experiment is 30W for each sample and the time taken is 5 minutes.

Thermal conductivity

Calculation of sample 1 = $Q * L / A (T_2 - T_1)$

$= 30W * (3.5cm \times 1m/100cm) / ((6.2cm \times 1m/100cm) \times (6.2cm \times 1m/100cm)) \times 11.2'C$

$= 24.39$

Thermal resistance

Calculation of sample 1 = L/ K * A

= 0.095/ 66.20 * 0.003844

= 0.3733

Substitute all the value of area of each sampel and the thickness length of each sampel. The unit of thermal conductivity is W/m°C can be measured then will fill in the Table 4.2. The Table 4.2 shows the data recorded and calculated.

Table 4.2 shows the data taken and calculated.

sampel	heat flow W	Thickness (m)	Temperature °C	area m^2	Thermal Conductiviy W/m°C	Thermal Resistance °C/W
0%	30	0.095	11.2	0.003844	66.20	0.3733
4%	30	0.093	33.9	0.003904	21.08	1.1300
6%	30	0.095	44.3	0.004355	14.77	1.4767
8%	30	0.093	54.5	0.00416	12.31	1.8167
10%	30	0.095	65.7	0.004095	10.59	2.1900
12%	30	0.095	71.9	0.004225	9.38	2.3967

4.3 Result and Analysis of experiment.

Figure 4.3 shows the graph of thermal conductivity (W/m'C) vs the amount of sugarcane fiber (g). From sample 1 until sample 6 has a different number of thermal conductivity and thermal resistance itself. The sample 1 with 0 with % fiber has the highest number of the thermal conductivity and the lowest number of thermal resistance. However the sample 6 12 with % of fiber recorded the lowest thermal conductivity and the highest thermal resistance.

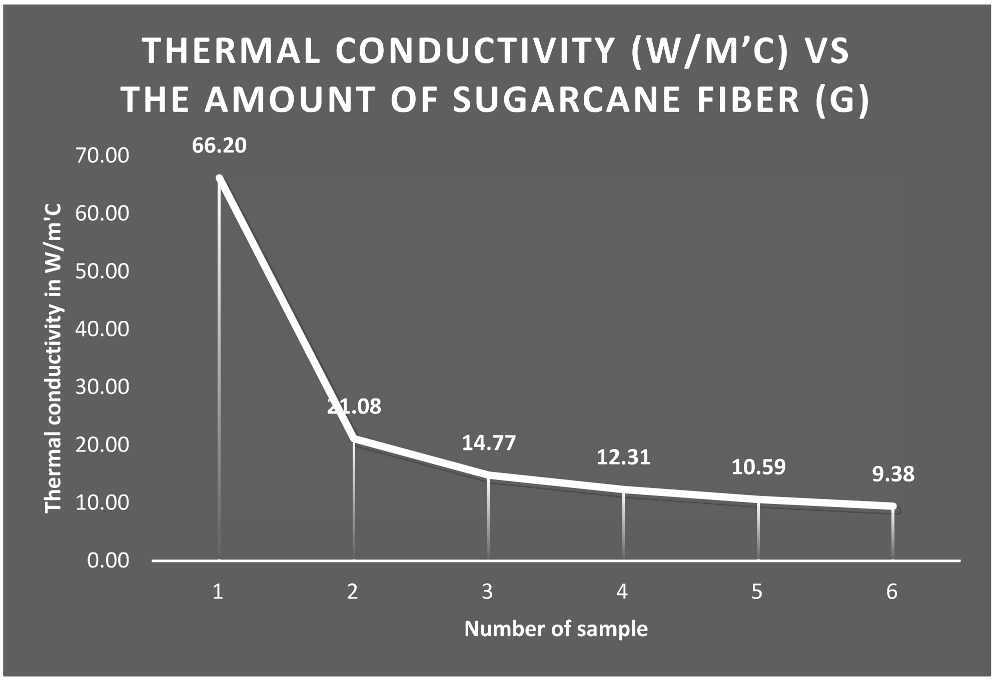


Figure 4.3 shows the graph thermal conductivity (W/M'C) vs the amount of sugarcane fiber (G).

Higher thermal conductivity materials will transmit heat quickly, either by absorbing heat from a hotter material or by releasing heat to a cooler material. Materials with lower thermal conductivity can be investigated as thermal conduction insulators, blocking the conduction of heat. Figure 4.4 shows the graph thermal resistance vs the amount of sugarcane fiber. The thermal resistance of a building layer is related to its thickness and inversely proportional to its conductivity. A high thermal resistance construction layer (e.g., rock wool) is a good insulator; a low thermal resistance construction layer (e.g., concrete) is a terrible insulator.

