Composite Bonding Increment by Banana Fiber as Alternate in Polypropylene Matrix

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Abstract— *The aim of this work was to fabrication of banana fiber reinforced fiber with polypropylene composites. Evaluation of mechanical properties such as tensile strength, impact strength flexural strength, and micro-hardness etc. of composites. To study the influence of fiber length and loading on the mechanical behaviour of composites. Inspite of, elevating the banana fiber as alternate filler material in a polypropylene matrix to increase the bonding between fiber and matrix. As a natural fiber due its availability, biodegradability, low cost and low weight, its tensile strength and tensile modulus along with the weight percentage are estimated and compared legitimately during this work.Here the experimental setup was made like injection moulding process, specimen preparation and composite compositions for overall research work.*

Keywords— ***Banana fiber, Polypropylene, Tensile strength, composite bonding.***

I. INTRODUCTION

In the resent past considerable research and development have been expanded in natural fibers as reinforcement in thermoplastic resin matrix. These reinforced plastics serve as an inexpensive, biodegradable, renewable, and nontoxic alternative to glass or carbon fibers. The various advantages of natural fibers over man-made glass and carbon fibers are low cost, low density, competitive specific mechanical properties, reduced energy consumption and biodegradability. Thermoplastic materials that currently dominate as matrices for natural fibers are polypropylene (PP), polyethylene, and poly (vinyl chloride) while thermosets, such as phenolic and polyesters, are common matrices. With a view to replacing the wooden fittings, fixtures and furniture, organic matrix resin reinforced with natural fibers such as banana, jute, kenaf, sisal, coir, straw, hemp, banana, pineapple, rice husk, bamboo, etc., have been explored in the past two decades. There is an increasing demand from automotive companies for materials with sound abatement capability as well as reduced weight for fuel efficiency. Natural fibers possess excellent sound absorbing efficiency and are more shatter resistant and have better energy management characteristics than glass fiber reinforced composites. In automotive parts, such composites not only reduce the mass of the component but also lower the energy needed for production by 80%. Eco-friendly composites can be made by replacing glass fibers with various types of ligno-cellulose fibers. However, such composites have a distinct disadvantage of load-bearing capability compared to glass fiber reinforced thermoplastics. The variation in the properties of natural fibers is another important aspect that has to be considered. Demands for natural fibers in plastic composites is forecast to grow at 15–20% annually with a growth rate of 15–20% in automotive applications, and 50% or more in selected building applications.

II. CLASSIFICATION OF FIBERS

According to the reinforcing phases the composites are mainly classified into three types, i.e. fiber reinforced composites, flake reinforced composites and particle reinforced composites.

2. FIBER: Fiber consist of thousands of filaments having a diameter of between 5-15 micrometres.

2.1 Natural Fibers: Coir, Jute, Bamboo, Palm, Corn etc.

2.2 Man Made Fibers: Carbon, Boron, Glass, Kevlar, Graphite etc.

Depending upon diameter of fibers can be classified as Filaments, Wires & Rods.

Filament form of fibers is attractive. Based on the strength, fibers can be grouped as high performance, medium performance and low performance.

Table 1. Mechanical properties of Banana & Jute fibers

Fiber Type	Tensile strength (MPa)	Young's modulus (GPa)	Failure strain (%)	Source
Banana	29.73095	8.65	1-3	3
Jute	200-450	20-55	2-3	7

2.3Advantages of Banana fiber:

Banana fiber possesses good specific strength properties comparable to those of conventional materials like glass fibers.

Banana Material has lower density than glass fiber.

Alkali treatments have been proven effective in removing impurities from the fiber,

Decreasing moisture sorption and enabling mechanical bonding and thereby improving matrix reinforcement

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interaction. And also Natural fibers are low-cost, recyclable and eco-friendly materials. Eco-friendliness and bio-degradability of these natural fibers may replace the glass and carbon fibers.

III. MATERIALS AND METHODS

The materials used are banana fiber and polypropylene.

3.1 Injection Moulding Technique:

The diversity of applications based on various factors, such as product performance, size, shape, and quantities, generated many different types of injection moulding machines (IMM) to form final products; however, the process of manufacturing these different applications are the same. In processing, the material is fed into the plasticiser barrel through the hopper, and the pressure in the barrel is between 2,000 and 30,000 psi (14 to 205 MPa). To meet pressure flow restrictions going from the plasticiser into the mould cavity, the barrel pressure must be enough for a given cavity pressure. A rotating screw located inside the plasticiser barrel helps the materials to move toward the nozzle, and during this motion, a heat system surrounding the plasticiser barrel causes the materials to melt. The heating system is comprised of different sections (front, centre, rear) each of which can be set to a different temperature depending on the type of material used. Also, another factor assists in the melting process – the friction between the rotating screw and the surface of the plasticiser – and this is known as 'shear heating'.

Fig.1: Co-rotating twin screw extruder, Compounding

When the melted materials reach the nozzle, they are injected into the mould that forms the product and its features as shown in figure 1. Commonly, steel or aluminium is used for moulds due to their high heat resistance. In order to prevent back flow of meltedmaterial during solidification, the injected materials should be under pressure for a certain amount of time (Rosato et al., 2000).

