A Comprehensive Review on Bio-based Materials used in HVAC-System & its Mechanical Properties

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Abstract *— Recently, the rise of globalization, the desire to advance technology without harming future generations has become increasingly important. Being able to offer green energy solutions and eco-friendly materials at competitive prices will be key to achieving market penetration for all-over world companies considering global expansion in the coming years. Some International industries takes the development of sustainable and greener technologies very seriously. Recognizing the need to move towards more environmentally sound materials and manufacturing techniques, they began to explore alternative materials as a means to help reduce our daily wastes. They looked closely at Biocomposites (Known as green composites) which is typically made up of natural resins and plant fibers but also assembled with recycled plastic bottles. This new solution is strong enough to be used in construction applications such as roofing, roads and walls. The composite materials are produced with high-performance features, making goods ideal for an air conditioning applications (AC). Air Conditioning systems have usually been built of metal in the past. A cost effective way of this system is provide greater durability, longer endurance, higher temperature resistance and higher resistance to corrosion. As the Biocomposites or bio-based materials are resistant to condensation, the probability of moulds is reduced. In the impacted locations this offers cleaner air. Reduces our industry's environmental effect and cost effective, which promotes climate change and damages the health*

Keywords *— Biocomposites, Sustainable, Greener Technologies, Eco-friendly, air conditioning, Cost effective.*

I. INTRODUCTION

A biocomposites material is created by mixing two or more materials from distinct elements with various qualities into a new product with mechanical properties that are different from the source components. Composite materials provide the following benefits over traditional table materials: they are lightweight and have good strength characteristics. Composite materials provide additional design freedom since they may be moulded into desired shapes, notwithstanding the intricacy of the shape design [1]–[3]. Many designers in the manufacturing sector are moving away from traditional production materials and toward composite materials, which allow them to produce things in a variety of shapes and forms. In addition, unlike metals, which are equally strong in all directions, composite materials may be designed to be strong in a specific direction.

A natural fiber composites, also known as a biological composite, is made up of materials derived from plants, animals, and humans [4], [5]. The use of bio-composite materials in furniture production is a relatively new development in the industry. Biocomposite materials generated from natural and renewable sources have attracted a lot of attention in recent years, owing to a growing awareness of and need for ecologically friendly technology. Biocomposite materials with good mechanical qualities, such as high strength, lightweight, low density, and high flexibility, as well as aesthetic appeal, are utilized to fabricate a tiny component of the system. The main advantages of composite materials compared to conventional table materials are they have lightweight and high strength properties. In terms of design flexibility, composite materials also cater more desirable feature, due to the fact that they can be moulded into desirable shapes, despite the complexity of the shape design [1]–[3].

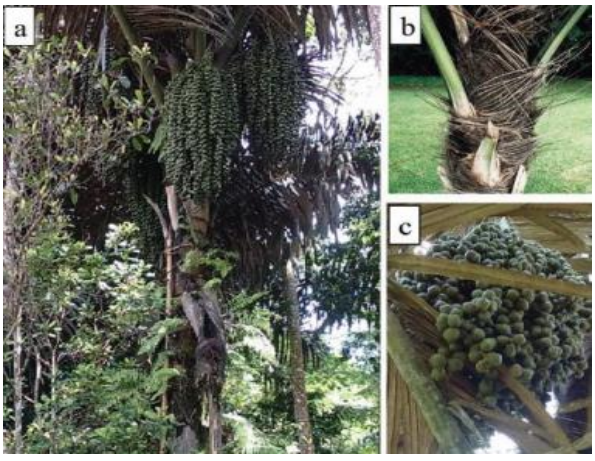

Fig 1.(a) Sugar palm tree, (b) Sugar palm fiber, (c) Sugar palm friut.

Many designers in manufacturing industry are shifting from using conventional manufacturing materials to composite materials that offer freedom for them to create products in any shapes and forms. In

additons, composite materials are notably strong can be engineered to be s trong in a specific direction, compare to metals that are equally strong in all directions.

