WATER ABSORPTION FOR INSULATION BOARD MADE FROM CIGARETTE BUTTS

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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 with Honours.

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DEDICATION

I humbly dedicated this project to my parents, Roziman Bin Ruzele and Rozitah Binti Abdul Karim, whose love, affection, and prays fueled me to succeed in this project. Not to forget my supervisor Puan Sushella Edayu Binti Mat Kamal for her constant guidance and patience, from start till end of this journey. Finally, I would like to thank my friends for their encouragement and abundance of idea towards this thesis study.

ABSTRACT

Due to the negative impacts of improper disposal, cigarette butt waste has grown to be a significant environmental problem everywhere, including in Malaysia. Toxic substances and contaminants found in cigarette butts pose dangers to ecosystems and public health by leaching into the environment. The goal of this project is to develop an effective method to removes harmful compounds from cigarette butt and reuse it as insulators. The initiative also aims to study the correlation between water absorption and varying percentages of cigarette butt fibers in the insulation material and analyse the effect of thickness on the water absorption of insulation board made from cigarette butt. The procedure implemented involves meticulous cleaning process including manual removal of external papers, washing, soaking, and heating at 50°C to eliminate chemicals and expand the fibers. Subsequently, the cleaned cigarette butts undergo additional washing in methanol. Methanol can help to extract the cellulose acetate fibers from cigarette butts. Then, the extracted fibers are dried under the sun for 48 hours. Then, epoxy resin were used an adhesive to bind together fiber to make an insulation board with different fiber content. The analysis and discussion of this project encompassed various parameters determined to achieve the objective successfully. This involves comparing the characteristics of cigarette butt fibers to those of other fibers, such as their weight, thickness, and surface. Before that, morphological assessment using an optical microscope was utilized to gain insights into the structure of the obtained fibers. The effectiveness of the process utilised to remove dangerous substances from the filters was also examined in the study to guarantee that the fibers produced are secure and environmentally friendly. The results shows a direct correlation between fiber content and the surface attributes of the insulation boards. Thickness variations in the insulation boards also reveal their influence on water absorption, weight, and surface features. The data indicates that thinner samples may exhibit higher water absorption percentages. It can be seen that recycling cigarette butts into insulating fibers is a promising approach to reducing cigarette butt waste. The project's accomplishment in creating a practical technique to eliminate hazardous substances raises the viability of this recycling strategy. In conclusion, recycling cigarette butts into possible insulating fibers offers a creative and environmentally friendly way to deal with the problem of cigarette butt waste. By recycling this waste material, the project aids in the fight against waste generation, lessens environmental harm, and gives a hazardous substance a useful use.

ABSTRAK

Disebabkan oleh kesan negatif daripada pembuangan yang tidak betul, sisa puntung rokok telah menjadi masalah alam sekitar yang berleluasa di serata dunia, termasuk di Malaysia. Bahan toksik dan tercemar yang terdapat dalam puntung rokok menyebabkan bahaya kepada ekosistem dan kesihatan awam dengan penyebaran ke alam sekitar. Matlamat projek ini adalah untuk membangunkan kaedah yang berkesan untuk membuang sebatian berbahaya dari puntung rokok dan menggunakannya semula sebagai penebat. Inisiatif ini juga bertujuan untuk mengkaji perkaitan antara penyerapan air dan peratusan berbeza gentian puntung rokok dalam bahan penebat dan menganalisis kesan ketebalan kepada penyerapan air di papan gentian yang diperbuat daripada puntung rokok. Prosedur yang dilaksanakan melibatkan proses pembersihan yang teliti termasuk mengeluarkan kertas luar secara manual, mencuci, merendam, dan memanaskan pada suhu 50°C untuk menghapuskan bahan kimia dan mengembangkan gentian. Selepas itu, puntung rokok yang telah dibersihkan menjalani pencucian tambahan dalam metanol. Metanol boleh membantu mengekstrak gentian selulosa asetat daripada puntung rokok. Kemudian, gentian yang diekstrak dikeringkan di bawah matahari selama 48 jam. Kemudian, resin epoksi digunakan sebagai pelekat untuk mengikat bersama gentian untuk membuat papan penebat dengan kandungan gentian yang berbeza. Analisis dan perbincangan projek ini merangkumi pelbagai parameter yang ditentukan untuk mencapai objektif dengan jayanya. Ini melibatkan membandingkan ciri gentian puntung rokok dengan gentian lain, seperti berat, ketebalan dan permukaannya. Sebelum itu, penilaian morfologi menggunakan mikroskop optik telah digunakan untuk mendapatkan gambaran tentang struktur gentian yang diperolehi. Keberkesanan proses yang digunakan untuk mengeluarkan bahan berbahaya daripada penapis juga diteliti dalam kajian untuk menjamin gentian yang dihasilkan adalah selamat dan mesra alam. Penemuan penyelidikan menunjukkan korelasi langsung antara kandungan gentian dan sifat permukaan papan penebat. Variasi ketebalan dalam papan penebat juga mendedahkan pengaruhnya terhadap penyerapan air, berat dan ciri permukaan. Data menunjukkan bahawa sampel yang lebih nipis mungkin menunjukkan peratusan penyerapan air yang lebih tinggi. Dapat dilihat bahawa mengitar semula puntung rokok menjadi gentian penebat adalah pendekatan yang menjanjikan untuk mengurangkan sisa puntung rokok. Pencapaian projek dalam mencipta teknik praktikal untuk menghapuskan bahan berbahaya meningkatkan daya maju strategi kitar semula ini. Kesimpulannya, kitar semula puntung rokok menjadi gentian penebat yang mungkin menawarkan cara yang kreatif dan mesra alam untuk menangani masalah sisa puntung rokok. Dengan mengitar semula bahan buangan ini, projek ini membantu dalam memerangi penjanaan sisa, mengurangkan bahaya alam sekitar, dan memberikan bahan berbahaya kegunaan yang berguna.

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LIST OF SYMBOLS AND ABBREVIATIONS

%	-	Percentage
g	-	Grams
kg	-	Kilograms
WHO	-	World Health Organization
VOC	-	Volatile Organic Compound
C	-	Celcius
cm	-	Centimeter
mL	-	Millimeter
ASTM	-	American Society for Testing and Materials
SEM	-	Scanning Electron Microscopy

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CHAPTER 1

INTRODUCTION

1.1 Background

Insulation is a critical component in buildings and structures to enhance energy efficiency, reduce heat transfer, and maintain comfortable indoor environments. Fiberglass, mineral wool, and polystyrene are common types of conventional insulating materials used in building. However, because of how they are made and disposed of, they frequently have a negative impact on the environment. As a result, there is rising interest in researching green insulating solutions that are environmentally friendly and long-lasting.

Insulation made of cellulose is one promising green alternative. It is made from recycled paper and given a chemical fire-retardant treatment to improve performance. Insulation made of cellulose has various advantages for the environment. It starts by using recycled materials, which cuts waste and encourages a circular economy. Second, compared to conventional insulation materials, it requires considerably less energy to create. Thirdly, it uses less energy and has a smaller environmental impact since recycled paper has the capacity to store carbon. Additionally, cellulose insulation has great qualities for thermal insulation, sound absorption, and fire resistance.

Aerogel insulation is a further eco-friendly option. Aerogels are extremely porous substances made from gel structures, with a typical composition of 90% air. Due to its low heat conductivity, aerogel insulation has incredible thermal insulating qualities. It is a good option for insulation applications because it is lightweight and exhibits a strong resistance to heat transfer. Additionally, the sustainability profile of aerogels can be improved by the use of renewable resources in their production, such as silica extracted from rice husks or other agricultural waste.

Natural fibers including hemp, flax, and wool from sheep have drawn interest as ecofriendly insulating materials. These fibers can be generated sustainably and have strong thermal insulation qualities without requiring a lot of chemical processing. Natural fiber insulation is also biodegradable and has a low energy content, making it an advantageous choice for the sake of the environment.

Environmental considerations, waste management, and the potential for sustainable resource utilisation are the primary reasons for research into recycling cigarette butts into insulating fibers. Effective solutions are required because cigarette butts contribute to environmental damage and littering. In addition to addressing the environmental impact of cigarettes, turning cigarette butts into insulating fibers provides a useful waste management method. This waste stream can be recycled, which encourages a circular economy and enables resource recovery. Furthermore, insulation fibers made from cigarette butts may have adequate thermal and acoustic insulation qualities. This strategy lessens the need for virgin resources while simultaneously improving public health and safety by lowering the fire dangers associated with inappropriate cigarette butt disposal.

1.2 Problem Statement

Cigarette butt pollution is a significant environmental issue that poses detrimental effects on ecosystems and public health. In Malaysia, where smoking is highly prevalent, insufficient waste management procedures have resulted in widespread cigarette butt littering. Cigarette butts are a significant contributor to environmental pollution, including air, water, and land pollution, with an estimated 11 billion butts fouling the country each year.

The cellulose acetate fibers used in cigarette filters are non-biodegradable and take up to 10 years to break down, exacerbating the persistence of cigarette butt pollution. The excessive accumulation of non-biodegradable waste in public areas, lakes of water, and urban areas endangers wildlife, taints water supplies, and causes damage on natural environments. Additionally, poor cigarette butt disposal raises the risk of fires, endangering ecosystems, property, and human life. Nicotine, heavy metals, and chemical additives, among other dangerous substances found in cigarette butts, leak into the environment and have a negative impact on water ecosystems and soil quality. Furthermore, the visual appeal of public spaces has been impacted, tourism potential is diminished, and community wellbeing is threatened by the perception of uncleanliness associated with cigarette butt litter.

1.3 Research Objective

This is the project's aim:

a) To develop an effective method to removes harmful compounds from cigarette butt's filter and reuse it as insulators.

b) To study the correlation between water absorption and varying percentages of cigarette butt fibers in the insulation material.

c) To analyse the effect of thickness on the water absorption of insulation board made from cigarette butt.

