Effect of Reinforcement of Polypropylene Withcoir, Based Studies

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Abstract- *Polymer composites played a significant role in variety of applications. The fibre which serves as a reinforcement in reinforced plastics may be synthetic or natural. Although glass and other synthetic fibre-reinforced plastics possess high specific strength, their fields of application are very limited because of their inherent higher cost of Production and also they are not biodegradable.*

The present work describes the development and characterization of a new set of natural fibre based polymer composites consisting of coconut coir as reinforcement.The usage of composite material for engineering applications is increasing to derive various advantages such as reduction in weight, corrosion resistance, manufacturing process flexibility. Experiments are carried out to study the effect of fibre content on mechanical behaviour of these composite's.

Keywords- fibre reinforced polymer, specific strength, thermo mechanical properties, flexibility.

I. INTRODUCTION

Today's world require the materials with high combinations of properties that can't be done by the conventional metal alloys, and metals.The advantage of composite materials over conventional materials stem largely from their higher specific strength, stiffness and fatigue characteristics, which enables structural design to be more versatile.

Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix). Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder maintains the position and orientation of the reinforcement. Significantly, constituents of the composites retain their individual, physical and chemical properties; yet together they produce a combination of qualities which individual constituents would be incapable of producing alone. The reinforcement may be platelets, particles or fibres and are usually added to improve mechanical properties such as stiffness, strength and toughness of the matrix material

In the present study we used a thermoplastic polymer (polypropylene) as the matrix and Coconut coir as the reinforcing filler to prepare a particle reinforced composite to study the effect of using these fibre on polypropylene onvarious properties such as mechanical, thermal and impact strength.

II. EXPERIMENTAL PROCEDURE

A. Materials-

The materials used in the preparation of composite sample was commercial PP in the form of polymer pellets. The Coir powder, used as reinforcing filler, was obtained from a local coconut coir factory in Vijayawada.

B. Fabrication of test specimens-

Coir processed as mentioned above was initially mixed thoroughly with PP granules at 15/85, 25/75 , 40/60 and 50/50 wt. % mixing ratios. The compounding of reinforcement and matrix was carried out with a JSW Twin Screw Extruder at a temperature of 220℃. The extruded composites were cut into long pieces. All the pieces were then crushed into smaller granules using a pelletizer attached to the extruder. The granules were dried in a hot air oven at 70°C for 1 h and then fed into an Automatic injection-moulding machine for making specimens. The specimens for tensile, impact tests were prepared as per ASTM D standards from dried granules using the Automatic injection-moulding machine at a moulding temperature profile of 160°C to 220℃.The binding agent plays a major role in the extrusion process of the materials.

Figure 1: Coir powder

Figure 2: JSW Twin screw extruder

Figure 3: Injection moulding machine

Figure 4: Specimen to be tested

C. Testing-

Determination of the Mechanical Properties, after fabrication the test specimens were subjected to various mechanical tests as per ASTM standards.

D. Tensile properties-

Tensile elongation and tensile modulus measurements are among the most important indications of strength in a material and are the most widely specified properties of plastic materials. Tensile test is a measurement of the ability of a material to withstand forces that tend to pull it apart and to determine what extent the material stretches before breaking. Tensile modulus is an indication of the relative stiffness of a material can be determined from stress – strain diagram.

Tensile properties of composite samples were measured using universal testing machine. The load capacity was 40KN and cross-head speed was 80 mm/min using gauge length of 105 mm. tensile test is generally performed on a flat specimens. Test specimens were Folded in a size of 12.5 mm (width), 60.66 mm (length) and 3.10mm (thickness)

$$\text{Tensile strength} = \frac{\text{force (load)(lb)}}{\text{cross section area (sq.in)}}$$

$$\text{Tensile modulus} = \frac{\text{difference in tensile stress}}{\text{difference in tensile strain}}$$

E. Bending properties-

Flexural strength is the ability of the material to withstand bending forces applied perpendicular to its longitudinal axis. Flexural properties of composite samples were measured using universal testing machine. For bending tests, cross-head speed was 2.0mm/min and span distance was 90 mm. tensile tests and three-point bending tests were carried out following ASTM 1599D standard methods respectively. For each treatment level, three replicated specimens were tested.