Recently, the entire globe has been confronted with environmental concerns and challenges such as cost and sustainability. As a result, industrial research has centered on biomaterial technology, which has a lot of potential. Many researchers have been drawn to bio-composites because of their ease of disposal and ability to compost after the expiry date, which is not always achievable with traditional synthetic materials. Bio-fibers are also more appealing due to the advantages of natural fibers over synthetic counterparts, such as low weight, corrosion resistance, and high strength. However, bio-fibers have certain disadvantages, such as being anistropic and absorbing a lot of moisture.

II. LITERATURE REVIEW

Several types of studies have focused on laboratory simulation and theoretical previsions for air conditioning applications, environmental and environmental, throughout the last few decades. Various modern technological software and hardware have aided in the calculation of cooling loads to save energy, the improvement of waste heating recycling to absorb vapour, the optimization of cost, and the creation of an energy efficient system. Protecting the planet and the environment, which is critical for humanity, is the uniting concern. Researchers from all around the world have played a key role in bringing attention to the classic electric chiller, which uses coolant and harms the ozone layer in the atmosphere. In the past, most research was conducted using a vapour compression refrigeration system rather than a vapour uptake chilling system. However, with the usage of biocomposites, thermoset composites, power crises, and the absorption and cogeneration system, efficient and cost-effective building design has become increasingly important in recent years.

The growing popularity and relevance of bio-composites has resulted in an increase in the number of publications on the subject from a range of perspectives. The importance of the issue is demonstrated by the publications, which include books, essays, and reviews. Bio-composite materials made with natural fiber and matrices were reviewed by John and Thomas (2008), Faruk et al. (2012), Hassan et al. (2010), Shinoja et al. (2011), Venkateshwaran and Elayaperumal (2010)[1][2][3].[4]. This study reviews recent research on bio-composites, concentrating on natural fiber sources (as opposed to animal (hair, silk, wool, etc.) based fibers and matrices, manufacturing techniques, mechanical and chemical characteristics of bio-composites, and bio-composite applications.

Kenaf fibers is part of a bast (stem) has a great potential for application as a bio-composite reinforcing material due to its fast growth rate and structural similarity to jute and cotton, which are the most commonly utilized crops for fiber production [42]. Kenaf is an annual crop with an African heritage. The majority of it is grown in Africa, Bangladesh, India, China, and Malaysia.

Sisal leaf is a part of plant native to Mexico that is primarily grown in Brazil. It may be used in a variety of situations. Because sisal fibers have high mechanical characteristics, they are utilized to make bio-composite materials [9].

One of the most significant leaf fibers is abaca. Abaca is mostly grown in the Philippines, where it originated. It belongs to the banana family. Mechanical characteristics of abaca fibers include great strength and flexibility [10].

Kudzu is a part of an invasive plant native to Japan and China's southern regions. It is mostly used to prevent erosion. For ages, it has been utilized for apparel and basketry. It has a morphology comparable to flax and hemp [8], and so has the potential to be used as a bio-composite reinforcing material.

Henequen is a plant that is native to Guatemala and Mexico. It is mostly grown for its fibers, which are used to make ropes.

It's also known as Cuban or Yucatan sisal [48] and possesses characteristics comparable to sisal.

Kapok is a plant that contains attributes identical to cotton and is mostly grown in Malaysia. Kapok husk, a by-product of kapok manufacturing, can be utilized as a raw material for fiber production [7].

Using bio-fibers offers both advantages and disadvantages. The excessive moisture absorption, relatively low structural strength, and poor adherence with matrix material are the primary disadvantages of bio-fibers. As a result, numerous researchers investigated the morphological features of bio fibers as well as the treatments used to modify them. Many publications [55, 95-97] have also been published that evaluate treatment techniques and their impact on mechanical, chemical, and morphological characteristics of bio-fibers and bio-composites. The fundamental objective of all treatment methods (physical, chemical, or physio-chemical) is to increase the fiber adhesion qualities and, as a result, the mechanical properties of bio-composites.

Marriott et.al found out during his research that many builders choose for sustainable architecture9 since economics is now significant. The payback times for energy efficiency-enhancing capital upgrades are being shortened by increasing energy prices. But surprisingly little use information on sustainability is accessible among the profusion of promotional content that promotes the advantages of employing sustainable construction technologies. In all three primary sustainable activity investigations Marriott [3] described energy rates: (a) the optimal air regime; (b) condenser

water energy recycling; and (c) geothermal heat pump systems.