1.4 Scope of Research

The scope of this research are as follows:

a) Study the process to clean the cigarette butts using the most suitable method.

b) Selection of natural ingredient to treat the cigarette butts filter such as methanol.

c) Epoxy resin were used as a mixture to make the fibers more insulated.

d) Conducting water absorption test to assess material's ability to absorb and retain moisture.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Cigarette butts are the most littered item worldwide and pose a significant environmental risk. Hence, ways to recycling cigarette butts is made to solve the cigarette butts littering issues. In the United States, tobacco was first used to create cigarettes. The leaves of the tobacco plant are harvested and dried before being fermented and used in tobacco products. Nicotine is a highly addictive chemical of tobacco that can cause addiction. Nicotine is so addictive because it causes the release of dopamine in the brain, which gives people a good feeling, which is why so many tobacco users have trouble quitting.

Cigarette is made early in the 16th century where beggars in Sevilla (Seville) began to pick up discarded cigar butts, shred them, and roll them in scraps of paper for smoking as shown in Figure 2.1. The cigars were referred to as cigarillos, which is Spanish for "little cigars." Every cigarette was created by hand, either by a smoker or in a factory where the steps included rolling by hand on a table, pasting, and packaging by hand. Early in the 19th century, the Civil War saw a considerable increase in cigarette popularity, which was facilitated by the growth of the cigarette manufacturing sector.

Figure 2.1 Roll-up cigarettes

Cellulose acetate filter which was added to cigarette in the 1950s is derived from acetylated cellulose, and it is used primarily in the production of cigarette filters. In general, natural plant-based sources like wood pulp, cotton, flax, and hemp can be used to produce cellulose. Tobacco companies include cellulose fiber in their products to help reduce tar and nicotine flavour while preserving a pleasant taste for the smoker. In addition, cellulose may control the amount of smoke produced and how the tobacco burns. The more cellulose used in the cigarette, the greater the amount of smoke that is produced.

2.2 Environmental impact of cigarette butt littering

Environmental pollution is any addition of toxic substances to the environment, that causes a change to the composition of the environment. Changes to these variables' natural properties can have significant effects on ecosystems and human existence. These factors include air, water, soil, noise, and light. Environmental pollution causes from cigarette is one of the biggest threats to life as it contains hundreds of hazardous chemicals which can cause bad consequence. Around the world, an astounding amount of cigarette butts up to 766,571 metric tons annually that ends up as litter. Cigarette butts continue to be one of the most frequently recovered materials during litter cleanup operations, despite efforts to address this issue.

In Riyadh, cigarette butts were gathered from 28 randomly chosen areas, which led to another discovery. The data from Table 2.1 showed that there was a significant volume of cigarette waste on city streets, parks, and roadside areas. Overall, the research points to potential environmental and health risks related to cigarette trash. This study reveals an uncommon aspect of smoking-related problems in the Kingdom of Saudi Arabia (Qamar et al., 2020).

Table 2.1 Cigarette butts that were collected in Riyadh. (Qamar et al., 2020)

Cigarette litter	**Mean**	**Median**	**Minimum**	**Maximum**
Number of cigarette butts (N= 28)	71.892	69.5	19	122
Weght of cigarette butts(g) (N= 28)	19.093	18.515	4.410	34.160
Weight(g)/ Cigarette butts	0.2669	0.27	0.2160	0.2536

Meanwhile, Figure 2.2 below shows a total of 4,500 cigarette butts was collected in a clean-up cigarette program in one and a half hours in Putrajaya. Cigarette butts were found to be the most prevalent type of trash during the program and from the data, 30 participants succeed in collecting 21 kg of cigarette litters. These findings highlight the significant issue of cigarette litter and the efforts made by individuals and volunteer groups to address this environmental concern.

Figure 2.2 Cigarette butts collected in Putrajaya (NanaCyber2., 2020)

2.2.1 Waste pollution

Cigarette waste pollution is a significant environmental issue that arises from the consumption and disposal of cigarettes. According to Dr Ruediger Krech, Director of Health Promotion at WHO, tobacco products are the most littered item on earth (Krech, 2022). They contain over 7000 toxic chemicals that leech into the environment when discarded, and about 4.5 trillion cigarette filters pollute the oceans, rivers, city sidewalks, parks, soil and beaches every year. From Figure 2.3, it can be seen that cigarette butts are unethically thrown at the sidewalks which pollutes the environment.

One of the main contributors to this pollution is the non-biodegradable filters found in most cigarettes. As these cellulose acetate filters take quite a while to break down, cigarette butts accumulate into the environment. Along with the filters, impulsive disposal of cigarette packaging materials as plastic wrappers and boxes results in waste contamination. Environmental issues are presented by the presence of cigarette waste, which is frequently seen in many urban and natural places. Additionally, cigarette butts contribute to the contamination of microplastics. Microplastics, which are small plastic fibers, are released by the filters as they deteriorate over time.

A comprehensive strategy is needed to address the pollution caused by cigarette waste. It involves sharing knowledge about how smoking trash affects the environment, encouraging appropriate disposal methods, and putting in place efficient waste management systems. The damaging impacts of cigarette waste on the environment can be reduced by employing tactics including expanding the availability of authorised cigarette disposal units, enforcing stricter littering regulations, and informing the public about the significance of correct disposal.

Figure 2.3 Cigarette butts found on street drainage

2.2.2 Impact on marine ecosystem

Marine ecosystems are significantly harmed by cigarette pollution, which also threatens the delicate balance of these environments (Fig. 2.4). The introduction of hazardous substances into the marine ecology is one of the main worries. The chemicals in cigarette butts filters leak into the water when they are illegally disposed of and end up in the ocean, damaging marine habitats. For marine organisms, this pollution may have detrimental effects, including physical harm, problems reproducing, and even extinction.

The contribution of cigarette trash to marine environment microplastic pollution is another significant effect. The main material used to make cigarette filters is cellulose acetate, a kind of plastic that takes a very long time to break down. The filters degrade into smaller fragments known as microplastics over time. Due to the fact that they can be consumed by a variety of animals, from tiny zooplankton to bigger marine mammals, these microplastics constitute a hazard to marine life. Consuming microplastics can impair bodily systems, hinder digestion, and alter feeding habits, which can starve marine species and reduce health. Furthermore, cigarette pollution causes habitat loss in marine habitats. Along coastlines, beaches, coral reefs, and mangroves, cigarette butts and other tobacco-related trash amass. Animals can also get caught up in used filters, which can result in injury or even death. Smoke pollution disturbs the biological balance of coastal ecosystems, which has an effect on biodiversity and the general ecological health of these habitats.

Additionally, the pollution caused by cigarettes affects marine habitats' water supplies. Nicotine and heavy metals are two chemicals emitted from cigarette filters that damage the water in the area. Water quality is impacted by this pollution, which may alter nutrient cycles and destroy important creatures like phytoplankton. The pollutants can impact organisms at various trophic levels as they cascade through the marine food web. Consuming seafood from contaminated places puts human health at risk due to the build-up of pollutants in the water.

Figure 2.4 Cigarette butts found on the ocean. Photo by Guez, J. (2020).

Moreover, pollution from littering poses a serious threat to the ecosystem and is a growing source of worry in many nations. People throw trash anywhere out of carelessness and without considering the effects of their acts. Many people are unaware of or underestimate the harm that littering causes to the environment. People think that their own acts will not have a negative impact on society. As a result, it is typical to see people dumping trash, including wrappers and cigarette butts, in open spaces. Contrary to popular belief that cigarette butts degrade relatively fast in only a matter of days, cellulose acetate causes cigarette butts to take a total of ten years to decompose.

2.3 Natural fibers insulation

Insulation derived from renewable and organic sources, such as plants, animals, and recycled materials, is referred to as natural fiber insulation. These insulation materials provide a number of advantages, including environmental sustainability, improved interior air quality, and energy efficiency.

As alternatives to conventional insulation materials, natural fiber insulation materials are considered environmentally benign. They also have a smaller carbon footprint and can be recycled or composted at the end of their lifecycle. In addition, they frequently emit minimal or no volatile organic compound (VOC), which contributes to improved indoor air quality.

It is essential to consider R-value (thermal resistance), moisture resistance, fire resistance, and compatibility with the building structure when selecting natural fiber insulation. In order to ensure the insulation's efficacy and durability, proper installation techniques and adherence to building codes and regulations are crucial.

2.3.1 Cellulose insulation

Cellulose insulation (Fig. 2.5) is a commonly used natural fiber insulation material. It is produced with fire-retardant additives and recycled paper. This eco-friendly insulation option provides several benefits, including outstanding thermal performance as well as effective heat transfer reduction, making it a popular choice for both residential and commercial buildings.

Figure 2.5 Cellulose insulation

The eco-friendliness of cellulose insulation is one of its primary advantages. It is composed predominantly of recycled materials such as newspapers, cardboard, and other paper products. By repurposing these cigarette filters as insulation, cellulose contributes to the reduction of environmental impact and the promotion of sustainable practises.

Insulation made from cellulose is renowned for its superior thermal performance. Its high density and ability to fill gaps and voids reduce air infiltration and thermal transfer. This results in increased building energy efficiency and decreased heating and ventilation costs. Moreover, cellulose insulation has a relatively high thermal resistance or R-value, a measure of its insulating capacity. Another benefit of cellulose insulation is its ability to absorb sound. Cellulose's dense fibers effectively absorb sound waves, reducing the transmission of pollution between different areas of a building. This characteristic contributes to improved acoustic comfort and a tranquil interior environment.

Additionally, cellulose insulation has excellent fire resistance. During the manufacturing process, it is treated with fire-retardant additives to improve its fire safety properties. In the event of a fire, these compounds reduce the flammability of the cellulose fibers, providing an additional layer of protection. Overall, cellulose insulation distinguishes itself as a natural fiber insulation material with numerous benefits. It is a desirable option for sustainable and energy-efficient building insulation applications due to its eco-friendliness, outstanding thermal performance, sound-dampening properties, fire resistance, safety, and ease of installation.

2.3.2 Wool insulation

Sheep wool insulation is another popular natural fiber insulation (Fig. 2.6). Wool is naturally flame resistant, breathable, and has a high absorption capacity for moisture. The thermal and acoustic insulation provided by sheep's wool is helpful.

Figure 2.6 Wool insulation

The thermal efficiency of wool insulation is one of its advantages. Wool fibers are naturally crimped and fluffy, resulting in air pockets that capture heat and provide excellent insulation against cold. This feature reduces the need for extensive heating or cooling while maintaining a consistent and comfortable indoor environment.