F. Impact strength-

The impact properties of polymeric materials are directly related to the overall toughness of the material.Impact strength is the measure of toughness. It was measured using an impact tester according to ASTM 1599D[Low Velocity Impact Testing].Values reported were average of three measurements. The impact strengths of the composites were conducted on notched specimens.

Figure 5 : Izod Impact testing machine

III. RESULTS AND DISCUSSIONS

The mechanical properties of the coir fibre reinforced composites prepared for this investigation. Details of processing of the composites and the tests conducted on them have been described in the previous chapter. The results of various characterization tests are reported here. This includes evaluation of tensile strength, impact strength has been Studied and discussed. The interpretation of the results are presented.

III. Ⅰ Mechanical properties of components

The characterization of the composites reveals that the different composition of fibre is having significant effect on the mechanical properties of composites. The properties of composites with different compositions of fibre under this investigation are presented in TABLE I.

TABLE I: Mechanical Properties of the PP-Coir Composites

Composites	Tensile strength(MPa)	Tensile modulus(GPa)	Flexural strength (MPa)	Flexural modulus (GPa)	Impact energy (kj/m²)
PP	35.972	0.57	27.24	1.15	45.89
C1	36.837	0.623	32.21	1.27	62.1
C2	39.98	0.696	35.12	1.58	105.3
C3	39.11	0.749	37.3	1.65	114.1
C4	37.34	0.789	39.1	1.69	119.4

Where,
PP=Polypropylene ;
C1=composition prepared with 15% coir in PP ;
C2=composition prepared with 25% coir in PP ;
C3=composition prepared with 40% coir in PP ;
C4=composition prepared with 50% coir in pp .

Tensile properties:

The effect of fibre addition on tensile strength of pp-coir composites is shown in Fig. 6

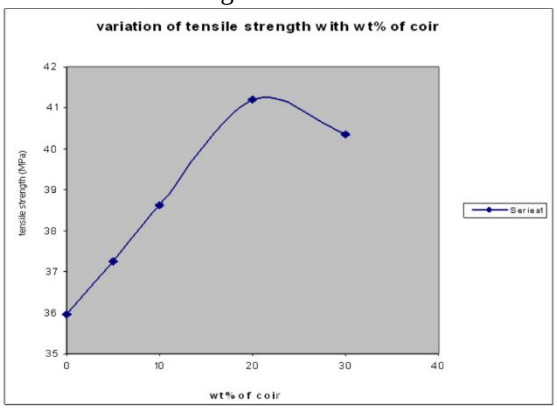

Figure6 : Tensile strength of coir reinforced pp composites

The strength of a composite may increase or decrease with the introduction of natural fibres to the polymer matrix. Normally fibres are able to improve strength but some of the fibres are not consistent or irregular in shapeinfluences the strength of the composite. In the study, poor reinforcement of the fibre inthe pp matrix is themain cause of the lower tensile strength value .

It states that the tensile strength increases with the increase of fibre addition upto certain range and after that it decreases. It is to presented that, the tensile strength values remained higher compared to that of neat PP. Upto this composition the fibre andthe polymer are well distributed.Up to 18% treated fibre addition the fibre and matrix bear the load and make resistance to slip as in the case of age hardening of metals.After that fibres are present as bundle of fibres and fibre-fibre bonding strength is lesser and the interfacial bonding between the fibre and matrix is poor. After that the fibre are coagulated as bundle of fibres, bundle of fibres fractured during load to slips and does not make resistance to slips. Consequently, after 18% fibre addition the tensile strength decreases.

TABLE Ⅱ: Tensile properties of composites

Composites	Max. Displacement (mm)	Stress (MPa)	Strain %	Yield point (MPa)	Breaking force. (N)
PP	6.318	35.972	0.63	9.348	1837.11
C1	9.221	36.837	0.59	9.6436	1891.54
C2	7.218	39.98	0.55	9.767	1876.1
C3	7.422	39.11	0.53	9.343	1782.6
C4	7.623	38.12	0.49	8.912	1698.3

The tensile properties of the composites made with the twin-screw extruding system were better than those of the composites made with the single-screw extruding system, due to the improved dispersion of the filler.