Douglas et al. [8] has found in non-arid regions that an increase in outside air volume will lead to 10 times the level of interior moisture. Several reports have been made of the harmful effect on individuals and homes of high humidity. Douglas et al. [8] has found in non-arid regions that an increase in outside air volume will lead to 10 times the level of interior moisture. Several reports have been made of the harmful effect on individuals and homes of high humidity. In wet situations, this criteria is best practiced to avoid problems which occur at greater humidity levels.

III. RESEARCH METHODOLOGY

The best design for any part of a bio-based Air conditioning system already selected from previous study based on the concept evaluation designs. The design process was performed using the total design activities from identification of the market needs up to the satisfying the customer needs with eco-environment. The selected design will be fabricated with Natural fiber composites at the same times make the table have a great view, joining, and strength. Figure 2 shows the overall flow of the methodology.

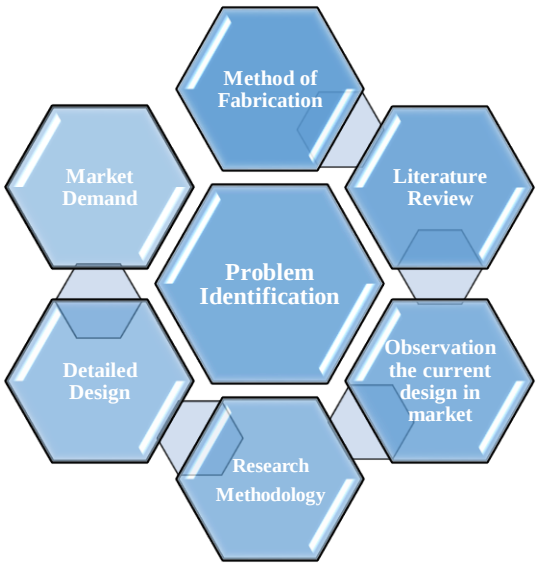

Figure 2: Overall methodology

The methodology of research provides a general overview of what must be done to attain a certain aim, without identifying all particular actions (Jonker & Pennink, 2009). Since the aim of qualitative study is not hard but focused on cultural and contextual components of an event, technical interviews with open-ended questions (Kvale & Brinkmann, 2009) were used as a strategy for obtaining empirical data for this thesis. The questions opened up to allow the respondents to communicate their views and experience using their own words (Jonker & Pennink, 2009).

A second technique for generating data on the EP rules in France and Sweden was a desk research to prevent this. In order to give a more complete picture of the issue investigated, data from both sources were combined with analysis (Patel & Davidson, 2003). Multiple data sources may be called triangulation in order to increase the dependability of the results and to check their authenticity. The reliability of the selected measuring technique relates to whether it will yield the same findings if the research is repeated and valid if it is measured using the selected method.

(Brussels, August 2011) The study concept for this thesis involves decisions, such as selection of the five features of regulations considered significant for innovation impacts that may have an influence on outcomes. If the work is replicated, however, using the same theoretical framework and analysis model, the findings are probably comparable to those included in the thesis. On the other hand, if a different theoretical framework is taken into account, the results are more likely to diverge from those of this thesis. The approach used is regarded very valid in terms of validity and for the objective of the study. It would most likely result in a low validity research to measure and quantify two difficult concepts (regulation and innovation).

A. A BIO-COMPOSITES MATERIALS AND ITS MECHANICAL PROPERTIES

The matrix material preserves the structure in solid phase, forming the shape and appearance of the product, while the fibers bear the structural loads of the composite elements. Non-renewable matrices of petroleum-based chemicals are used in the majority of composite goods today. However, several research have looked at the use of renewable and sustainable matrices in the manufacturing of composite materials. Polystyrene (PS), polyethylene (PE), polypropylene (PP), and polyvinylchloride (PVC) are the most widely utilized thermoplastic composites for bio-composite material manufacturing (PVC). The thermoset resins used to make composite materials reinforced with natural fibers are epoxy, vinyl esters, polyester, and phenol formaldehyde [2]. Many distinct parameters influence the final material's mechanical characteristics. The primary parameters are the fiber and matrix material characteristics, as well as the matrix and fiber bundle compatibility. Many researchers investigated the mechanical properties of various matrices and fibers, and Table 3 summarizes the findings.[5]. Sugar palm fiber and their composites are can be potentially used for heat insulation in various application of rolling barrier properties such as stiffness and high strength [6].

