EVALUATION OF MECHANICAL PROPERTIES ON SUGARCANE BAGASSE FIBRE-REINFORCED EPOXY BIO-COMPOSITES

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Abstract- *In this study, experiments are performed to study the physical and mechanical behavior of chemically-treated sugarcane bagasse fiber -reinforced epoxy composite. The effect of alkali treatment, fiber varieties, and fiber lengths on physical and mechanical properties of the composites is studied. Resin content level and panel density were very important incontrolling the strength properties of the panels. Strength and hardness are evaluated from this composite material by using UTM & Rockwell hardness testing machines.*

Keywords- fiber, Resin

I. INTRODUCTION

The abundant agricultural/industrial waste generated from modern technologies has proved to be a barrier to sustainable development. The natural fibre reinforced composites have been identified as a potential substitute in various applications due to the availability, cost-effectiveness, non-toxicity, and biodegradability. Moreover, the natural fibre-reinforced composites display excellent properties such as high strength and stiffness that make them an excellent alternative to glass or carbon fibres for high strength applications such as construction. Various natural fibres have been reported to be used for the fabrication of composites such as Jute, Coir, Sisal, Pineapple, Ramie, Bamboo, Banana, Hemp, Bagasse, Coconut, Flax, and Curaua. The hybridizing of composites improves the tensile strength and modulus of curaua/glass fibre composites.

Bagasse is the dry pulpy residue left out after the extraction of sugarcane. Apart from sugarcane, other plants also yield bagasse such a cassava, agave and guayule. A study of the layering pattern of hybrid composites of epoxy novolac reinforced with short bagasse and coir fibres started that the tri-layer's tensile properties are better compared to bi-layer composites. The morphology of uncarbonized and carbonized composites of different bagasse particles show that the microstructure of the polymer composites is essential and responsible for the increase/decrease in mechanical properties.

It is expected that the improved properties of bagasse-reinforced composites may gain attention in sustainable development owing to their advantages with regard to ecological concern. The bagasse fibres are readily available as agricultural waste. The waste can be turned into a source of bio-composite that has many applications and an edge over conventional composites. This study's main objective is the effective utilisation of bagasse and fabrication of a new class of epoxy-based composites reinforced with different lengths and varieties of sugarcane bagasse fibre. The bagasse fibre used to reinforce the composites was treated using NaOH solution. We also evaluated the physical and mechanical behaviour of the fabricated composites using hardness, tensile, wear, water absorption, and impact resistance tests.

Bagasse is the fibrous residue which remains after sugarcane stalks are crushed to extract their juice. It is mainly used as a burning raw material in the sugar mill furnaces. The low caloric power of bagasse makes this a low efficiency process. Also, the sugarcane mill management encounters problems regarding regulations of clean air from the Environmental Protection Agency, due to the quality of the smoke released in the atmosphere. Presently 85% of bagasse production is burnt. Even so, there is an excess of bagasse.

Usually, this excess is deposited on empty fields altering the landscape. Approximately 9% of bagasse is used in alcohol (ethanol) production. Ethanol is not just a good replacement for the fossil fuels, but it is also an environmentally friendly fuel. Apart fromthis, ethanol is a very versatile chemical raw material from which a variety of chemicals can be produced6. SCB wastes are chosen as an ideal raw material in manufacturing new products because of its low fabricating costs and high-quality green end material. It is ideal due to the fact that it is easily obtainable given the extensive sugar cane cultivation making its supply constant and stable. The associated costs of extraction, chemicalmodifications and/or other pre-treatments of SCB in the transformation process to ready- to-be used materials are potentially reduced as the complex processes are simplified by the mere usage of Bagasse.

Figure1 preparation of bagasse

When appropriate modifications and manufacturing procedures are applied, bagasse displays improved mechanical properties such as tensile strength, flexural strength, flexural modulus, hardness, and impact strength. Bagasse is also found to be easily treated and modified with chemicals besides blending well with other materials to form new types of composite materials. It also satisfies the greening requirements by being biodegradable, recyclable and reusable7. The compression and injection moulding processes were performed in order to evaluate which is the better mixing method for fibers (sugarcane bagasse, bagasse cellulose and benzylated bagasse) and Polymer matrixes.