Additionally, wool insulation is very breathable and moisture-regulating. It is capable of absorbing and releasing moisture vapour, thereby regulating the humidity levels in a space. This feature contributes to a healthier indoor environment by preventing excess moisture accumulation and inhibiting mould and mildew growth.

In addition, wool insulation is renowned for its ability to absorb sound. Wool fibers' natural structure allows them to absorb and dampen sound waves, thereby reducing noise transmission and augmenting acoustic comfort within a building. This makes wool insulation particularly advantageous in noise-sensitive environments, such as dormitories, offices, and recording studios. Wool insulation is relatively manageable and can be cut to suit specific spaces, ensuring adequate coverage and optimising its insulating performance.

2.3.3 Cotton insulation

The other natural fiber insulation materials include cotton insulation, which contributes to waste reduction and the utilisation of renewable resources. Figure 2.7 shows the cotton insulation.

Figure 2.7 Cotton insulation

The environmental sustainability of cotton insulation is one of its primary advantages. Primarily, it is composed of recycled cotton fibers, such as denim or textile scraps. Cotton is a renewable resource whose production has a smaller influence on the environment than synthetic insulation materials. It also provide outstanding thermal performance. Cotton insulation helps regulate indoor temperatures and improves energy efficiency. Cotton's natural fibers have excellent insulating properties, minimising heat transfer and energy consumption for heating and chilling.

In addition, cotton insulation absorbs sound, making it an ideal material for noise control in residential and commercial settings. Cotton fibers reduce sound waves effectively, reducing noise transmission and creating a quieter interior environment.

Cotton insulation is installed similarly to other forms of insulation materials. It can be installed using batts, coils, or loose-fill forms in wall cavities, attics, and floors. Cotton insulation is simple to manipulate and can be cut to suit specific spaces, ensuring adequate coverage and maximising its insulating performance.

2.4 Method to obtain fibers from cigarette butts

In this project, a few methods to obtain fibers have been studied which is chemical, physical, and physico-chemical treatment. Obtaining insulation fibers from cigarette butts is not a common or recommended practice due to the potential health risks associated with handling and processing cigarette waste. Cigarette butts contain numerous toxic chemicals and pollutants that can be harmful when released or inhaled. Some methods were come up to explore the safest procedure in handling cigarette butts so it can be recycled from continuously damaging the environment.

2.4.1 Physical treatment

Physical treatment is a method that modifies the properties of the cigarette butts by using mechanical and physical processes. Maderuelo et al., (2018) used this method to discover the potential use of cigarette filters as sound porous absorber. In this process, cigarette butts were dried and manually separate the cigarette paper before shredding it into fibers. They found that cigarette butts treatment into absorber can demonstrated high sound absorption performance that is even better than commercial absorbers.

For another experiment, Mohajerani et al., (2016) transforming cigarette butts into fired-clay brick where they disinfected the cigarette butts at 105°C and mixed in different percentage with brown silty clayey sand, dried, and fired. They found that the characteristics of the fired-clay brick can be used as building material and it has potential uses in construction.

2.4.2 Chemical treatment

In chemical treatment in cigarette butts typically refers to the application of specific substances or compounds to alter the properties or behavior of the butts. This treatment can serve various purposes, such as reducing the toxicity or environmental impact of the cigarette waste. Sansone L., et al., (2020) used this method to develop fashion product, by washing the cigarette butts in water multiple times before disinfect it with ethanol washing. This helps to extract the cellulose. Then, the fibers obtained were dried at a temperature of 60°C for 60 minutes. They found that this method provide a low-cost, simple, and efficient approach for obtaining useful fibers from cigarette butts which can help to convert them into fashion product.

2.4.3 Physico-chemical treatment

Physico-chemical treatment of cigarette butts involves the application of both physical and chemical processes to manage and modify the properties of the butts. This method is used by Teixeira et al., (2017) where they separating cellulose content in the cigarette butts using four different processes by dissolving the ash and all chemicals adsorbed, hydrolyzing cellulose acetate into cellulose, removing lignin from the remaining tobacco and liberating its cellulose as well as disaggregation of the remaining paper to convert it to cellulose pulp. They found that the evaluation of physical and optical parameters of the cellulose pulp for commercial use can be used in the paper industry.

2.5 Application of fibers from cigarette butts

There are numerous prospective applications for fibers derived from cigarette butts in various industries. One conceivable application is in the textile and fabric manufacturing industry. These fibers can be combined with other natural or synthetic fibers to create unique and eco-friendly textiles. They can be used to produce clothing, upholstery, carpets, and other textile products, providing an opportunity to repurpose cigarette waste and reduce reliance on traditional fibers.

Another potential application is the manufacture of building materials. The fibers can be incorporated into building materials like brick, concrete, and insulation products. This not only provides a sustainable alternative, but also reduces the environmental impact of cigarette waste by repurposing it into durable and useful building materials.

In addition, these fibers can be used to manufacture paper products. They can be processed and combined with other cellulose fibers to manufacture recycled paper and packaging materials. This application reduces the demand for virgin wood pulp and encourages cigarette waste recycling.

In general, the use of fibers derived from cigarette ashes presents opportunities for innovative and sustainable solutions in a variety of industries. By recycling this waste, environmental pollution can be decreased.

2.5.1 Concrete

The use of concrete containing cigarette waste offers a promising solution for sustainable building practises. In the production of concrete, cigarette butt can be processed and incorporated as a partial replacement for conventional aggregates. This utilisation not only helps divert cigarette waste from landfills, but also provides a number of additional advantages. Cellulose acetate, a form of plastic, is one of the primary components of cigarette filter tips. The fibrous nature of cellulose acetate can improve the mechanical properties of concrete when combined with it. According to studies, the fibrous nature of cigarette ash can enhance the tensile strength and crack resistance of concrete. This can result in structures that are more enduring and resilient (Mohajerani A. et al., 2020).

Second, incorporating cigarette ashes into concrete can reduce the construction industry's environmental impact. By utilising this waste material, the demand for natural materials can be reduced, conserving natural resources and reducing carbon emissions from aggregate extraction and transportation.

In addition, the chemical composition of cigarette ash, specifically the presence of cellulose acetate, can improve the thermal properties of concrete. The presence of cellulose acetate fibers can result in the formation of air cavities within the matrix of the concrete, thereby reducing heat transfer. This can result in enhanced insulation capabilities, thereby minimising heating and cooling energy consumption in buildings.

In the construction industry, incorporating the remains of cigarettes into concrete offers a sustainable and innovative approach. It addresses the environmental issue of cigarette waste while providing enhanced mechanical properties and the possibility of energy savings.

2.5.2 Pillow

The use of pillows made from cigarette butts is an innovative concept that aims to reduce the environmental impact of cigarette waste while providing a practical application for these discarded materials. The procedure entails accumulating and processing cigarette butts in order to transform them into usable fibers, which are then used as pillow filling.

Similar to conventional pillow fillings, these fibers can provide a supportive and pleasant cushioning effect. They can be blended with other natural or synthetic fibers to better their properties and increase the pillows' overall comfort and durability.

The use of cigarette butt fibers in cushions has a number of advantages. First, it reduces the amount of cigarette butts that wind up in the environment, fostering a more sustainable waste management strategy. Second, it offers a viable solution for reprocessing and repurposing these discarded materials, giving them a second chance at life and decreasing the demand for virgin materials. Additionally, dependent on the specific characteristics of the fibers, the incorporation of cigarette butt fibers into pillows may offer unique properties, such as enhanced breathability or moisture-wicking capabilities.

2.5.3 Insulator

The use of insulation made from cigarette butts is an intriguing solution to the worldwide issue of cigarette waste and the need for effective insulation materials. Utilising the fibrous components of the remains of cigarettes makes it possible to create thermally resistant insulation products that contribute to the energy efficiency of buildings.

Using insulation made from cigarette butts has numerous advantages. In the first place, it reduces the environmental impact of cigarette remains. Second, it offers the chance to repurpose these discarded materials and reduce reliance on conventional insulation materials, some of which may have larger environmental impact.

Moreover, cigarette butt insulation can provide comparable thermal insulation properties to conventional insulation materials, thereby contributing to energy efficiency, reducing heat loss or gain, and enhancing indoor comfort.

2.6 Water absorption

Water absorption test is meant to evaluate the material's capabilities to absorb and retain moisture, which can affect its insulating properties over time. From research conducted by Matilla, H-P. et al, all the examined insulations materials absorb water when exposed to moisture, although with significant differences in wetting and drying capacities.

2.6.1 Factor affecting water absorption

Water absorption in materials, particularly plastics and composites, is affected by a variety of factors, each of which has a substantial impact on the overall behavior. The type of plastic is a significant variable in water absorption qualities. Different plastics have varying degrees of water permeability. Hydrophobic plastics, such as polyethylene, resist water absorption, whereas hydrophilic plastics, such as nylon, quickly absorb water. These changes are caused by the polymer's chemical structure and polarity.

Water absorption is also affected by morphology, which refers to the arrangement of polymer chains. The fiber percentage and orientation of composite materials have a major impact on water absorption. Water absorption streams are influenced by the arrangement and density of fiber inside the composite structure. Because of the increased tortuosity for water transport, higher fiber fractions and aligned fiber orientations frequently result in lower water absorption. The environment, specifically relative humidity, and temperature, plays an important impact in water absorption. Higher humidity levels allow for higher water vapor absorption, which affects materials differently depending on their essential qualities.

The duration of time took together with water is also a crucial factor in water absorption. Even materials with initially low water absorption rates may develop saturation over time, resulting in greater penetration. In applications where materials are regularly exposed to moisture or variable environmental conditions, the period of exposure becomes very important.

2.6.2 Effect caused by water absorption

One of the effects of water absorption in insulation fiber is dimensional changes, which can exhibit in swelling and changes in the material's proportions. This has consequences for the suitability and efficacy of insulation within a structure. Furthermore, the increase in mass caused by water absorption might influence the overall weight and strength of insulation material.

Another impact is the extraction of water-soluble components from the insulators. Water absorption can change the composition of the material, potentially affecting its performance and qualities. The common results can be seen through its elasticity, tensile strength, and impact strength. These changes can have an impact on the material's ability to sustain stress and strain.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss the process production of insulation fibers from discarded cigarette butts with combination of resin/epoxy in order to help others to understand the flow of this experiment and provide method to recycle cigarette butts.