The most commonly researched biocomposites characteristic is mechanical testing, such as tensile, flexural, and impact tests. The tensile strength of fiber-reinforced biocomposites rises with fiber content until it reaches an optimal value, after which it falls. This is owing to the fact that fibers have significantly better strength and stiffness than polymeric matrix [1]. When natural fibers are mixed with hydrophobic polymer

matrices, their hydrophilic nature contrasts with matrices that cause significant water absorption and, as a result, low biocomposites tensile strength. Surface treatment is a critical solution for modifying fiber hydrophobicity and fiber/matrix interfacial contact, resulting in enhanced tensile characteristics. As numerous studies have shown, the longitudinal tensile modulus of hybrid biocomposites follows the linear rule of mixtures.

Another important feature of biocomposites is impact resistance, which is closely linked to their strength a testament of fortitude Energy absorption during a penetration impact, residual characteristics after the impact, and damaged area after a non-penetration impact may all be used to identify it. Furthermore, dispersion and layer placement are recognized to be important factors for impact in hybrid biocomposites. Among the many biocomposites constructions, laminated composites are the most commonly produced configuration. shows several new biocomposites with laminated designs and various layer stacking sequences.

According to these designs and other published results, placing energy-absorbing fibers on the exterior layer rather than the interior allows the hybrid composite to absorb more energy and, as a result, achieve greater penetration impact resistance. Due to the smaller delaminated area and greater interfaces between different layers that absorb more energy, a higher degree of dispersion exhibited superior penetration impact resistance. Interfacial adhesion between fiber and matrix is also important for impact performance [14]. Hybridization with synthetic fibers might enhance the poor adhesion of natural fiber-reinforced composites (NFRCs) and the load transmission between fiber and matrix. To maintain optimal adherence with matrices, even synthetic reinforcements such as carbon fibers must boost their surface energy by surface changes.

IV. MECHANICAL PROPERTIES OF SOME NATURAL FIBER [5]

Type	Fiber	Density)g/cm^2)	Tensile Strength (MPa)	Elastic Modulus (GPa)
GRASS	Bagasse	1.2-1.25	20-290	17-27.11.1
FRUIT	Coir	1.15-1.45	106-593	1.27-6.0
BAST (STEM	Flax	1.4-1.5	345-1500	27.6-80
WOOD	Hard Wood	0.3-0.88	51-210.7	5.2-15.6
LEAF	Abaca	1.5	400-980	3-12
SEED	Cotton	1.5-1.6	287-597	5.5-12.6
SYNTHETIC	Carbon	1.4	4000	23-240

B. ENVIRONMENTAL FRIENDLY AIR CONDITIONING SYSTEM

Air conditioning is a broad field. The simplest hand-stoked burner for comfort heating to the ultra-reliable complete air-conditioning systems used in submarines and space shuttles are all examples of AC systems. Refrigeration equipment vary in size from small residential units to 10,000-times-larger industrial refrigeration machines. The HVAC designer must consider considerably more than just maintaining appropriate temperatures, depending on the complexity of the demands. This course will introduce you to the fundamental concepts that designers use to make system design, operation, and maintenance choices.

V. MARKET DEMAND IN RECENT SCENARIO

Biocomposite HVAC system is a new production in commercial industry. Hence, some study is needed in the implementation of this project. The designs of existing system were gathered from HVAC engineers, internet sources and catalogues. The pattern, materials, processing cost and technique were identified in previous study. In this study, some improvements are made in the designs and materials to improve the strength and reducing the weight of the table besides making the overall production process greener through the utilization of plant-based biocomposites materials.