II. LITERATURE REVIEW

Norizan Ali et.al (2012): The characteristics and water/oil sorption effectiveness of kapok fiber, sugarcane bagasse and rice husks have been compared. The three biomass types are subjected to field-emission scanning electron microscopy energy dispersive x- ray spectroscopy while the surface tension analyses for liquid-air and oil-water systems have also been conducted. Both kapok fiber and sugarcane bagasse exhibit excellent oil sorption capabilities for diesel, crude, new engine and used engine oils since all their oil sorption capacities exceed 10 g/g. Synthetic sorbent exhibits oil sorption capacities comparable to sugarcane bagasse while rice husks exhibit the lowest oil sorption capacities among all the sorbents. Kapok fiber shows overwhelmingly high oil-to-water sorption (O/W) ratios ranging from 19.35 to 201.53 while sugarcane bagasse, rice husks and synthetic sorbent have significantly lower O/W ratios (0.76 to 2.69). This suggests that kapok fiber is a highly-effectual oil sorbent even in well-mixed oil-water media. An oil sorbent suitability matrix has been proposed to aid relevant stakeholders for evaluation of customized oil removal usage of the natural sorbents.

S Vidyashri et.al (2019): Bagasse fiber which is abundantly available as waste after processing of sugarcane is used as reinforcement with an epoxy polymer in forming the natural fiber reinforced composites. The raw fibers were treated chemically to improve compatibility and adhesion with the epoxy polymer. Treated and untreated fibres were subjected to analysis such as Scanning Electron Microscopy (SEM), X-Ray Diffraction (XRD) and Thermogravimetric Analysis (TGA) to understand the structural changes and to determine thermal stability. The mechanical properties of fibers and the composites were evaluated by conducting tensile tests. The results reveal alkaline pre-treated and KMnO4 treated fibres show improved mechanical and thermal properties.

Nor Azlina Ramlee et.al (2019): Recently, agriculture residue such as oil palm empty fruit bunch (OPEFB) and sugarcane bagasse (SCB) fiber have been attracting attention to a researcher as a high potential reinforcement material for composite material in building sector. Agriculture biomass are biodegradable, sustainable, low cost and lightweight materials for composite industries. In this paper, OPEFB and SCB fiber used as filler in different ratio to fabricate hybrid composites by hand lay-up technique while maintaining total fibre loading 50 wt%. Tensile test using UTM INSTRON machine, water absorption, thickness swelling, density, void content and micrographs of hybrid composites and pure were determined. This research found that hybridization of OPEFB/SCB fiber composites indicates better performance and properties comparing with pure fiber composites. Obtained results showed that 7OPEFB:3SCB hybrid composites display highest tensile strength and modulus, 5.56 MPa and 661.MPa, respectively with less porous and voids area compared to pure composites. While 3OPEFB:7SCB hybrid composites show lower water absorption and thickness swelling after 24 h analysis. This research addresses agriculture residue seen as an alternativegreen product material to apply in wall as a thermal insulation and heat retention, which are important in buildings and construction sector for the purpose of energy saving.

L Prasad et.al (2020): The experiments are performed to study the physical and mechanical behavior of chemically-treated sugarcane bagasse fiber-reinforced epoxy composite. The effect of alkali treatment, fiber varieties, and fiber lengths on physical and mechanical properties of the composites is studied. To study the morphology of the fractured composites, scanning electron microscopy is performed over fractured composite surfaces. The study found that the variety and lengths of fibers significantly influence the physical and mechanical properties of the sugarcane bagasse-reinforced composites. From the wear study, it is found that the composite fabricated from smaller fiber lengths show low wear. The chemically-treated bagasse-reinforced composites fabricated in this study show good physical and mechanical properties and are, therefore, proposed for use in applications in place of conventional natural fibers.

