Fabrication of Bio Composites Using Natural Fiber: An Affordable Way to Go Green

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Abstract - A growing demand for sustainable technological breakthroughs is a result of globalisation. International enterprises are investigating environmentally friendly materials like Bio composites, comprised of plant fibres and natural resins. These materials are extremely robust, heat-resistant, and corrosion-resistant, making them ideal for construction applications including roofs, walls, and roads. Additionally, they improve air quality and lessen environmental effects including climate change and health risks. Commercial, industrial, residential, and medical buildings all have unique ventilation and humidity needs, making air conditioning installation essential. For these applications, designing energy-efficient systems is crucial to market penetration and solving engineering problems.

Key Words: Bio composite materials, Ventilation, Sugar Palm and Polyester Resin

1. Introduction

Composite materials are made by combining materials from different elements with different properties, offering lightweight and high strength properties. They offer design flexibility and can be moulded into desirable shapes, making them more desirable in the manufacturing industry. Natural composites, or biological composites, are derived from plants, animals, and humans. Bio-composite materials, derived from natural and renewable sources, have gained significant interest in recent years due to the growing awareness of environmentally sustainable technologies. Sugar palm fibre (SPF) is a natural fiber derived from the Arenga pinnata tree, grown in Southeast Asia, particularly Malaysia and Indonesia.

Sugar palm trees are used as fiber and fillers in polymeric composites due to their easy availability and high tensile strength and modulus. The reinforcement of a resin matrix with sugar palm fibres results in a composite with good strength and rigidity, making it suitable for table making and furniture industries. Understanding the mechanical characteristics of sugar palm fibres is crucial for exploring their potential use as reinforcement for polymer composites.

2. REVIEW OF LITERATURE

Due to their potential as environmentally friendly substitutes for conventional materials, bio composite materials have attracted a lot of attention recently. The qualities, techniques of creation, and uses of bio composites have been the subject of several investigations. Here is a quick summary of the major conclusions from the literature.

Kazachki et. Al [1]

According to research by Kazachki et al. and others, indirect cooling systems are 30% more expensive and consume 30% more energy in secondary systems. This was due to the fact that the secondary coolant (brine) had subpar thermophysical properties and that the initial implementation's manufacturing techniques were flawed. In recent decades, improved secondary coolants based on organic salt water solutions have made it possible for secondary coolant technology to compete successfully with traditional DX systems (direct expansion), both in terms of installed cost and energy use. Building cooling and heating requirements for the principal temperature zones were evaluated by Kavanaugh et al. For buildings with energy-efficient insulation, appliances, ventilation, and envelopes, he estimated heat gain and heat loss.

Marriott et.al [2]

As a result of the growing importance of economics, builders are increasingly choosing sustainable architecture, according to research by Marriott et al. The longer payback periods for capital improvements that improve energy efficiency are being cut by rising energy costs. But among the abundance of promotional content that touts the benefits of using sustainable construction technologies, there is surprisingly little information about sustainability that is readily available. Marriott described the energy rates for the best air regime, condenser water energy recycling, and geothermal heat pump systems in each of the three main sustainable activity investigations.

Bridger et.al [3]

According on the kind of energy stored, Bridger et al. recommended three main aquifer thermal energy storage strategies. These include systems for storing chilled water, systems for storing heat, and systems for storing both heat and cold simultaneously. Air conditioning, cooling devices, and industrial cooling of buildings and commercial structures are just a few uses for cold storage. In hot locations, HVAC cooling efficiency increased by 10%, and in cold climes, it increased by 7%, reflecting the variance in temperature cooling efficiency.In their recent study, Kosar et al. examined data from the National Centre for Energy Management and Building Technologies, which demonstrated the development of several air conditioning units with enhanced dehumidification capacities. The great dehumidification of these modern cooling systems is their main focus. Buildings that are manually ventilated with outside air that contains moisture must meet increased dehumidification requirements. Determining builders' HVAC moisture removal design needs, particularly those coming from outside airstreams, has become much simpler because to others' ready quantification of outside air dehumidification loads

John A. Paulauskis

John A. Paulauskis [7] investigated the screw chiller noise issue. There are several sources of noise in HVAC systems. Examples include the movement of air from ductwork, air terminals, and air equipment as well as mechanical blower fan noise, compressor noise, and the brisk sound of cooling equipment. When numerous random wavelengths of the sound travel beyond the range of the human ear, the sound is referred to be "Broadband," hence the name. Whether one or more frequencies are distinguishable from the neighbouring frequencies (often by more than 5 to 8 decibels [db]), broadband sound provides audible, clean sounds that are noticeable. The inhabitants have a number of challenges as a result of the pure tone noises, so Paulauskis et al presented a solution to lessen the noise.