Flexural properties:

Flexural strength and modulus of the composites of reinforced PP composites are shown in Figs.16, respectively. In both cases, addition of fibre has increased the flexural strength of the composites. However, the values remain almost constant for 15% to 30% filler Loaded composites. For 0% fibre the polymer strength was obtained 27.24 MPa. The flexural properties of composites are presented in TABLE III.

TABLE III. Flexural properties of composites

Composites	Max force-(kg)	Flexural stress (MPa)	Strain (%)	Flexural modulus (MPa)
PP	116.3	25.9	6.12	1.15
C1	132.1	35.9	7.6	1.43
C2	142.2	38.4	6.6	1.70
C3	177.7	40.4	5.5	1.84
C4	184.5	41.6	4.7	1.91

Flexural strength and filler loading are directly proportional, as filler loading increases there is a increase in flexural strength too. The values of flexural modulus of composites are found to increase with the increasing coir content.

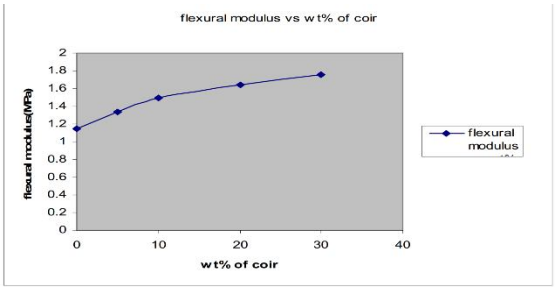

Figure7: Flexural modulus for coir reinforced pp composites

Since coir is high modulus material higher fibre concentration demands higher stress for the same deformation and higher degree of interfacial adhesion between the coir and the matrix provides better stress transfer from the matrix to the coir.

Impact strength :

Figure 8 shows the impact strength behaviour of coir-PP composites as a function of coir content. It is evident in the Figure that up to 35% coir content the impact strength shows a linear increase and then show a plateau with a little increase in the values up to 28% coir content. The impact strength of composites is governed mainly by two factors: first, the capability of the coir to absorb energy that can stop crack propagation and second, poor interfacial bonding which induces micro-spaces between the coir and the matrix, resulting in easy crack propagation Probably these two factors offset each other when the coir content exceeds 18%, showing a steady behaviour in the impact strengths of the composites.

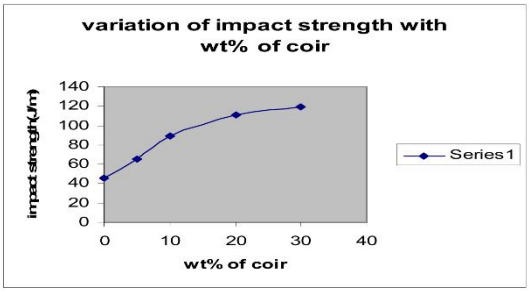

Figure 8: Impact strength for coir reinforced pp composites

The impact strength of the composite depends on the amount of fibre and the type of testing. whether the samples were notched or un-notched. In case of notched samples, the impact strength increases with the amount of fibres added until a plateau is reached at about 45% fibre weight. Addition of the fibres creates regions of stress concentration that require less energy to initiate a crack. The strength of the composites merely depend upon the different compositions of the filler and polypropylene.

IV. CONCLUSION

In the present study, the effect of fibre content on the mechanical properties of coir reinforced pp composites has been investigated. This experimental investigation leads to the following conclusions.

- For coir-PP composites, the values of tensile strength are initially increased up to 25% and then shown decreasing trend to 40% with further increases in coir content.
- It is to be noted that for coir-PP composites, the tensile strength values remained higher compared to that of neat PP.
- Other mechanical properties such as flexural strength and flexural modulusof coir reinforced PP composites are found to be much higher as increase of coir increases the hardness and stiffness.
- The addition of coir decreased the decomposition temperature and increasing the melting temperature.
- This suggests that due to the nature of coir the degradable studies can be studied which are helpful in biodegradable composites.
- Main functioning of the composite is reduction of plastic materials and also increasing of biodegradable nature.

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