Shiv Kumar et.al (2020): In this study, experiments are performed to study the physical and mechanical behaviour of chemically-treated sugarcane bagasse fibre-reinforced epoxy composite. The effect of alkali treatment, fibre varieties, and fibre lengths on physical and mechanical properties of the composites is studied. To study the morphology of the fractured composites, scanning electron microscopy is performed over fractured composite surfaces. The study found that the variety and lengths of fibres significantly influence the physical and mechanical properties of the sugarcane bagasse- reinforced composites. From the wear study, it is found that the composite fabricated from smaller fibre lengths show low wear. The chemically-treated bagasse-reinforced composites fabricated in this study show good physical and mechanical properties and are, therefore, proposed for use in applications in place of conventional natural fibres.

JASUAROCKIAM NAVEEN et.al (2021): In Malaysia, the majority of household electricity (45%) is consumed by air conditioning. Such high energy consumption is mainly caused by inefficient insulating materials with poor thermal performance. Hence, the selection of a thermal wall insulator with low thermal conductivity is vital to reduce the energy consumption. Utilizing agro waste based thermal insulation materials has become an efficient and economical method for energy efficient building. In this review, the standards required for an efficient thermal insulator have been addressed. Moreover, thermal, acoustic, physical and mechanical performance of oil palm empty fruit bunch fiber (OPEFB) and sugarcane bagasse fiber and their composites are described in detail. Optimal fiber loading and different surface modifications were reported to enhance the thermal performance, acoustic, physical and mechanical performance of composites. From the observations, it has been concluded that agro waste based OPEFB and bagasse fibers can act as an efficient thermal insulator, which will significantly reduce the excess utilization of energy and thus the costs.

M. Mohan prasad et.al (2022): This present study investigates the role of adding sugarcane bagasse biosilica (SBB) fine particle on Opuntia dillenii fibre (ODF)- reinforced epoxy resin composite and its mechanical, thermal and laminar shear strength properties. In this study, the biosilica particles were prepared from Indiana sugarcane bagasse via thermo-chemical process. The fibre and particles were silane surface-treated (SST) using 3-aminopropyltrimethoxysilane via acid hydrolysis process. Hand layup was used to create the composites, which were then post-cured at 120 °C for 48 h. The composites were characterized using ASTM standards in order to evaluate the mechanical, thermal and laminar shear strength properties. The tensile strength of SST fibre and particle produced the highest strength of 178 MPa for 40 vol.% of fibre and 2 vol.% of particles in epoxy resin. Similarly, the SST fibre and particle retained high thermal stability than as-received fibre and particle in the composite. The laminar shear strength of SST fibre shows the highest value of 33 MPa against shear load. The SEM morphology shows highly adherence surface between SST fibre and resin. Thus, in the process of making bio composites using plant-based fibres, the silane treatment is mandated in order to achieve high performance.

III. METHODOLOGY

Collection of sugarcane wastage

The sugar cane bagasse is a residue widely generated in high proportions in the agro- industry. It is a fibrous residue of cane stalks left over after the crushing and extract ion of juice from the sugar cane. Bagasse is generally grey-yellow to pale green in colour. Itis bulky and quite non uniform in particle size.

Materials

Sugarcane bagasse fibers were brought from the local market. Chemicals used for the modification of sugarcane bagasse fiber are NaOH pellets, Potassium permanganate, Phosphoric acid, and Oxalic acid. Collected sugarcane bagasse was dried under the sun for 2 weeks by spreading on waterproof sheet. This was to ensure that there was no fungi accumulation on bagasse. Such bagasse fibers were cut into 9–10 cm length and soaked in water for two hours and then dried.