3.2 Flow Chart

The flow chart in Figure 3.1 indicates the project's workflow or process in order of sequence. Through the use of symbols and texts, the flow chart effectively refined and summarised the complete process of producing insulating fibers from discarded cigarette butts with combination of epoxy/resin in a diagram. The workflow and process are graphically represented to allow for effective visualisation of the information.

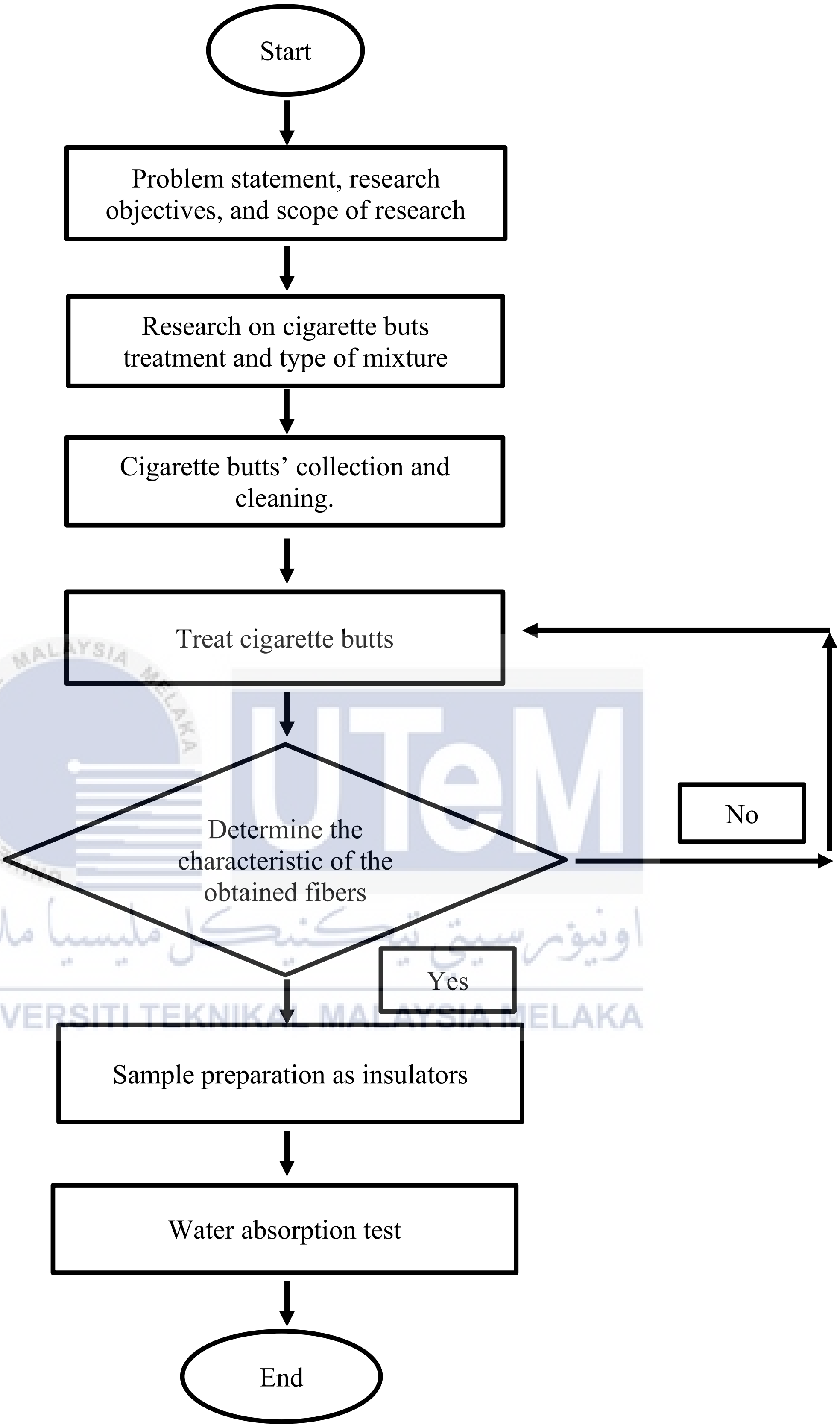


Figure 3.1 Flow chart of development of cigarette butts into fibers

The process starts by identifying the problem statement, research objective and scope of research. Then, a research on cigarette butts treatment and identify the type of mixture that will be used to produce the insulated fibers. Next, collecting the cigarette butts from the public places and do the cleaning process which include washing with methanol and drying for 48 hours under the sun. Following that, after the cleaning process is done, characteristics of the obtained fibers is determined before installing it as insulators. All findings are recorded and reported in the next chapter.

3.3 Experimental Method

Figure 3.2 shows the process involves in experimental method section. Process of developing insulation fibers from wasted cigarette butts is divided into two parts which are cleaning process of cigarette butts and production of insulation fibers. Cleaned cigarette butts is an process designed to remove the toxic substances present in cigarette butts and produce only the clean fibers, as well as reduce the bacteria on the cigarette butts. The next step is the production of insulation fibers, which involves mixing cleaned fibers with epoxy or resin to create an insulating fiber.

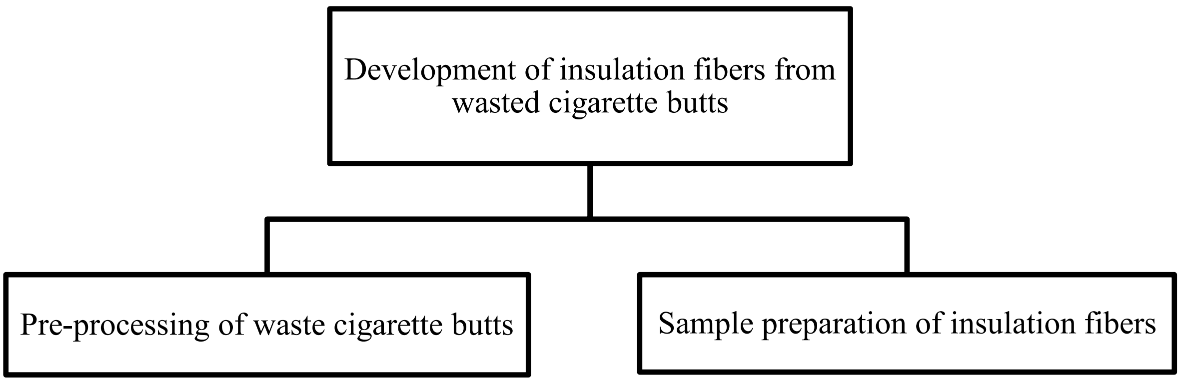


Figure 3.2 Chart of experimental method process

3.3.1 Pre-processing of waste cigarette butts

The apparatus that were used to clean the cigarette butts were beaker glass, hotplate, and thermometer. The use of hotplate was to heat the water to soften the discarded cigarette butts. Furthermore, on figure 3.3 methanol were used instead of ethanol as an agent to eliminate dirts in the cigarette butts. There are not much difference between using methanol and ethanol, but methanol has a level of acidity slightly higher than water that will effectively elimate any bacterias in cigarette butts. Methanol is also known to be cheaper than ethanol.

Figure 3.3 Methanol

The preparation to clean the discarded cigarette butts using methanol before producing the insulation boards was shown in the following figure 3.4.

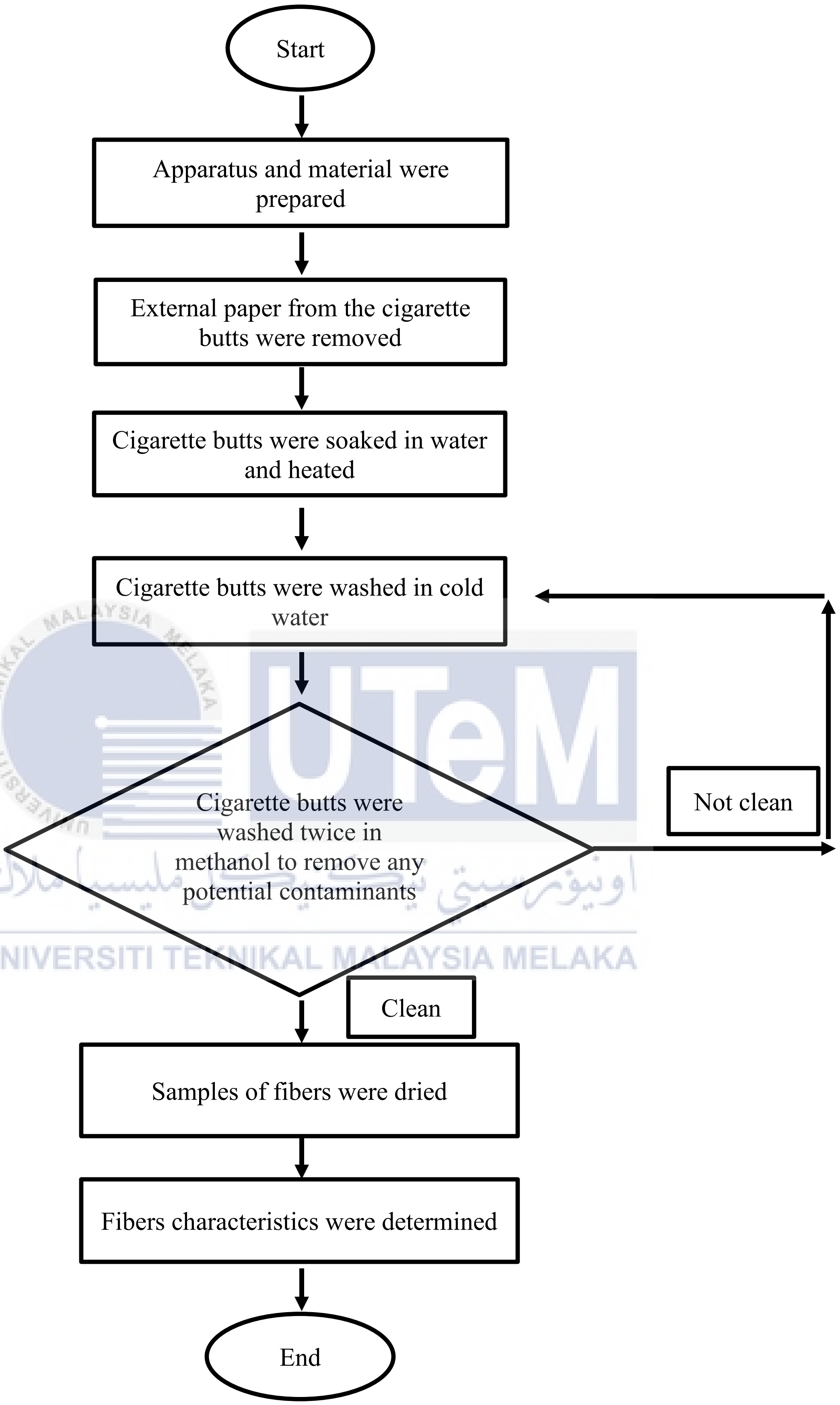


Figure 3.4 Flow chart of pre-processing of waste cigarette butts

The cleaning process starts by preparing all the apparatus and material needed. After the initial preparation was completed, external papers on cigarette butts were removed. This process was done manually by hand. After the procedure was done, cigarette butts were washed to remove any excess papers on the cigarette butts. Next, the process involved were soaking the discarded butts in water and heated for an hour at temperature of 50°C using hotplate.

