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Mechanical Properties of Hybrid Pineapple /Coconut Sheath Fibre Reinforced Polyester Composites

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ABSTRACT

The tensile, flexural and impact properties of randomly oriented short Hybrid Pineapple /CoconutSheathFibre/polyester(PCSFP) composites are described for the first time in this work. Composites were fabricated using Hybrid Pineapple/CoconutSheathFibre /polyester(PCSFP) with varying weight percents of fibre. PCSFP composites showed a regular trend of an increase in properties with fibre weight percent until 10% and afterwards a decrease in properties for composites with greater fibre weight percent. Tensile tests revealed that the tensile strength was about 11MPa, the tensile modulus was 0.7 GPa and the elongation at break was between 1.26% and 10%. The flexural strength and modulus were estimated to be around 76 MPa and 7.9 GPa, respectively. Impact tests exhibited a strength of approximately 7.86 kJ/m2.The analysis of the tensile, flexural and impact propertiesof PCSFP composites displayed a optimum fibre weight percent of 10%, respectively

Keywords: *Pine apple Fibre, Coconut Sheath Fibre, Tensile Strength, Flexural Strength, Impact Strength*

1. INTRODUCTION

The composite technology of a polymer matrix reinforced with man-made fibers such as glass, Kevlar, carbon etc. has come of age especially with the advances in aerospace applications since 1950s. The developments in composite material after meeting the challenges of aerospace sector have cascaded down for catering to domestic and industrial applications. Composites, the wonder material with light-weight, high strength-to-weight ratio and stiffness properties have come a long way in replacing the conventional materials like metals etc. The material scientists all over the world focused their attention on natural composites reinforced with jute, sisal, coir, pineapple etc. primarily to cut down the cost of raw materials. Jute as a natural fiber has been traditionally used for making twines, ropes, cords, as packaging material in sacks & gunny bags, as carpet backing and, more recently, as a geo-textile material. But, lately, a major share of its market has been eroded by the advent of synthetic materials, especially polypropylene.

In order to save the crop from extinction and to ensure a reasonable return to the farmers, non-traditional outlets have to be explored for the fiber. Composites can be used as a substitute for timber as well as in a number of less demanding applications. Interest in using natural fibers as reinforcement in polymer matrices and also in certain applications as partial replacement of glass fibers has grown significantly in recent years for making low cost composite materials. Pothana et al. [1] analyzed the dynamic mechanical properties of banana fiber reinforced polyester

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composites with special reference to the effect of fiber loading, frequency and temperature. Rana et al. [2] fabricated natural fibres(sisal, kenaf, hemp, jute and coir) reinforced polypropylene composites processed by compression moulding using a film stacking method and analyzed the mechanical properties of the different natural fibre composites and compared. Idicula et al. [3] fabricated randomly oriented intimately mixed short banana/sisal hybrid fibre reinforced polyester composites and analyzed the dynamic and static mechanical properties of the natural fiber composites. Mathur [4] presented an overview of building materials from local resources with a particular attention on natural fibres based composites. Idicula et al. [5] investigated the thermal conductivity, diffusivity and specific heat of polyester/natural fibre (banana/sisal) composites as function of filler concentration and for several fibre surface treatments. K.J. Wong et al (6) studied the fracture behaviour of short bamboo fibre reinforced polyester composites is investigated.The matrix is reinforced with fibres ranging from 10 to 50, 30 to 50 and 30 to 60 vol.% at increments of 10 vol.% for bamboo fibres at 4, 7 and 10 mm lengths respectively. Fractured surfaces investigated through the Scanning Electron Microscopy (SEM) describing different failure mechanisms are also reported.