Figure 2 sugarcane bagasse.

preparation of strings

Initially we have to collect the sugarcane waste or pulp from sugarcane mills or sugarcane juice shops. Next, we have to make the collected sugarcane waste into thin sheets. This can be done by drying up the sugarcane bagasse under the sunlight and then combing them in order to make them into thin strings. So, by this way thin strings were made. The chemical treatment of strings is done. Alkali treatment of natural fibers is the common method to produce high quality fibers. Alkali treatment is also called as mercerization. Mercerization leads to fibrillation, which causes the breakdown of the composite fiber bundle into smaller fiber. Mercerization reduces the fiber diameter, thereby increasing the aspect ratio, which leads to the development of a rough surface topography that results in better fiber matrix interface adhesion and an increase in mechanical properties.

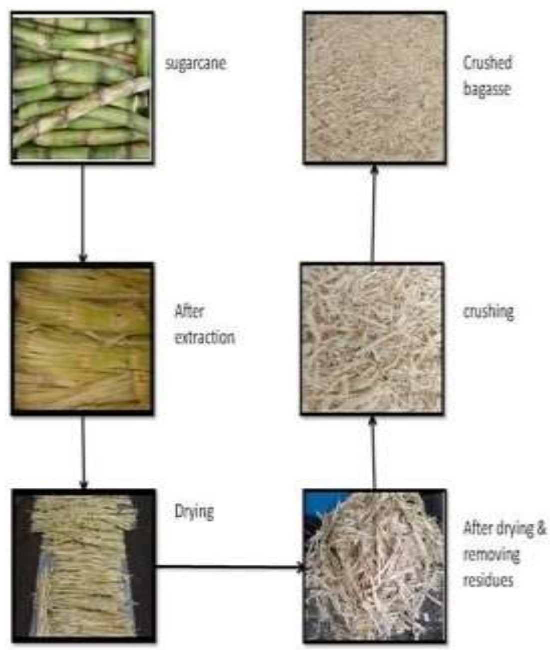

Figure 3 preparation of crushed strings.

Dry the strings under sunlight

The thin strings which are made should be kept under direct sun light for nearly 12 hours so that these strings will be dried up and the moisture content in the strings will be gone.

Alkaline treatment

Extracted sugarcane bagasse fibers were subjected to alkali pretreatment by soaking in aqueous 10%\ NaOH solution for 3 hours. The soaked bagasse was separated and rinsed with distilled water until a neutral pH was achieved. After rinsing, the fibers were dried for 24 hours.

Epoxy resin and Hardener

Epoxy resins are relative low molecule weight pre polymers capable of being process under a variety of conditions. Two important advantages of these over unsaturated polyester resins are first, they can be partially cured and stored in that state and second they exhibit low shrinkage during cure. However, the viscosity of conventional epoxy resins is higher and they are more expensive compared to polyester resins. The cured resins have high chemical, corrosion resistance, good mechanical and thermal properties, outstanding adhesion to a variety of substrates, and good and electrical properties. Approximately 45% of the total amount of epoxy resins produced is used in protective coatings while the remaining is used in structural applications such as laminates and composites, tooling, moulding casting, construction, adhesives.

Composite preparation

A conventional hand layup technique was used to fabricate the composite slab. The hardener and low temperature curing epoxy resin were mixed in a ratio of 1:9 by weight. The fibres were added to the epoxy in the ratio of 3:10 by weight. A mould of dimensions220 _ 220 _ 20 mm3 made of plywood was used for composite fabrication. The mylar film was spread on the pattern first, and a releasing agent (silicon-free spray) was sprayedover mylar film to ensure the safe removal of composite from the mould. A constant load of 25 kg was applied to ensure the proper curing of the composites at room temperature for 24 h. The weight percent of sugarcane bagasse fibre and epoxy resin in each composite was fixed. The air bubbles which were entrapped during fabrication were removed by sliding rollers. Specimens were cut from the composites with dimensions as per the ASTM standard

Physical properties of the bagasse fibers

Dia. (μm)	100-340
Length(mm)	8-28
Aspect Ratio(l/d)	76
Moisture content (%)	49

Chemical composition of bagasse fibers

Cellulose (%)	45-55
Hemi cellulose (%)	20-25
Lignin (%)	18-24
Pectin (%)	0.6-0.8
Ash (%)	1-4
Extractives (%)	1.5-9