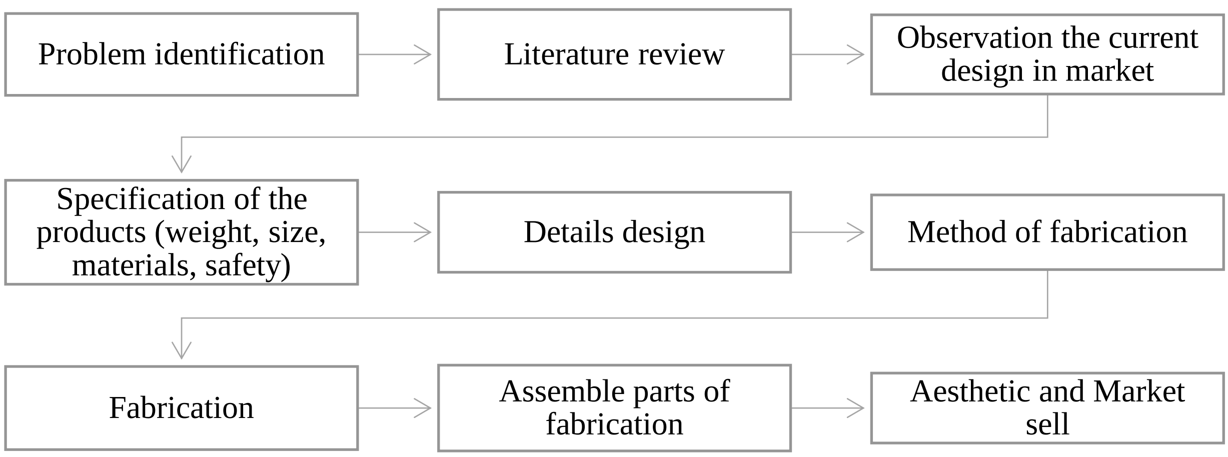
Douglas et al

According to research by Douglas et al., an increase in outside air volume causes internal moisture levels to increase by ten times in non-arid locations. Numerous reports have been made about the negative impact that high humidity has on people and homes. According to Douglas et al. [8], an increase in outside air volume causes interior moisture levels to increase by ten times in non-arid environments. Numerous reports have been made about the negative impact that high humidity has on people and homes. This guideline should be followed as much as possible in rainy conditions to prevent issues that arise at higher humidity levels.

Richard Taft et al

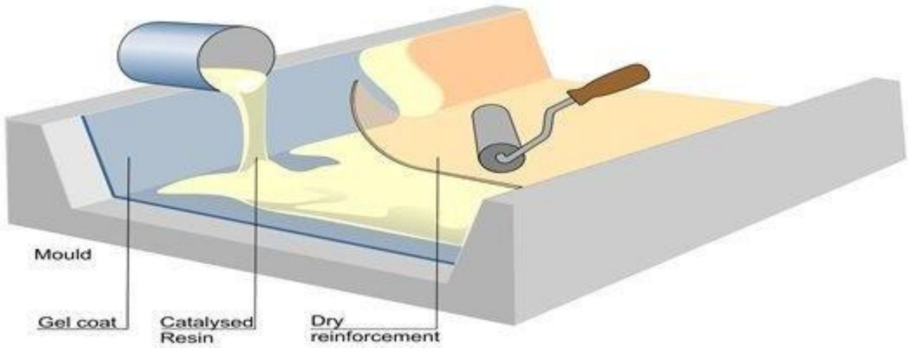
In their study for Health Care HVAC, Richard Taft et al. [9] note that a 60 percent RH is the recommended condition for excellent surgical design. Although we believe that a 60% HR is the upper limit of an acceptable design, it is not a compromise and does not provide protection for good design. How frequently HVAC systems are chosen is covered in his section. The main goals of HVAC systems are to offer occupants with the ideal levels of temperature, humidity, and airflow comfort, maintain excellent indoor air quality, and reduce energy and expense consumption.

3. Methodology



3.1 Manual Hand-Lay Process

The manual hand lay-up process was chosen because table fabrication just requires a direct mould or an open mould. This method is suitable for producing composite products of a wide range of sizes that can be fabricated from the open moulding technique. The fabrication was started after finalizing the table design by extracting the fiber from a sugar palm tree and preparation of the resin and mould. Before the start of the process, the gel coat was used for coating the mould/s surface to ease the final product's removal from the mould at the end of the process.