IV. SPECIMEN PREPARATION METHOD

The banana fiber is obtained from banana plant, which has been collected from local sources. The extracted banana fiber were subsequently sun dried for eight hours then dried in oven for 24 hours at 105° C to remove free water present in the fiber. The dried fibers were subsequently cut into lengths of 10 mm. The banana fiber based polypropylene composite is fabricated using hand lay-up process. The moulds have been prepared with dimensions. The banana fiber of length has been mixed with matrix mixture with their respective values by simple mechanical stirring and mixture is slowly poured in different moulds, keeping the characterization standards and view on testing condition. The releasing agent has been use on mould sheet which give easy to composites removal from the mould after curing the composites. A sliding roller has been used to remove the trapped air from the uncured composite and mould has been closed at temperature 30° C duration 24 hour. The constant load of 50 kg is applied on the mould in which the mixture of the banana, polypropylene has been poured. After curing, the specimen has been taken out from the mould. The composite material has been cut in suitable dimensions with help of zig saw for mechanical tests as per the ASTM standards. The designation and detail composition of composites is shown in Table 2. The fabricated short banana fiber based polypropylene composite is shown in Figure 2.

Table 2. Designation & composition of composites

Designation	Composition
C1	Fiber length (10 mm)(30%) + polypropylene (70%)
C2	Fiber length (10 mm) (20%) + polypropylene (80%)

Fig.2: Fabricated short banana fiber with polypropylene composites

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V. TENSILE STRENGTH

The specimen prepared is shaped into required dimension using a hand cutter and the edges are polished using a salt paper. It is prepared according to the ASTM D638 standard. The dimensions, gauge length and cross head speeds are chosen according to the ASTM D638 standard. The tensile test is performed on the Universal Testing Machine (UTM) Make FIE (Model: UTN 40, S. No. 11/98-2450). The process involves placing the test sample in the UTM and applying tension to it until the fracture of the material. Then the force is recorded as a function of the increase in gauge length. During the application of tension, the elongation of the gauge section is recorded against the applied force. There are three different types of samples prepared according to the ASTM standards and the experiments are repeated for several times and the average values are used for discussion. Tensile test specimens were made in accordance with ASTM D 638M to measure the tensile properties. The sample was 160 mm long, 12.5 mm wide and 3 mm thick; five identical specimens tested for each composition. Overlapping aluminium tabs were glue to the ends of the specimen with polypropylene, filling the space at the tab overlap to prevent compression of the sample at the grip. The samples were tested at a cross-head speed of 0.5 mm/min and the strain was measured using an extensometer.

Fig .3: Loading arrangement of tensile test

Table 3. Experimental tensile strength of composite samples

SAMPLE	STRESS (MPa)	STRAIN (%)	YOUNGS MODULUS (E)
PP	34.19	8.8	3.89
PBF20	29.73095	3.43609	8.65
PBF30	29.15255	4.133	7.05

VI. FLEXURAL STRENGTH

The flexural specimens are prepared as per the ASTM D790 standards and the test has been carried out using the same UTM. The 3-point flexural test is the most common flexural test and used in this experiment for checking the bending strength of the composite materials. The testing process involves placing the test specimen in the UTM and applying force to it until it fractures and breaks. Three-point bend tests were performed in accordance with ASTM D 790M test method to measure flexural properties. The samples were 100 mm long, 25 mm wide and 3 mm thick. In three-point bending test, the outer rollers were 64 mm apart and the samples were tested at a strain rate of 0.5 mm/min. A three-point bend tested was chosen because it requires less material for each test and eliminates the need to accurately determine centre point deflections with test equipment.

$$\text{Flexural strength} = \frac{3\text{pl}}{2\text{bt}^2}$$

Fig.4: Flexural strength testing machine

Table 4. Experimental flexural strength of composite samples

SAMPLE	STRESS (MPa)	STRAIN (%)	YOUNGS MODULUS (E)
PP	24.05	3.77	6.38
PBF20	9.9845	3.76217	2.65
PBF30	9.9885	3.763655	2.653936134

VII. IMPACT STRENGTH

The impact test specimens are prepared according to the required dimension following the ASTM-A370 standard. During the testing process, the specimen must be loaded in the testing machine and allows the pendulum until it fractures or breaks. Using the impact test, the energy needed to break the material can be measured easily and can be used to measure the toughness of the material and the yield strength. The effect of strain rate on fracture and ductility of the material can be analysed by using the impact test. Impact test specimens were prepared in

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accordance with ASTM D 256M to measure the impactstrength. The specimens were 63.5 mm long, 12.7 mm deep, 10 mm wide. A sharp file with included angle 45o was drawn across the centre of the saw cut at 90 o to the sample axis to obtain a consistent starter crack. The samples were fractured in a plastic impact testing machine and the impact toughness was calculated from the energy absorbed and the sample width.

$$\text{Impact strength} = \frac{\text{energy observed}}{\text{thickness in meters}}$$

Fig.5: Impact testing machine

Table 5. Experimental impact strength of composite samples

Samples	Trial
30%bananafiber+70%polypropylene	42.682
20%bananafiber+80%polypropylene	62.06

VIII. RESULTS AND DISCOUSIONS

The samples are tested in their corresponding testing machines and the tensile, flexural and impact properties are determined. Each type of sample is tested three times and the average values are found. The sample graphs generated with respect to load for banana fiber is presented below. The results indicated that the banana fibers exhibited excellent mechanical properties and the maximum values obtained are 22.33 MPa as tensile strength, 47.33 MPa as flexural strength and 42.682 Joules as impact strength.

