Investigation of mechanical properties and thermal properties on sugarcane fiber composite material reinforced with polyethylene terephthalate matrix material for sustainable applications

G J. Saikishore[1*], *K*. Giridhar Saikiran[1], *V*. Chakri[1], *Anshuman*. K[1], *D.S.* Naga Malleswara Rao[2], *G*. Saravanan[3], *LSP*. Subbu[1]

[1]Mechanical Engineering Department, Gokaraju Rangaraju Institute of Engineering and Technology, Hyderabad, Telangana, India.
[2]Electrical and Electronics Engineering Department, Gokaraju Rangaraju Institute of Engineering and Technology, Hyderabad, Telangana, India.
[3]Mechanical Engineering Department, PSNA Collège of Engineering and Technology, Dindigul, Tamilnadu, India.

Abstract. In this modern age composite materials are become the primary material for engineering production because composite materials have several specific properties such as high strength-to-weight ratio, low cost, ease of fabrication, tensile strength, compressive strength, Impact strength, high resistance to thermal which does not realize in pure material or non-composite material. Fabricating composite materials involves producing something useful from waste materials. The experimental investigation involves the fabrication of sugarcane fiber-reinforced PET composites through a controlled manufacturing process. Because of its vast application, every Mechanical Engineer should have the knowledge about the fabricate and test the composite material. In this research, two waste materials are used - bagasse and waste plastic to fabricate a composite. The main purpose of the composite material is for heat insulation that is applicable for industrial roofing. The main purpose of the composite material is for heat insulation that is applicable for industrial roofing applications and manufacturing for sustainable components. The mechanical results after compression and shear tests are 4.57 and 0.37 MPa respectively. The maximum thermal test after an exposed surface temperature test is 54 °C

Keywords: Composite material, Sugarcane fiber, Plastics, heat insulation.

[*] Corresponding Author - jsaikishore80@gmail.com

1 Introduction

Composite materials are manufactured from different materials by combining together in with their own properties aimed at forming a single material with better performance. Composites utilize certain components' strengths and minimize their weaknesses in order to display better mechanical, thermal and chemical characteristics than those of individual parts [1-4]. Varieties of industries utilize these materials such as aerospace, automotive, construction, sports. Their properties can be personalized according to specific use-cases; thus they are multipurpose and applicable everywhere. In a composite, the components are generally with matrix material that holds the structure together and a reinforcement material that improves individual characteristics such as strength, stiffness or toughness. For instance, matrix materials include epoxy resins, which are thermoplastics, whereas reinforcement materials may consist of fibers like carbon, glass, or aramid [5-8].

The importance of composite materials is further highlighted in the resolution of worldwide issues such as energy usage when it comes to movement and the use of sustainable techniques. Through constant advancements upon various materials, composite materials are making a mark in a number of areas characterized by their better quality, long lastingness, environmental friendly nature [9-12]. As the research on composite materials continues, they are projected to further increase their influence across various sectors maintaining their critical role alongside other developments among modern materials and engineering. The aim of this composite material is to combine the positive aspects of two things to create something that is light yet very strong thus it can be used in many different ways and is also good for the environment [13-17].

The project involves the creation of a new and innovative composite material by mixing together sugarcane fiber reinforcement and a polyethylene terephthalate (PET) matrix. Sugarcane fibers are preferred for their natural strength and eco-friendly properties. While serving as sticking substance, PET matrix is both versatile and durable. When creating this, The goal of this mixed material is to blend the composite material and as a result obtain a light, solid and ecological material for different use [18-22]. The project will contains high-quality sugarcane fibers and PET resin. The processing and preparation includes the application of techniques like molding, extrusion or injection molding will make sure that sugarcane fibers are evenly distributed within the PET matrix. Mechanical testing, such as compression and shear tests were conducted to assess the structural integrity of the materials and their performance under diverse loading conditions [23-27]. Additionally, this project will be infused with sustainable practices and eco-friendliness standards, which are consistent with the global campaign for green materials. The outcomes of this project have the potential to contribute to the development of sustainable composite materials, opening avenues for eco-conscious applications in industries such as packaging, construction, automotive components, few sustainable applications like power plant equipments and components [28-32].

2 Experimental Procedures

2.1 Materials specification

The raw materials are taken from the wastage materials, the sugarcane bagasse like the wastage of the sugarcane as shown in Fig 2.1. The other material is the wastage of the plastic material like cool drink bottle, water bottle etc that material is also known as Polyethylene Terephthalate as shown in Fig 2.2.

Fig. 1. Chopped sugarcane bagasse

Fig. 2. PET material

2.2 Material processing

The sugarcane bagasse is subjected to drying process to remove the moisture content present in it, later the sugarcane bagasse is copped into the fine particle. The Polyethylene terephthalate is taken in the form of PET bottles, the PET bottles are copped into small granules. As shown in Fig.2.3 the mould is prepared. Then the PET granules are poured and melted, after that the sugarcane bagasse particles are poured into the molten PET and stirred [33-37]. Then the molten composite material is poured into the mould for the solidification process. The composite material is taken out from the mould, then the composite material Fig 2.4.