3.2 Fabrication Process

Before finishing a fabrication process, there are a few steps that must be taken into account: (1) the lay-up procedure; and (2) the volume of the resin and hardener. Some of the supplies and tools, including wax, a release anti-adhesive agent, gel coat, an iron roller, a container, resin, and hardener, were prepared prior to the lay-up procedure. This job was completed using a hand-lay-up method.

The hand lay-up process involves the following steps:

1. A release anti-adhesive agent was applied to the mould to prevent the mould component from adhering to the mould surface.

2. To create a shining surface and enhance the end product's appearance, the gel coating was applied to the prime surface layer.

3. The mould received a layer of fibres and matrix.

Figure 1: SPF in mixed condition with grass and small branches.

Figure 2: Sugar palm in line arrangement.

Figure 3: Sugar palm was blended to small pieces and sieved.

Figure 4: Polyester resin used in this project

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 07 | July - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

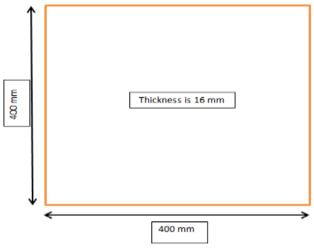
Figure 5: Resin mixed with SPF fibers

4. RESULTS AND DISCUSSIONS

4.1 Calculation for resin and hardener

Volume of resin and hardener depend on the type of the resin used, in this case is polyester resin. The volume of resin and hardener were based on their weight (gram). The calculation below shows the ratio of the resin and hardener needed for the top part and leg part.

The ratio of resin to hardener is 4:1. Total ratio = 4 + 1= 5. Figure 7 shows the drawing and parameters of the top plate part. The width and length of the part is 400 mm. The thickness of the top plate is 16 mm.



The drawing and parameter for sample plate mould

4.2 Calculation of resin weight for the sample plate

The weight of the resin was calculated from the volume, density and the ratio between resin and hardener. This value depends on the density and type of resin and hardener. The calculation below shows the weight of resin and hardener needed for a complete fabrication of top plate part.

- Volume of specimen, V = Width x Length x thickness

  = 40 cm x 40 cm x T cm

  = 1600T cm^3

T is the thickness of the layer to be laminated. In this lay-up process, thickness for each layer was set to be 4 mm, 8 mm, and 4 mm, respectively for 1st, 2nd and 3rd layer, to give overall thickness of the top plate component to 16 mm as shown in Figure 7.

- Weight of resin for (T = 4), W = Volume of specimen x density x ratio for resin
  = 1600 (0.4) x 1.15 x (4/5)
  = 588.8 gram.

- Weight of hardener, W = Weight of matrix X ratio for hardener
  = 588.8 x (1/5)
  = 117.76 gram.
- Fibre weight used for top plate is 100 gram (two layers).
- Total weight

  Total weight for top plate = Weight resin + weight hardener + fibre weight Total weight for top plate = 588.8 gram + 117.76 gram + 100 gram

  Total weight for top plate = 806.56 gram

  The total weight of the top plate part is 806.56 gram.

- Total weight

Total weight for top plate = Weight resin + weight hardener + fibre weight

Total weight for top plate = 194.3 gram + 38.9 gram + 40 gram

Total weight for top plate = 273.2 gram

The total weight of the leg part is 273.2 gram.

4.3 Time for a complete fabrication

Time taken for a complete fabrication process.

Process	**Times**
Fibre extraction and resin process	9 days
Mould preparation /setup	1 day
Hand Lay-up (top plate)	1 day
Hand lay-up left (leg)	1 day
Hand lay-up right (leg)	1 day
Total process	13 days

Figure 6: The 15cm x 15cm wood blocks that use for the top plate of the mould.

Figure 7: Rough surface on the bottom part of the top plate due to excess excess amount of hardener.

Figure 8: Failure in compressing the fibre in mould.

5. Final Product

Figure 9: Completed fabrication for top part of a small plate.

Figure 10: Bottom part of the top for second fabrication.

6. CONCLUSION

In conclusion, this study was successfully performed to fabricate a small part of Bio-based HVAC-system from sugar palm fibres (SPF), following the main objectives to save our environment with fulfill 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 fibre 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 HVAC systems and development of computer-aided design, as well as software development. Bio-based HVAC 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.

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