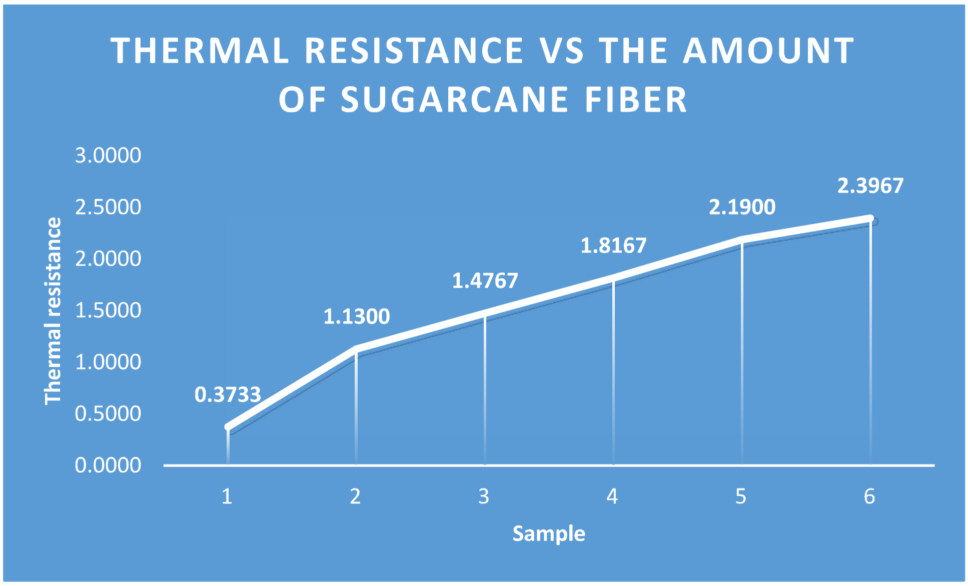


Figure 4.4 show the graph the thermal resistance vs the amount of sugarcane fiber

4.4 Summary

The research findings are methodically written out in Chapter 4, where you can see the differences in thermal conductivity values for each honeycomb sandwich composite sample. Discussions and analyses were also carried out to assess the influence of differences in each sample's thermal conductivity value and fiber content %. Using the information and replies from this chapter, it is feasible to develop a conclusion about the project being carried out, which will be explained in chapter 5.

CHAPTER 5

5.1 Conclusion

In conclusion, this project may be considered as successful because it met the project's objectives. The first is about creating the sandwich sugarcane fiber, polyester resin, and aluminium honeycomb panel, which can be observed in the literature review and methods in chapters two and three, where we can discuss sugarcane fiber, aluminium honeycomb, and polyester resin in detail. The entire material preparation procedure, as well as the process experiment to create a sugarcane fiber sandwich with aluminium honeycomb, were completed successfully. The attainment of this purpose is then regarded in terms of the construction of a composite sample to be utilised as a speciment experiment using the procedure that has been established. Furthermore, the second objective of investigating the thermal conductivity of the honeycomb sandwich sugarcane fiber reinforcement is also considered to achieve the project's goal, where the thermal conductivity value and thermal resistance value for each sample provided, which is a sample that differs in terms of the quantity of sugarcane fiber, can be translated and analysed with good to make a comparison.

According to the analysis, sugarcane fiber is a very effective thermal insulator, which is in line with the basic criteria of this project, where the major aim of employing this honeycomb sandwich with sugarcane fiber reinforcement is for outdoor usage as a shelter. Furthermore, based on the findings of the experiment, the thermal conductivity value of the sugarcane fiber sample is lower and thermal resistance value is high. Moreover, the findings of this experiment are extremely reliant on several major aspects, including the thickness of the composite during the test, the temperature employed during the experiment, and how uniformly and regularly the sugarcane fiber is organised in the composite. This element has a significant impact on the findings acquired to guarantee that the results obtained are correct.

Lastly, sugarcane fibre offers excellent properties for usage in a variety of industries, including building. Because of this unique feature of genuine sugarcane fibre will be in great demand in the future. It is having a good material for composite reinforcement because it is highly durable, can insulate heat well, and has a low thermal conductivity value and high thermal resistance value when compared to other fibre materials.

5.2 Recommendation

Some recommendations for future work are possible. The thermal conductivity testing guidelines for sandwich sugarcane fiber/polyester and aluminium honeycomb panels must be enhanced. The following are the recommendations:

I. Type of resin : Despite the usage of polyester, there are a variety of resins that may be utilised, including polyester resin and vinyl ester resin, which should be researched in order to achieve thermal conductivity experiment and physical qualities.

II. Sample fabrication : Because the surface is irregular, it is currently not exact enough to assemble the specimen. Because the fibre size ranges from 4 cm to 8 cm. If the fibre is smaller, the surface of the specimen may be more even. Furthermore, the aluminium honeycomb may be layered to absorb more heat and reduce heat loss to surrounding. Furthermore, the size of the honeycomb might vary. The mechanical characteristics of a honeycomb can be affected by its size and height of the composite.

III. Testing method : This research is focus on thermal analysis. However other testing can be used to test on sugarcane fiber and aluminium panel composite in order to create a shelter. The mechanical testing such as hardness test, impact test and flexural test.

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	PSM 1 & PSM 2																																					
Project Activity	March		April				May				June				July				October				November				December				January				February			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Title Selection	BP Briefing							Mid Term Break								Study Week	Final Semester Examination		Semester Break									Mid Term Break							Study Week	Final Semester Examination		
Description of Problem Statement																																						
Project Objective and Scope																																						
Study about Literature Review																																						
Prototype Design & Methodology																																						
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Fabricate Initial Prototype																																						
Prototype Testing																																						
Methodology																																						
Final Prototype																																						
Discussion and Conclusion																																						
Presentation BDP 2																																						
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