This process were done to remove chemicals in the cigarette butts, at the same time to make the fibers from the butts to expand. After one hour, the cigarette butts were brought to wash in cold water thrice to expand the fibers. To ensure that there were not potential organic compound in the fibers, the cigarette butts were washed twice in methanol. The last step in cleaning process were drying process of obtained fibers under the sun for 48 hours. After all the fibers samples has dried, the characteristics of fibers were determined using optical microscope. It is to assess the shape and properties of fiber that has been cleaned. Figure 3.5 shows cleaning process of cigarette butts.

(a) (b) (c)

Figure 3.5 (a) CB soaked at 50°C; **(b)** CB washed with methanol; **(c)** clean and dried CB

3.3.2 Sample preparation of cigarette butts insulators

In order to produce insulating fibers, an experiment is conducted by using epoxy resin. Furthermore, several steps and processes are used in this experiment to produce fiber insulation board with low cost using cigarette butt fibers and epoxy adhesive as a binder (Anh Nguyen T., et al., 2021). Epoxy adhesive is a two-part adhesive that forms when epoxy resin and hardener were mixed. Figure 3.6 shows an epoxy resin.

Figure 3.6 Epoxy resin

The preparation to produce insulation fibers using epoxy adhesive as a binder was shown in figure 3.7.

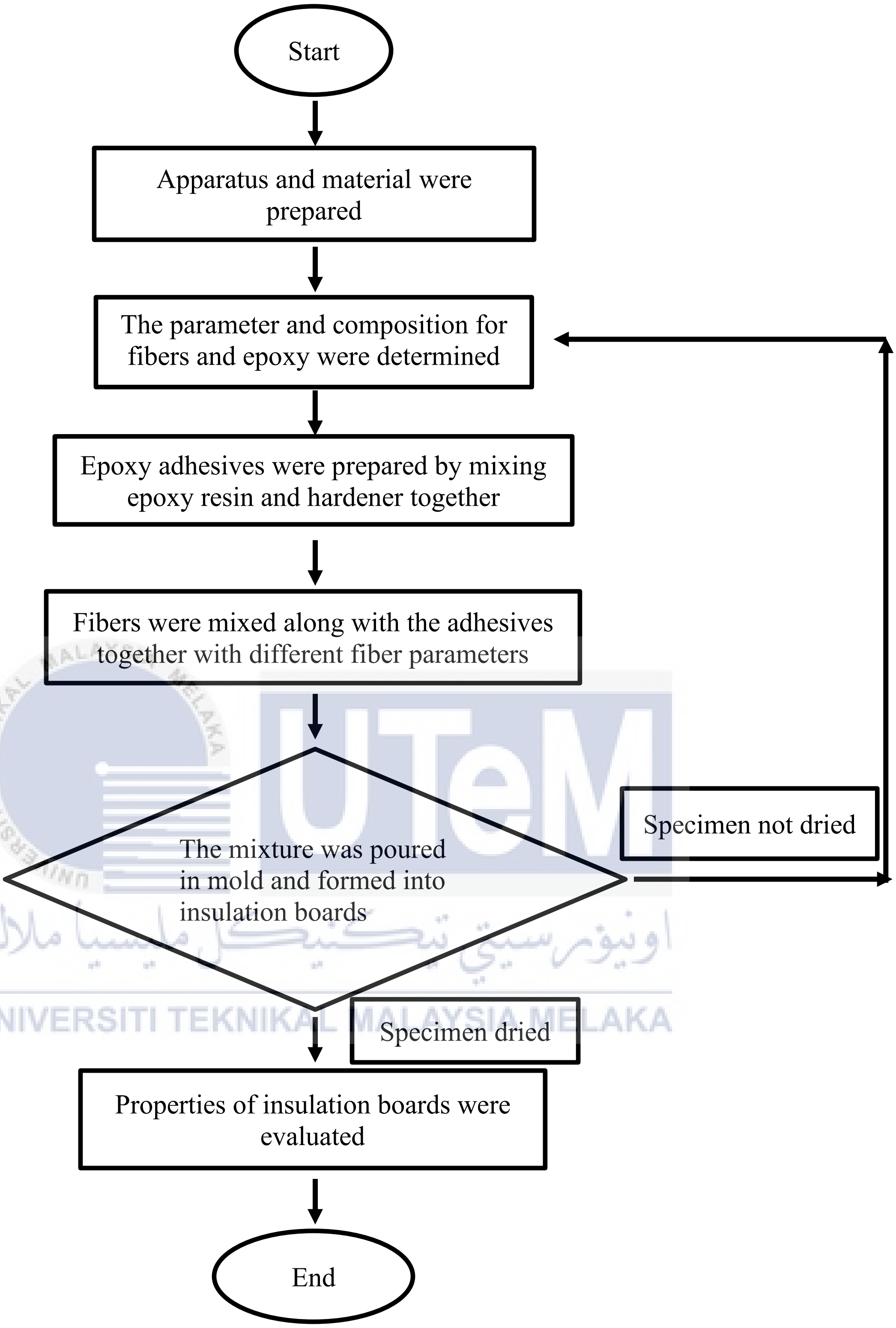


Figure 3.7 Preparation of insulation fibers using epoxy adhesive

The preparation process starts by preparing all the apparatus and material needed. It was important to ensure that the parameters and composition of fibers and epoxy adhesive were determined before began the experiment. Next, epoxy adhesive were prepared by mixing together epoxy resin and hardener. The parameters of epoxy used was tabled on the next sub-topic. After that, fibers were mixed with epoxy mixture. The percentage of fibers used were 0%, 5%, 10%, 20%, and 40%. The mixture of both fibers and epoxy were poured into silicone mold. The mixture were left harden for 72 hours and formed into insulation board. The final specimens were cut and absorption test was conducted to evaluate its properties. Figure 3.8 shows the sample preparation for water absorption testing.

(a) (b) (c)

Figure 3.8 (a) ratio A:B for 20% fiber; **(b)** mixture of epoxy and fiber; **(c)** mixture in mold

3.3.2.1 Parameter of epoxy fibers compositions

To improve the properties of a cigarette butts fiber insulation board using an epoxy adhesive as a binder, several suggestions can be considered. Initially, by optimising the formulation of the adhesive by experimenting with various concentrations and composition of the adhesives, it can help achieve the desired balance of mechanical strength, water absorption behaviour, and morphology of composites.

Figure 3.9 shows the silicone mold with dimension of 30 cm × 20 cm × 1.2 cm that was used. The process involved pouring the mixture of fibers and epoxy resins into the silicone mold. Silicone mold was used as the specimens can be easily taken out without any spillage of epoxy. Epoxy is a type of thermosetting polymer that serves as an adhesive when cured. During curing, epoxy resins would undergo a chemical process that irrevocably solidifies them. This curing procedure in the case of epoxy adhesives involves the epoxy resin and a hardening agent or curing agent. The mixture then left dried for 72 hours to make sure that it was fully dried. Epoxy adhesives are well-known for their high bonding strength, durability, and resistance to heat, chemicals, and moisture. They are frequently used for bonding materials together in a variety of industries, including construction, electronics, automotive, and others.

Figure 3.9 Silicone mold

As for the procedure, ratio is very crucial for achieving optimal performance and desired adhesive properties. The specific ratio is usually specified and must be followed accurately during the mixing process. Ratio that will be used was 2.25:1, indicating the respective amounts of epoxy resin to hardener. The ratio used was expressed as volume ratio (mL). For this experiment, the total volume for fibers and epoxy were fixed which is 300 mL.

Fibers percentage also plays a crucial role to ensure the desired insulation properties. The proportion of fibers will be added together to the epoxy resin. The specific percentage of fibers can vary based on the type of fibers used. The percentage needs to align perfectly with epoxy which the total volume should be ≈ 300 mL. Table 3.1 provides information on the composition of epoxy and percentage of fiber used for each type of insulation board produced.

Table 3.1 Composition of epoxy and percentage of fiber used for insulation board

Sample	**Fiber (mL)**	**Total Volume (mL)**	**Percentage Fiber (%)**
A	0	299.93	0
B	15	299.99	5
C	30	299.97	10
D	60	299.99	20
E	120	299.98	40

3.4 Water absorption

Laboratory testing for insulation fibres serves several important purposes. The test that will be conducted was water absorption which to check the quality of the insulators. Laboratory test is done to ensure that insulation fibres meet specified standards. Important factors need to be consider such as additives used, exposure length, and plastic form. These factors will be affecting the water absorption of the specimens.

Moisture absorption test is meant to assess the material's ability to absorb and retain moisture, which can affect its insulating properties over time. Moisture can affect fiber in many ways. It can affect the wear rate of the fiber. The most widely used standards to measure water absorption in plastics are ASTM D570. It is used for the calculation of the relative water absorption rate during immersion in specified conditions.