A.V. Ratna Prasad et al (7) were done experiments of tensile and flexural tests were carried out on composites made by reinforcing jowar as a new natural fibre into polyester resin matrix. The results of this study indicate that using jowar fibres as reinforcement in polyester matrix could successfully develop a composite material in terms of high strength and rigidity for light weight applications compared to conventional sisal and bamboo. V.S. Sreenivasan et al (8) presented the tensile, flexural and impact properties of randomly oriented short Sansevieria cylindrical fibre / polyester (SCFP) composites are described for the first time in this work. K. Ramanaiah et al(9) focussed study to utilize waste grass broom natural fibers as reinforcement and polyester resin as matrix for making partially biodegradable green composites. Thermal conductivity, specific heat capacity and thermal diffusivity of composites were investigated as a function of fiber content and temperature. V.S. Sreenivasan et al (10) presented to improve the interfacial bond between Sansevieria cylindrica fibres (SCFs) and polyester matrix, chemical surface treatments have been performed on the fibres. Treatments including alkali, benzoyl peroxide, potassium permanganate and stearic acid were carried out to modify the fibre surface and find out the mechanical properties. In the present work, There has been a growing interest in utilizing Hybrid natural fibers as reinforcement in polyester composite for making low cost materials in recent years.

Hybrid natural fiber are selected to hybridise and reinforce polyester matrix to develop cost-effective and high performance composites because these fibers are strain compatible. Fibers having high cellulose content and low microfibrillar angle possess high tensile properties. Hence better stress transfer from matrix to fiber takes place in natural fiber reinforced composites. Again it can be observed that the elongation at break of the two fibers are comparable. Hence stress is transferred from one fiber to another without failure of the matrix. So natural fibers can be selected to hybridise and reinforce polyester and a combination of properties of both the fibers can be achieved in the hybrid composites.An attempt was made to use raw PCSF as reinforcement in a polyester matrix. A detailed investigation was also carried out on randomly oriented short hybrid PCSFP composites, especially on the effect of varying fibre weight percent. The tensile, flexural and impact performance of these composites were analysed. The optimum fibre weight percent for short PCFP composites were identified and reported.

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2. EXPERIMENTAL

2.1MATERIAL

PCSFs were separated from Pineapple leaves,which is shown fig.1and coconut sheath is collected from Coconut tree which were collected from farms around the city of coimbatore, Tamil Nadu, India. The matrix used for the investigation was commercially available unsaturated polyester, trade name Satyan polymer. Methyl ethyl ketone peroxide [MEKP] and cobalt naphthenate were used as curing catalyst and accelerator.

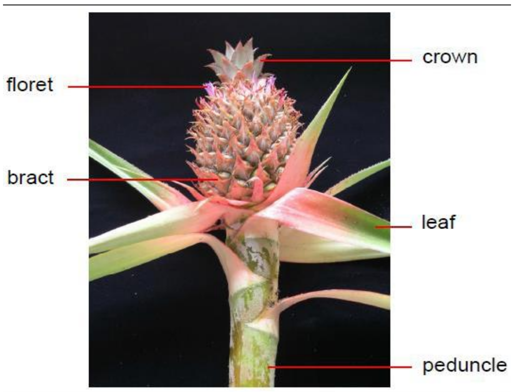

Fig.1 Coconut sheath and Pineapple leaves fibre plant

2.1 Preparation of Composite Specimen

The Hand layup Method was adopted for the fabrication of composites. The cleaned and dried PCSFs were chopped into lengths of 10 mm. A known weight of PCSFs of definite 10mm length of pineapple fibres was randomly spread in first layer and coconut sheath was kept in middle layer and finally 10mm length of pineapple fibres was randomly spread in final layer between two mild steel plates. Extreme care was taken to obtain a uniform distribution of fibres. A load of 10 kg was applied on the mild steel plates by compression to form a single sheet. This compressed sheet was placed in a mould with a size of 300mm x300mm x3mm. Then, 97.5% of unsaturated polyester resin was mixed with 2% MEKP (catalyst) and 0.5% cobalt naphthenate (accelerator). The prepared matrix solution was degassed before pouring. The degassed matrix solution was applied on the compressed sheet by using a brush, and air bubbles were removed carefully with a grooved roller. The mould was closed, and hydraulic pressure was applied until complete closure. The closed mould was kept under pressure for 24 h. The

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composites were fabricated in the form of a flat plate with a size of 300mm x 300mm x 3mm. Composite plates were prepared for fibre weights of 5%, 10%, 15%, in fibre length 10 mm.