Low quality of joining parts and not eco-friendly surface are the common problems in the existing products. Based on the market study, almost all of the table are made from wood and a few of them from metals. Wood is desirable over metal for reducing the weight of the table, however, wood is unable to stand moist condition and commonly absorbs the water. This is not a good feature for new system for long term use. To overcome the limitations of existing HVAC system, a biocomposites-based system from Natural fiber was fabricated in this study. Polyester resin used has good characteristic, includes high strength and water resistance. Combination between SPF and this resin has resulted in a great quality of table to compete the market demand [13].

VI. FUTURE WORK

It is a well stablished finding that several limitations are associated with biocomposites composed of a single natural fiber in a matrix. Many such problems can be addressed by the method of hybridization. A biocomposites, which consists of more than one biodegradable reinforcement materials exhibit extraordinary favourable properties. The most important aspect is that their properties can be tailored

according to the requirement. Various such properties which cannot be imparted in a simple biocomposites can be imparted by developing biocomposites for air conditioning purposes. Therefore, biocomposites have great scope in various crucial applications in future. Although, such applications include Air conditioning industry, automobiles, sports accessories, furniture, civil structural components etc., the most attracting and demanding applications are in the field of aerospace. Several applications in the aerospace industry need highly specific requirements which can be fulfilled by the biocomposites. The most important property of an aerial vehicle is that it should be as lighter in weight as possible. However, the reduction in weight cannot be made responsible for reduction in other crucial properties. For instance, strength of such structures cannot be sacrificed at any cost. Light weight unmanned aerial vehicle is one of the application areas where the hybrid biocomposites are attracting the researchers. The light weight structure of the vehicle must have the desired strength compatible with unfavourable conditions. These criterion can be easily fulfilled while selecting proper reinforcement materials and arranging them in a proper fashion. There are several biodegradable materials which serve the purpose satisfactorily as described in the previous sections. Another application associated with the aerospace industry is the development of sound proof structures for passenger aircrafts. For unmanned vehicles, sound proofing is not essential. The concept of air taxi is also coming to be in effect in the very near future. Significant investments and research are being conducted in the area of Urban Air Mobilities(Ward et al. 2021)(Winter et al. 2020). Safe, quiet and efficient aircrafts will make the dream true (Scheff et al. 2020). Biocomposites are exhibiting the features favourable for such applications.

The ability to accelerate technologies without affecting future generations has become particularly relevant as a result of globalization. For North American companies seeking global growth in the coming years, being able to sell renewable energy options and eco-friendly products at affordable prices would be critical to market penetration. With that goal in mind, Annexair believes that this innovative business model is critical and important for Canada and the United States to achieve their greenhouse gas emission goals. Quite seriously, the advancement of renewable and greener technology. Recognizing the need to move to more friendly products and packaging methods, they started to look at alternative materials as a way to better minimize our everyday waste. They studied Biocomposite, which is usually made of natural resins and plant fibers but can also be made of recycled plastic bottles.

VII. CONCLUSIONS

In conclusion, this review was successfully performed to Bio-based Air Conditioning system from natural fibers, following the main objectives to save our environment with fulfil customers' demands also. A lightweight, strong and high aesthetical value part was fabricated using compression of SPF and resin mixture and more economical due to reduction in amount of resin used in the fabrication. However, the natural fiber composite is a new type of material in HVAC industry. Hence, further research on the equipment preparation, composite fabrication and parts assembly should be made to improve the quality and aesthetical value of the fabrication product. The current study examines the use of Biomaterials in the computation of cooling loads with high strength for AC systems and development of computer-aided design, as well as software development. Bio-based Air conditioning system are used to make with the help of sugar palm fibers and some polymers to use for reinforcement or to enhance the properties of Bio-based small part of a system as a high-performance material. The huge advantages of biocomposites, such as abundance, light weight, biodegradability, several other intrinsic properties, and preferable properties compared with metallic materials or any other types of materials.

In the near future, great scope exists for the research and development in this direction. Biodegradable matrix, two or more reinforcement materials, their orientation and stacking sequence etc. are important parameters and must be taken into consideration judiciously. Their proper selection tailors the characteristics of the composites making them suitable for aerospace application. The research described in this chapter demonstrate that Hybrid biocomposites are very promising for developing environmentally friendly materials as an alternative material.

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