The ASTM D570 test method for water absorption provides two purposes, which are as a guide to the amount of water absorbed by a material and as a guide to the effects of exposure to water or humid conditions on materials. Water absorption is measured as an increase in weight percent or weight gain percentage of a plastic specimen. The formula in equation (1) can be used to calculate the percentage of water uptake of the samples. High water absorption percentage indicates a greater propensity for water ingress, which can potentially impact the material's structural integrity, mechanical strength, and thermal insulation properties.

$$Increase\ in\ weight,\ \% = \frac{wet\ weight - dry\ weight}{dry\ weight} \times 100$$

By following the ASTM D570 test method for water absorption, the samples are dried for a given time at a specified temperature. The weight of the samples is measured immediately before it is placed in the water under specified conditions. Usually at 23°C for 24 hours or until it reaches an equilibrium. After the duration of time, the samples are removed from the water, and weighed.

However, for this experiment, the weights of the insulation fiber will be taken and then submerged in normal water at room temperature for different time periods. The time intervals for the test will be 12, 24, 36, 48, 60, and 72 hours respectively. During certain time intervals, the samples will be taken out and weighed immediately. The percentage of water absorption will be calculated using the formula of percentage of water uptake. Figure 3.10 shows the process of the water absorption test.

(a) (b)

Figure 3.10 (a) Initial weight of samples were taken; **(b)** samples were submerged in water

3.5 Limitation of Proposed Methodology

The key limitation is the time-consuming process of collecting a large quantity of cigarette butts for the insulating material. The collection process may bring variation in the types and conditions of cigarette butts acquired, which may affect the consistency of the final insulation boards. Cleaning cigarette butts may be a substantial logistical obstacles. Depending on the method used, it may be time-consuming and require additional resources. As perform cleaning is critical for the material's functioning, this phase could be an issue in the overall process.

When utilising epoxy in a 2.25:1 ratio, concerns might arise during the preparation step. The potential of the texture being too runny indicates that the ratio needs to be adjusted to get the required consistency. The variation in the epoxy mixture may generate uncertainty in the characteristics and performance of the final insulation board. Though water absorption testing is included in the approach, a disadvantage is the lack of mechanical testing following water absorption. Assessing mechanical qualities after water absorption may provide a more complete understanding of the material's durability and structural integrity, providing insights into its performance under real-world settings.

In conclusion, the proposed methodology's primary limitations are the time-consuming gathering of cigarette butts, potential issues in the cleaning process, variability in epoxy ratio impacting texture, and the lack of mechanical testing post-water absorption. Addressing these limitations through optimisation and further testing could improve the whole process's resilience and reliability.

3.6 Summary

This chapter unfolds the proposed methodology to develop an effective way to eliminate toxic chemicals in cigarette butts before transforming them into insulation materials. The primary focus of the proposed methodology is to come up with a simple preparation method for sample preparation for potential applications in insulation boards using epoxy resin. This chapter not only addresses the challenges of collecting and processing cigarette butts but also underscores a commitment to sustainability through the recycling of waste materials for insulation. The cleaned fiber will be characterized by morphological assessment using optical microscopy and the insulating material will get their moisture absorption evaluated.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the pre-processing of waste cigarette butts into fibers as well as sample preparation for insulation boards using epoxy resins as adhesive. The results obtained through meticulous experimentation and analysis provide a detailed understanding of the studied variable.

4.2 Morphology of obtained fiber from waste cigarette butt

The cleaning process of cigarette butts meticulously transformed the waste into a refined and purified fiber material. The characteristics of the obtained fiber were determined by using an optical microscope. Through careful observation, the cleaning process of discarded cigarette butts effectively eliminate residual chemicals present in the butts. The fiber exhibited a distinct expansion, due to the soaking and heating at 50°C. The expansion not only eliminates the toxic chemicals in the cigarette butts, but it also enhances the fibrous structure of cigarette butts.

The optical microscope showed a finer and clearer structure, indicating the successful removal of impurities and the transformation of the discarded cigarette butts into cleaner, more uniform fiber. Figure 4.1 shows the optical microscopy image for cleaned cellulose fiber.

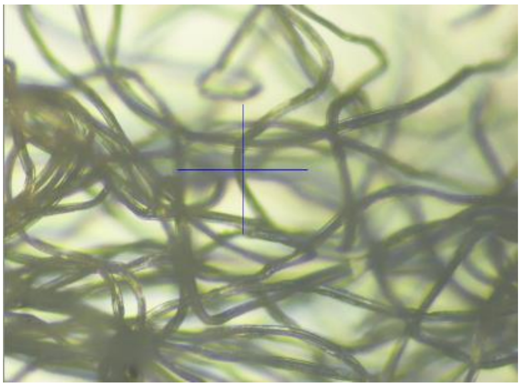


Figure 4.1 Optical microscopy image for cleaned cellulose fiber

4.3 Initial weight

After the completion of samples preparation for insulating material, the initial weight for each samples were taken to compare the specimen. After the cleaning process were done, the fibers undergo binding process to produce composites with a very high strength to pressure. The experiment involves mixing together fiber with epoxy resin during its curing process. The percentages used for the fiber were 0%, 5%, 10%, 20%, and 40% respectively. The total volume for each samples made were 300 mL. Table 4.1 show the composition of materials that were used to make the insulating board.

Table 4.1 Composition of epoxy and percentage of fiber used for insulation board

Sample	Fiber (mL)	Percentage Fiber (%)
A	0	0
B	15	5
C	30	10
D	60	20
E	120	40

After all the specimens were dried for 72 hours, all the specimens from each different composition were cutted into three samples for water absorption testing. By using vertical band saw, the samples were cutted into 6 cm × 6 cm. The initial weight for all specimens were recorded on table 4.2. From the table, a graph were made. The graph on figure 4.2 shows the relationship between fiber content vs average weights in grams. The average weights on table 4.2 show perceptible differences as the fiber content increases from 0% to 40%. The average weight is 17.33 gram with 0% fiber content. With the addition of 5% fiber, the average weight falls slightly to 16 gram. As the fiber percentage increases to 10%, 20%, and 40%, the average weights vary, ranging from 16.67 to 12.33 grams.

Table 4.2 Initial weight for each sample

Fiber content (%)	Initial weight (g)	Average weight (g)
0	21	17.33
	19	
	12	
5	16	16
	17	
	15	
10	16	16.67
	17	
	17	
20	10	12.33
	15	
	12	
40	12	12.33
	13	
	12	

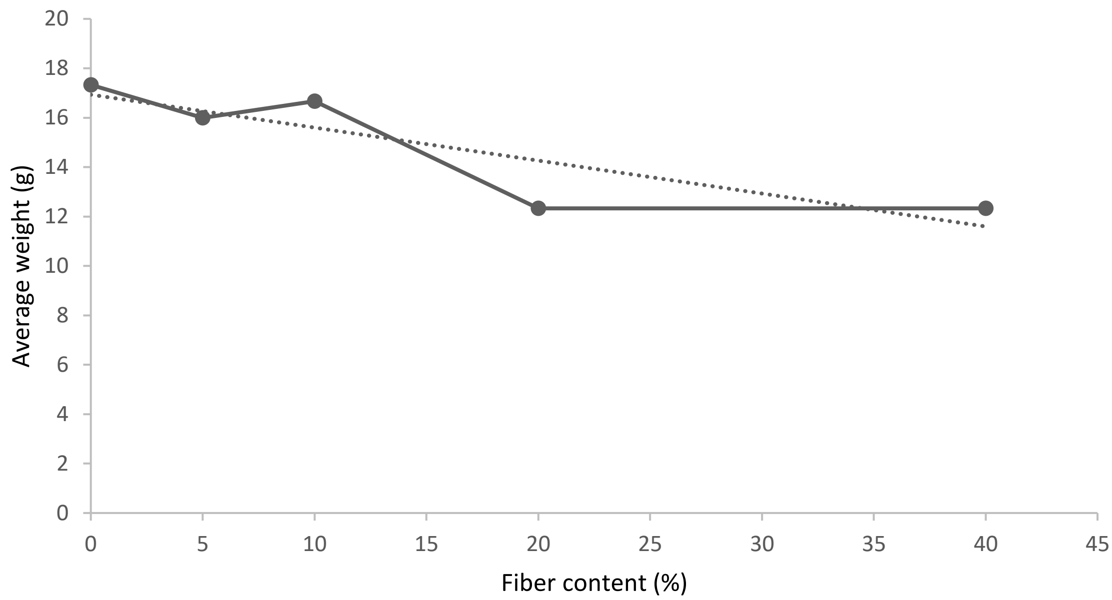
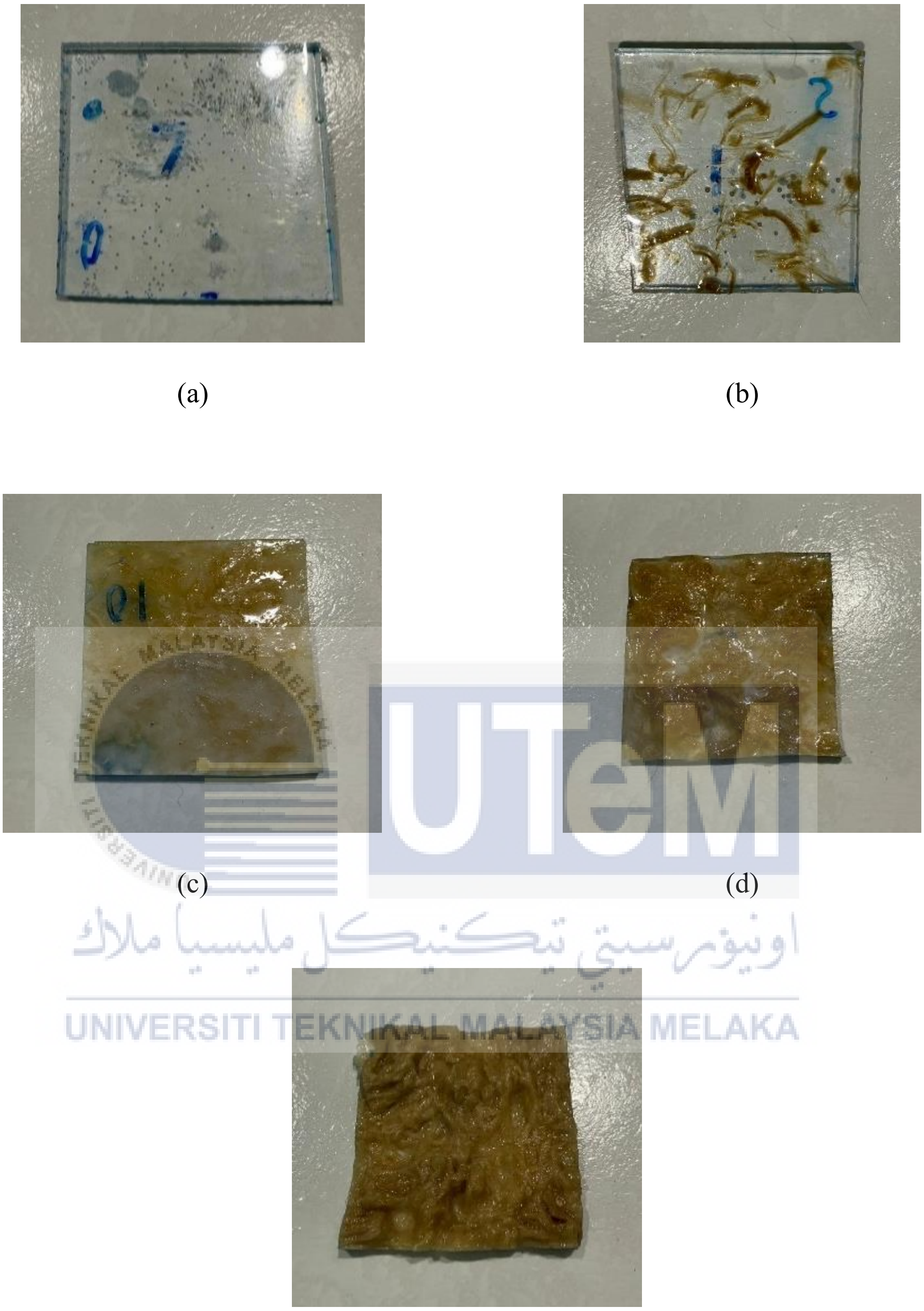