2.3. Mechanical Tests

Test specimens were cut from the composite plates as per the ASTM standard [1,14,17]. Tensile testing was carried out in a FIE universal testing machine UTE-40 with a 400 kN capacity with a gauge length of 100 mm and a cross head speed of 1 mm/min, as per ASTM D 638-03. The three-point flexural properties were determined by an INSTRON universal testing machine 4301 with a 5 metric ton capacity, a gauge length of 50 mm and a cross head speed of 1 mm/min, according to ASTM D 790-86 . The Izod impact test was done on un notched specimens with a KARL FRANK GMBH 53568 impact testing machine with a pendellange of 390 mm. The impact test was carried out with an impact speed of 3.46 m/s and an incident energy of 2.75 J according to ASTM D 256-88. A minimum of five samples were tested in each case, and the average value is reported. All testing was conducted at ambient temperature (21 C) and a relative humidity of about 65%.

3. Results and discussion

3.1Tensile behavior

It is necessary to examine the suitability of pineapple fibre and coconut sheath (PCSF) as reinforcement prior to making of the composites. The tensile properties and density of fibre along with those of some important natural fibre are presented in table for better comparison. From the Table1 it is clearly evident that the tensile strength of pineapple fibre is better than those of all available fibre. The tensile modulus is much higher than that of elephant grass fiber, banana fibre. The percentage elongation at break is also much less than those of Elephant grass fibre and banana fibre. The density of pineapple fibre is lower than for established fiber like Elephant grass fibre and banana fibre which is an attractive parameter in manufacturing light weight material.

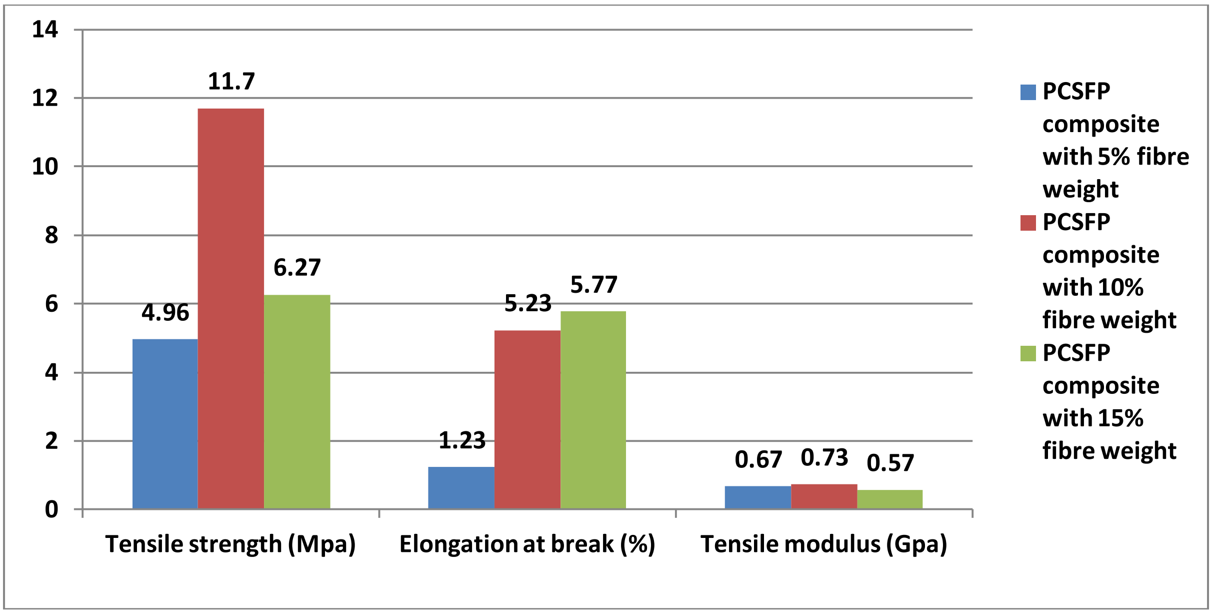

Fig. 2.Tensile properties of PCSFP composites at different fibre weight percents (constant fibre length (10 mm)).