Mechanical properties of the bagasse fibers

Tensile Strength (Mpa)	180-290
Young's Modulus (Gpa)	15-19
Failure Strain (%)	1-5
Density (Kg/m3)	880-720

Epoxy composites are a type of polymer material that uses an epoxy resin to create a polymer matrix which is reinforced with fibers or other fillers. This allows for the fabrication of long-lasting parts with very high strength-to-weight ratios. The low densities of epoxy composites compared to metals also offers substantial fuel savings in aerospace and automotive applications. Compared to traditional materials of construction metal, concrete, wood, etc.epoxy-based polymer composites are more resistant to deterioration from corrosion, spalling, or rotting.

Figure 4 final epoxy resin bagasse composite

IV. RESULTS AND DISCUSSION

Tensile Test

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. The commonly used specimen for tensile test is the dog-bone type. During the test a uniaxial load is applied through both the ends of the specimen. The dimensionof specimen is (165x19x3) mm. The tensile test is performed by universal testing machine (UTM).and results were analyzed to calculate the Tensile Strength of composite samples. The tensile strength increases with increase in concentration of fibre up to certain limit, later it decreases. The optimum level of tensile strength is obtained due to proper distribution and dispersion of fibre in the matrix. fibre will get max tensilestrength 25.5 MPa

Table. Tensile Test

Name of the test	Result
Tensile test	25.5 MPa

Hardness Test

Rockwell hardness apparatus is used to measure the hardness shows figure 4.2. Type of indenter and the test load determine the hardness scale (A, B, C, etc.) is used to measure hardness. The value of hardness can directly measure by indenter scale attached to the machine.

Table. Rockwell Hardness Test

Name of the test	Result
Rockwell Hardness Test	22.03 HRC

Scanning Electron Microscope (SEM)

A smooth surface of fibre can be ensured by chemical treatments, especially using NaOH treatment. SEM images of the surface of tensile tested composites are shown in Figure. It shows that after the treatment, the fibres split out from the composites packed together, known as fibrillation. The fibrillation also broke the untreated fibre bundles down into smaller ones by the dissolution of the hemicelluloses. Because of the fibrillation, the active surface area available for contact with the matrix increased. An increment in the length of the fibre promoted the pull-out of the fibres from thematrix and debonding between the fibre and matrix took place.

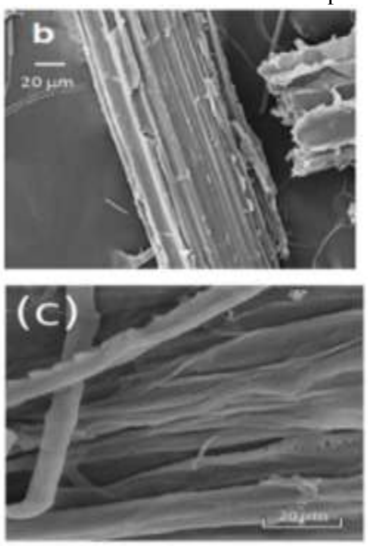

Figure 5 bagasse fibre

V.CONCLUSION

Thus, the Sugarcane Bagasse fiber reinforced with epoxy resin composite samples are fabricated and tested. The hybrids composite is subjected to mechanical testing such as Tensile test and hardness test. Based on the results, the following conclusions are drawn:

- The results indicated that Sugarcane Bagasse fiber reinforced with epoxy resin composite specimen gives tensile strength is high. The Maximum tensile force of the Sugarcane Bagasse fiber reinforced with epoxy resin composite sample is in the range of 25.5 MPa.
- Fiber treatment methods such as alkali treatment have shown improvement in adhesion between the matrix systems and the bagasse fibers.
- The Rockwell hardness test the strength obtains 22.03 HRC.

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