Figure 4.2 Graph of fiber content vs average weight

The graph demonstrates an decreasing trend as the fiber content percentage rises. This suggests that, on average, higher concentrations of fibers contribute to decreased weights in the insulation board. As the fiber content increases from 0% to 40%, there are observable patterns in the average weights of the specimens. Starting on the 0% fiber which was 17.33 gram, there was a slight initial decrease to 16 gram at 5% fiber, and the average weight remains relatively stable at 16 gram, suggesting a minimal impact on weight at this fiber concentration. As the fiber content increases to 10%, the initial weight of 16g results in a slight increase in average weight to 16.67g. This trend continues at 20% fiber content, when the initial weight is 10g and the average weight increases to 12.33g, demonstrating a correlation between higher fiber concentrations and higher average weights. Interestingly, at 40% fiber content, an initial weight of 12 gram results an average weight of 12.33 gram, indicating a slight rise. This deviation from the trend could be caused by a number of factors, including fiber distribution and insulating material composition.

4.4 Insulation board with different fiber percentages

The difference in surface layer of the composite samples was due to the impact of fiber percentages. Each fiber content reveals distinctive visual and textural attributes in the insulation boards. At 0% fiber content, the surface shows a smooth texture as it only contains epoxy. As the fiber content increases to 5%, 10%, and 20%, the surface begins to display a slightly more textured appearance, indicating that fiber has been incorporated into the epoxy. The surface texture became more apparent at 40% fiber content, indicating a higher fiber concentration. The 40% fiber percentage creates a rough and fibrous surface, highlighting the substantial presence of fibers in the composition. Overall, this shows how the fiber content affects the overall appearance and texture of the samples, that will be assessed through water absorption test. Figure 4.3 shows the samples from different fiber content.



(a) (b)

(c) (d)

(e)

Figure 4.3 (a) 0% fiber content; **(b)** 5% fiber content; **(c)** 10% fiber content; **(d)** 20% fiber content; **(e)** 40% fiber content

Table 4.3 shows the average thickness for each sample. The data highlighted the relationship between fiber percentage and the corresponding thickness of insulation boards, accompanied by the average thickness for each fiber content. Figure 4.4 shows the graph of fiber content vs average thickness.

Table 4.3 Average thickness for each sample

Fiber content (%)	**Thickness (cm)**	**Average thickness (cm)**
0	0.50	0.51
	0.55	
	0.50	
	0.50	
	0.50	
5	0.38	0.43
	0.40	
	0.50	
	0.40	
	0.45	
10	0.35	0.39
	0.40	
	0.40	
	0.38	
	0.40	
20	0.30	0.36
	0.45	
	0.35	
	0.40	
	0.30	
40	0.40	0.22
	0.20	
	0.15	
	0.25	
	0.10	

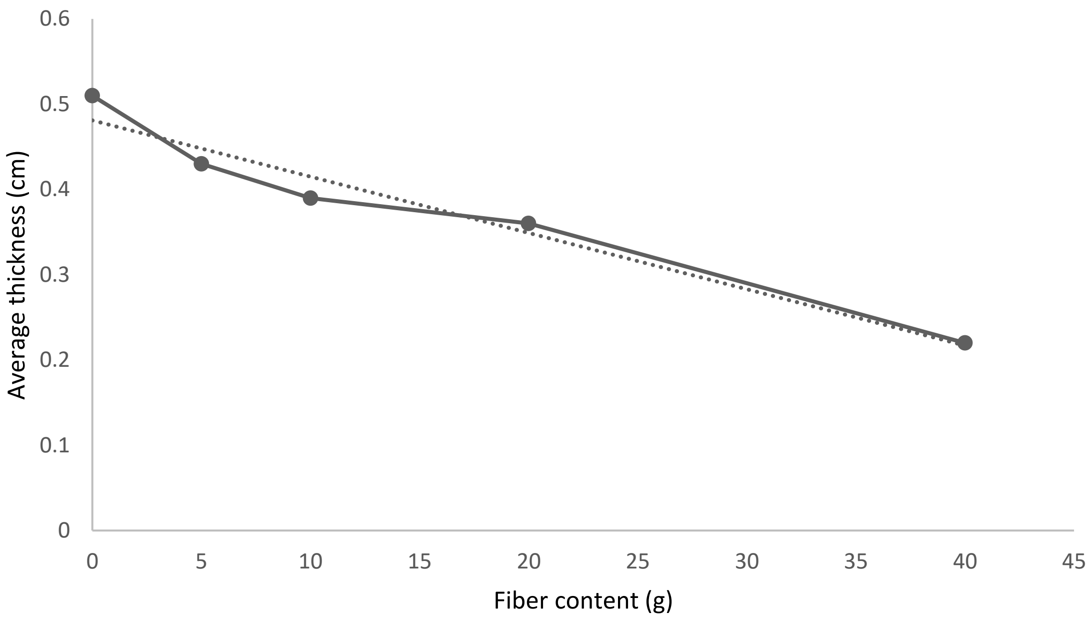


Figure 4.4 Graph of fiber content vs average thickness

According to the graph above, there was a noticeable decrease in thickness as the fiber percentage increased, which highlighted the correlation between higher fiber content and a denser, more compact material structure. Some variation in thickness measurements can be observed within each fiber content, which may represent inherent material heterogeneity or measurement precision. Notably, the greatest decrease in thickness occurs at 40% fiber content, showing the material's major influence on compression.

4.5 Water absorption test

To assess the effectiveness of insulation boards, water absorption analysis was done. The analysis can provide valuable insight on how varying fiber percentages influence the material's response to moisture. From the fiber percentage, initial weight and thickness of produced insulation board, the water absorption characteristics of the insulation boards can be evaluated.

The data on table 4.4 provides a detailed view of the increase in weight changes in insulation board samples at different fiber content across various immersion times. During the beginning of the experiment, the initial weights show visible difference, functioning as an initial reference for the subsequent water absorption analysis. As immersion time progresses, a consistent trend emerges with an increase in the weight of samples for all fiber content, indicating ongoing water absorption and swelling of the samples. Figure 4.5 shows the graph of immersion time vs increase in weight.

The different fiber percentages demonstrate varied rates of water absorption. Higher fiber content samples gained weight gradually over time compared to lower fiber content samples. The difference in absorption rate highlights the impact of fiber porosity on water absorption kinetics. Data observations throughout the whole 72-hour immersion period provide insights into potential saturation trends. Certain fiber percentages can cause the rate of water absorption to stabilize, indicating that the material is saturated.

Table 4.4 Increase in weight on every immersion time

Fiber content (%)	Increase in weight on every immersion time (%)					
	12 hours	24 hours	36 hours	48 hours	60 hours	72 hours
0	1.96	3.87	5.77	7.73	11.54	11.54
5	4.19	6.25	10.44	10.44	12.50	14.56
10	7.98	9.96	7.98	9.96	9.96	12.00
20	18.98	21.65	18.98	21.65	24.33	24.33
40	24.33	27.09	27.09	27.09	27.09	29.76