Fig. 3. Preparation of the Mould

Fig. 4. Manufactured Composite Material

3 Result and Discussion

3.1 Compression Measurements

Fig. 5. UTM Machine

The compression test is performed in UTM machine as shown in Fig 3. and the specifications of the machine are Capacity of 5KN Analogue, digital & with computer interface,make shimadzu, AGS-J Model. The testing Space: 1050 mm Height, 410 mm Width, Range of speed : 0.6 to 550 mm/min. Speed Setting resolution: 1.0 mm/min. Speed accuracy: ± 0.5% , 0.025 mm/min [38-41].

Table 1. Compression Test Under ASTM D3039

S.No	Composition	Input Data(mm)	Ultimate compression load	Compression Strength
1	Polyethylene Terephthalate -90% Sugarcane Bagasse -10%	W :18.88 L :21.04	1809 N	4.57 MPa

The compression test is observed from the above Table 3.1, that ultimate compression load is 1809N and the compression strength is 4.57 MPa for the composition of 9:1 ratio of Polyethylene Terephthalate and Sugarcane Bagasse. The Load vs Displacement graph, the graph increases upto 1791 N load at 1mm displacement, then gradually decreasing from that position [42-46]. The composite material got fracture point at 995 N Load at 1.8mm displacement.

3.2 Shear Measurements

Table 2. Shear Test Results Under ASTM D5379

S.No	Composition	Input Data	Ultimate Load	Shear Strength
1	Polyethylene Terephthalate -90% Sugarcane Bagasse -10%	W:17.60cm L:23.05cm	149N	0.37MPa

The shear test is performed on the Fig 3.1 and obtained results. From the above Table3.2 the ultimate load observed is 149N and shear strength is 0.37MPa for the composition of 9:1 ratio of Polyethylene Terephthalate and Sugarcane Bagasse. The maximum displacement in the shear graph is 1.8mm, maximum load of shear is absorbed at 149N at a displacement of 1mm [47-51]. The Load vs Displacement indicated in decreases with shear load acting on the specimen, the composite material has attained the shear strength of 0.3MPa.

3.3 Thermal Measurements

The thermal results are observed by FLIR E76 Thermal Camera as shown in Fig 3.4. The specifications of the FLIR E76 are The 320 x 240 true native resolution offers more than 76,000 points of temperature measurement and produces crisp, vibrant images, while interchangeable lenses offer complete coverage of near and distant targets [52-55]. Thermal distribution in composite material is resulted as the thermal insulating performance at 100 °C – 38°C, 200°C – 41 °C,400 °C – 54 °C.

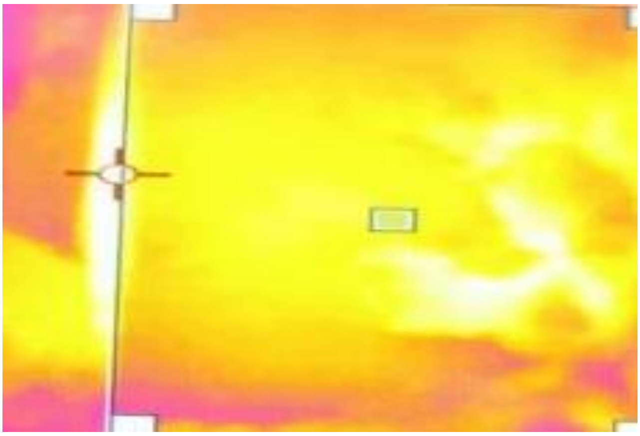

Fig. 6. Thermal Image of the Composite Material

Table 3. Thermal Test Performance Table

S. No	Material Dimensions (mm)	Supplied Temperature °C	Duration of Supplying Temperature °C (Minutes)	Exposed Surface Temperature °C
1.	W: 50 L: 50	100	45	38
2.	W:50 L:50	200	45	41
3.	W:50 L:50	400	45	54

Fig. 7. FLIR E76

4 Conclusion

Very few research scholars have contributed work on sugarcane bagasse reinforced with Polyethylene Terephthalate matrix material. The mechanical and thermal properties were tested on the composite material and performance characteristics were monitored. From the above research work, the following result were obtained

1. The composite material was subjected to Compression strength. A load of 1809N was applied and the compression strength was identified as 4.57MPa. During the

compression test, stress-strain values were monitored and the composite material has got the highest yield point at 1791N and ultimate tensile strength at 1807N.

2. Shear test were tested on the composite material. The shear strength was identified as 0.37 MPa at a load of 149N.
3. The thermal insulating performances were monitored on the composite material at 100ºC, 200ºC and 400ºC for a duration of 45 minutes. The exposed surface temperature on the composite material were measured and noted as 38ºC, 41ºC, 58ºC respectively.

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