Table 6. Experimental findings of composite samples

Samples	Tensile strength (MPa)	Flexural strength (MPa)	Impact strength (Joules)
30%banana fiber+70% pp	29.15255	9.9885	42.682
20% banana fiber+ 80% pp	29.73095	9.9845	62.06

8.1. Tensile Properties:

The banana fiber composite specimen are prepared with different volume fractions and tested in the universal testing machine (UTM). The tensile strength comparison of the different combinations of the banana fiber polypropylene composites are presented in Fig 6(a), 6(b). From the figure it has been clearly indicated that the 20% banana fiber and 80% polypropylene composites are performing better than the other composite combinations tested.

Fig. 6(a): Before testing the specimen

Fig. 6(b): After testing the specimen

8.2. Flexural Properties:

UTM flexural testing composites are presented in Figure 7(a), 7(b).The flexural strength comparison of the different combinations of the banana fiber with polypropylene composites are presented in the result indicated that the 20% banana fiber and 80%polypropylene composites are performing better than the other composite combinations tested which can withstand the flexural load of 48.12kN.

Fig.7(a): Before flexural testing of composite

Fig.7(b): After flexural testing of composite

8.3. Impact Properties:

For analysing the sudden load carrying capacity of the banana fiber composite samples an impact test is carried out. The energy loss is found out on the results obtained from the impact testing machine. The impact strength comparison of the different combination of banana fiber with polypropylene composites is presented in Figure 8. From the figure it can be observed that, the 30% banana fiber and 70% polypropylene composites are performing better than the other composite combinations tested which can hold the impact load of 42.682 Joules followed by 20% banana fiber and 80% polypropylene composites can withstand the impact load 62.06 Joules.

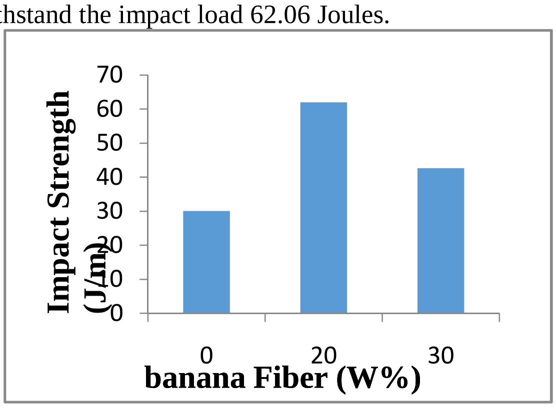

Fig.8:Impact Strength at different fiber weight percentages of banana / PP Composites

Fig.9 (a): Before impact test of composite

Fig.9 (b): After impact test of composite

IX. CONCLUSION

The main objective of this investigation is to gauge the possibility of utilizing the banana fiber which is abundantly available as an alternative filler material in a polypropylene matrix to increase the bonding between fibers and matrix. The following conclusions are made basing on the above analysis.

The incorporation of banana Fiber into the polypropylene matrix has resulted in a moderate improvement in the tensile, flexural and impact properties of the composites. It has been observed that the pure polypropylene has got a tensile strength of 34.19 MPa and a tensile strength of 22.99 MPa is noted at 20 weight % of banana fiber 80%PP composite.

The tensile modulus of pure polypropylene is 2.63MPa and the tensile modulus for banana fiber reinforced PP composites 8.36MPa which is 178.16 % higher than pure PP. The higher tensile modulus value is observed at 30% fiber weight fraction.

The flexural strength for pure polypropylene is 24.05 MPa and the maximum flexural strength of the banana fiber polypropylene composite is 47.33 MPa and occurring at 30% fiber fraction.

The flexural modulus of pure polypropylene is 6.37 MPa. The flexural modulus for banana fiber reinforced PP composites is 3.17 GPa which is 163.42 % higher than

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pure PP. The composites higher flexural modulus value is observed at 30% fiber weight fraction.

The impact strength of pure polypropylene is 30.033 J/m and the Impact strength of 62.06 J/m is noted at 20 weight % of coir fiber PP composite which is 20.01 % higher than PP matrix.

Based on tensile, flexural and impact properties, 20 % fiber weight fraction is the optimum value for banana fiber reinforced polypropylene composites. The composite can be regarded as a useful light weight engineering material and also the manufacturing cost of the composite can be reduced considerably by adding banana fiber as filler to the matrix.

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