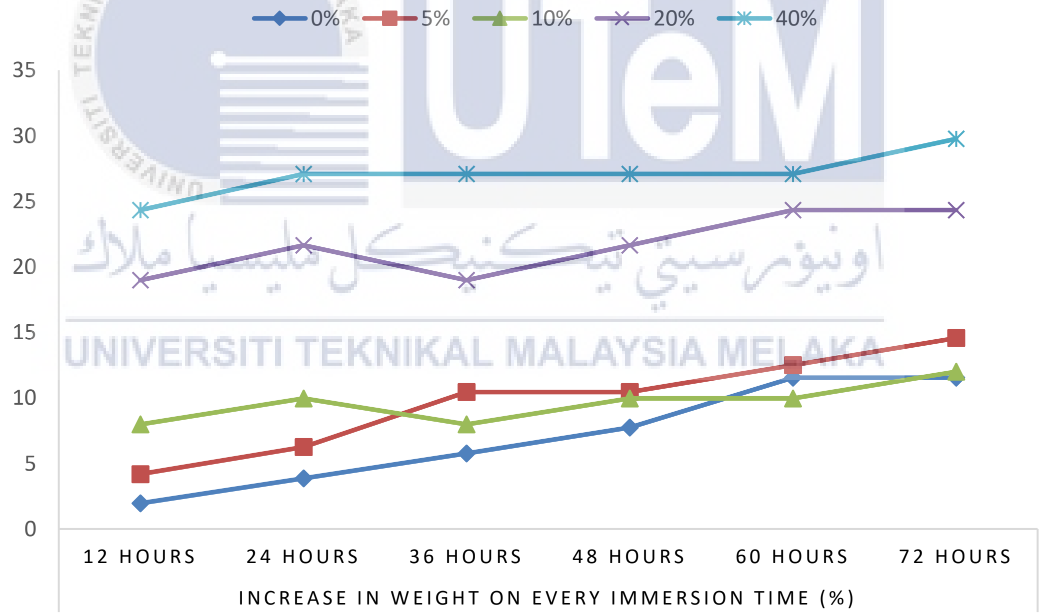


Figure 4.5 Graph of immersion time vs increase in weight

From the graph, we can see distinct water absorption behaviors. In the case of 0% fiber content, the increase in weight rises steadily over time, reaching a plateau at 72 hours, suggesting a potential saturation point. The addition of 5% fiber content enhances water absorption, with a more noticeable rise over longer immersion times. Additionally, the 10%

fiber content sample exhibits changing water uptake patterns, indicating non-linear behavior in water absorption kinetics. In contrast, the 20% fiber content exhibits a consistent, steep increase in weight, implying a significant improvement in water absorption ability, whereas the 40% fiber content shows a remarkable high and consistent percentage increase, perhaps reaching saturation after 72 hours.

4.6 Effect of thickness on water absorption

The thickness of insulating boards can have significant effects on their water absorption properties. Table 4.6 shows the thickness of samples and percentage increase in weight. The relationship between the thickness of each sample and the corresponding percentage increase in weight shows that thickness influences the material's capacity for water absorption. This phenomenon is attributable to the extended pathway water molecules must take through the substance. As the thickness of the insulation board increases, so does its overall volume, allowing for less water to be absorbed. However, the relationship between thickness and water absorption is not linear. At times, thinner materials may absorb water more rapidly due to their limited barrier properties. Thicker materials, on the other hand, might initially resist water penetration but could absorb more water over prolonged exposure. Figure 4.6 shows a graph of thickness and increase in weight.

Table 4.6 Thickness of samples and increase in weight

Sample	Thickness (cm)	Increase in weight (%)
A	0.51	11.54
B	0.43	14.56
C	0.39	12.00
D	0.36	24.33
E	0.22	29.76

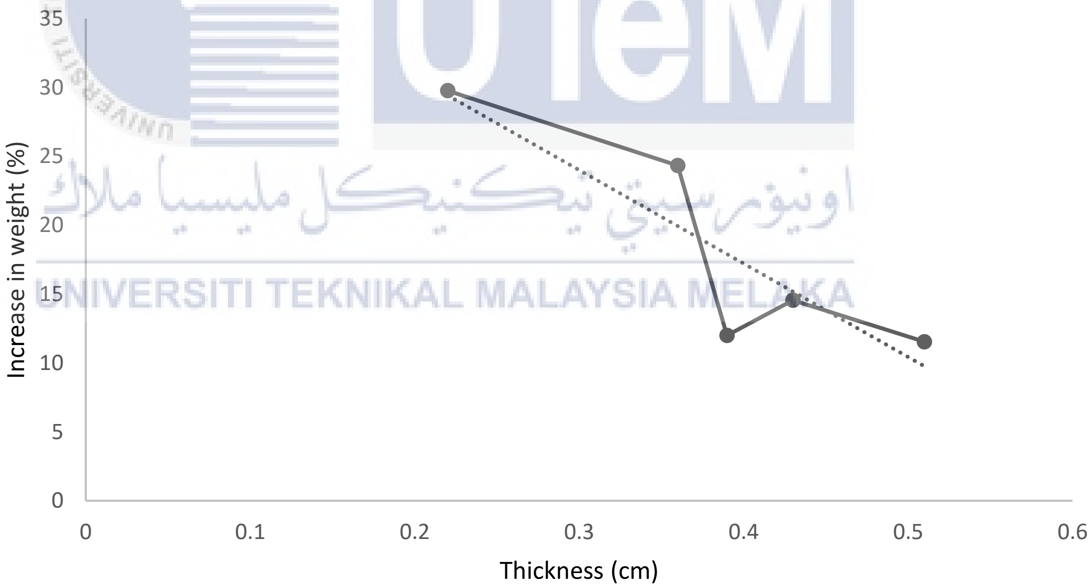


Figure 4.6 Graph of thickness vs increase in weight

The relationship between thickness and the increase in weight of the insulation boards from the graph shows that water absorption is not solely dependent on thickness. Even relatively thin samples which are samples D and samples E exhibit substantial increases in weight. Indicating that the material efficiently absorbs and retains moisture. We can conclude that not only thickness of the samples matter, but also the material's composition and inherent properties, play a significant role in determining its water absorption behavior.

Assessing how surface features impacted by fiber content interact with thickness helps to provide a thorough understanding of the material's reaction to different fiber concentrations. The visual and textural properties of the surface layer are important factors that can affect both water absorption and overall appearance. Analyzing how thickness affects these surfaces aspects provides useful information for creating materials that resist water while also maintaining desired visual and textural properties.

4.7 Summary

This chapter mainly about the study to investigate the impact of fiber percentages, thinkness variations, and water absorption on the overall performance of the insulation composite. The study demonstrates a direct correlation between fiber content percentage and the visual and textural characteristic of insulating boards. The observed alterations, which range from a smooth texture at 0% fiber content to a rough and fibrous surface at 40%, demonstrate the effect of fiber concentration on material appearance. This understanding is important as it sets the stage for the water absorption test, in which surface properties were expected to influence the material's interaction with moisture.

Thickness variations in insulating boards shows their impact on water absorption, weight, and surface characteristics. From the data obtained, it can be seen that thinner samples have larger water absorption percentages. This relationship provides insights into how the dimensional aspects of the material influence its moisture retention capacity and overall mass. Furthermore, the relationship between thickness and surface features emphasizes the influence of fiber distribution on the visual and textural properties of the insulation material.

Water absorption is important in insulation performance which shown to have several effects. The weight increase with varying immersion times indicates the material's water absorption behaviour. The percentage increase in weight is consistent, with changing patterns for different fiber content percentages. The study shows that the material's response to moisture is strongly linked to its composition, demonstrating how water absorption affects thermal conductivity, material density, structural integrity, and electrical insulating qualities.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This project took a holistic approach to changing cigarette butt filters into excellent insulation fibers, thereby adding to sustainable and eco-friendly material development processes. The objectives were methodically pursued, demonstrating important insights on the potential of recycled cigarette butts as insulators. The project's aim to create an effective method to remove hazardous chemicals from cigarette butts. The study overcame this problem adapting a thorough cleaning methods that included manual removal, washing, soaking, and drying. The procedure not only cleaned the butts, but also expanded the fibers, preparing them for use as insulation material.

This thesis also investigated the relationship between water absorption and different percentages of cigarette butt fibers in the insulation material. A thorough examination of various fiber content percentages ranging from 0% to 40% showed distinct visual, textural, and performance characteristics. The surfaces transitioned from smooth to rough and fibrous, demonstrating the impact of fiber concentration on the material's appearance. This analysis define the structure for determining how fiber content affects the material's overall properties.

This project mainly investigate how water absorption affects the fibers insulating qualities. The experiment demonstrated that water absorption has a significant impact on thermal conductivity, material density, structural integrity, and electrical insulation qualities. This understanding is critical for improving the performance of insulating materials under a variety of environmental circumstances. The thesis scope ranged from cleaning cigarette butts to selecting natural substances, which was methanol to cleanse the fiber. Epoxy resin emerged as important adhesive, increasing the insulating qualities of the fibers. The water absorption tests assessed the material's ability to absorb and hold moisture, providing a comprehensive evaluation of its performance.

In conclusion, this project successfully achieved its objectives by establishing a viable method for recycling cigarette butt filters into insulation fibers, analysing the relationship between fiber composition and water absorption and analysing the effect of water absorption on insulating features. These findings contribute to sustainable waste management and advancement of environmental conscious insulation materials with potential applications in various industries.

5.2 Recommendations

For future improvements, the following below are some recommendation that can be made to achieve a better results.

a) Conducting mechanical tests, such as tensile tests, flexural tests, and bending test to testify the material's capability to withstand pressure with existence of moisture.
b) Study morphology by using Scanning Electron Microscopy (SEM) to understand the fiber's surface structure, porosity, and any potential structural changes induced by water absorption.
c) Optimize the cleaning process for cigarette butt in detail, by exploring alternative cleaning methods or refining the existing process that can enhance the efficiency of removing harmful compounds and preparing the cigarette butts for insulation material production.

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APPENDICES

APPENDIX A Gantt chart for PSM 1

Task	Plan/ Actual	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Title selection	Plan														
	Actual														
Develop objectives and project planning from Gantt chart	Plan														
	Actual														
Literature review	Plan														
	Actual														
Report writing on Chapter 1	Plan														
	Actual														
Report writing on Chapter 2	Plan														
	Actual														
Material and specimen preparation	Plan														
	Actual														
Report writing on Chapter 3	Plan														
	Actual														
Submission of draft final report PSM 1	Plan														
	Actual														
Submission of final report PSM 1	Plan														
	Actual														
Presentation PSM 1	Plan														
	Actual														

APPENDIX B Gantt chart for PSM 2

Task	Plan/ Actual	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Discussion with supervisor regarding progress	Plan															
	Actual															
Fibres extraction from cigarettes	Plan															
	Actual															
Fibres morphological characterization	Plan															
	Actual															
Production of insulation fibres	Plan															
	Actual															
Laboratory test and analysis	Plan															
	Actual															
Report writing on Chapter 4	Plan															
	Actual															
Report writing on Chapter 5	Plan															
	Actual															
Submission of draft final report PSM 2	Plan															
	Actual															
Submission of final report PSM 2	Plan															
	Actual															
Presentation PSM 2	Plan															
	Actual															