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The behaviour is elastic in nature. However, the addition of fibres makes the matrix ductile, which is evident from the high elongation at break value of composites. It is also evident that for any given strain level, the stress increased with fibre weight percent up to 10% and then decreased, indicating an optimum fibre weight percent of 10% for short PCSFP composites.The influence of the fibre weight percent on the tensile properties of short PCSFP composites is shown from Fig.2. The tensile strength and Tensile modulus of PCSFP composites were found to increase with increasing fibre weight up to 10%, and then a decrease was found at higher fibre weight percents. The percentage elongation at break was very low in the cured pure polyester resin. The brittle nature of polyester resin decreased with the addition of PCSFPs; therefore, the elongation value increased with fibre weight percent. From the tensile behaviour of composites, a 10% fibre weight was found to be the optimum fibre weight percent for short PCSFP composites. At the optimum fibre weight percent, the load transmittance from the fibre to matrix was high. Thus, the composites exhibited high mechanical properties at the optimum fibre weight percent. From the tensile behaviour of short PCSFP composites, it was observed that the maximum tensile strength and modulus were around 11.70MPa and 0.7 GPa, respectively. The elongation at break 5.03%. This performance was produced by 10% weight (optimum fibre weight percent) fibre PCSFP composites.

3.2. Flexural Behaviour

The variation of flexural strength with the fibre weight percent of PCSFP composites with fibre length 10mm. The effect of fibre weight percent on the flexural properties of PCSFP composites was obtained from Fig 3.The flexural strength and modulus of short PCFP composites were found to increase with increasing fibre weight percent up to 10% and then decrease at higher fibre weight percent. From the flexural characteristics of PCSFP composites, it is observed that the maximum flexural strength and modulus were around 76.44 MPa and 7.9 GPa, respectively. PCSFP composites possessing 10% (optimum fibre weight percent) fibre weight marked the maximum flexural performance.

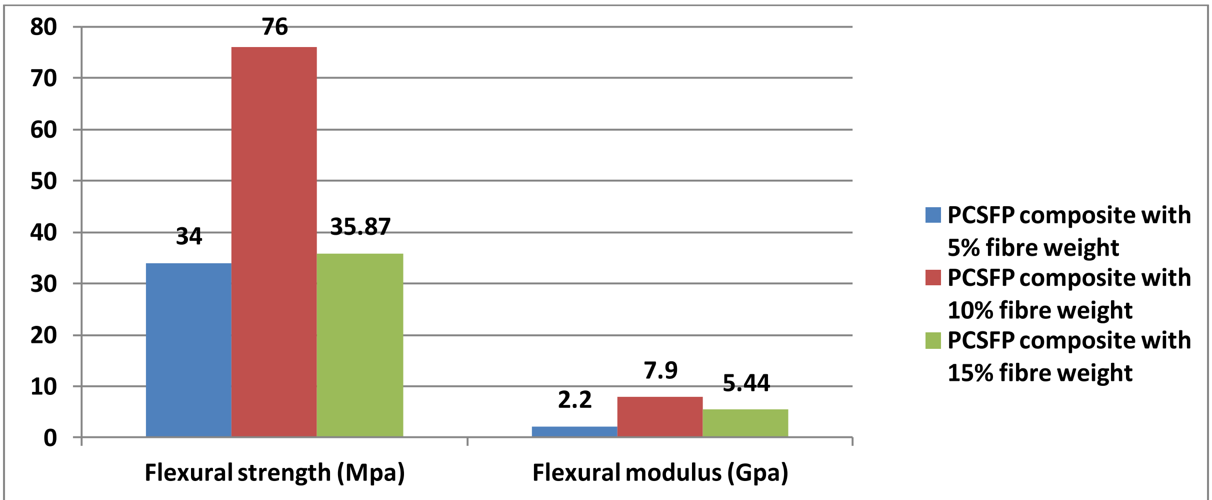

Fig. 3.Flexural properties of PCSFP composites at different fibre weight percents (constant fibre length (10 mm)).

3.3 Impact Behaviour

Fig.4 shows the variation of impact strength with fibre weight percent for PCSFP composites with constant fibre length 10mm. The impact strength of short PCSFP composites was found to increase with the weight fraction of fibres. When the fibre

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weight percent in PCSFP composites was increased greater than 10%, a slight decrease in impact strength occurred. The impact strength was found to decrease by a factor of 0.12 by increasing the PCSF weight from 10% to 15% when compared to PCSFP composites possessing a 15% fibre weight. From the impact behaviour of short PCSFP composites, it was observed that the maximum impact strength was around 7.86 KJ/m2.

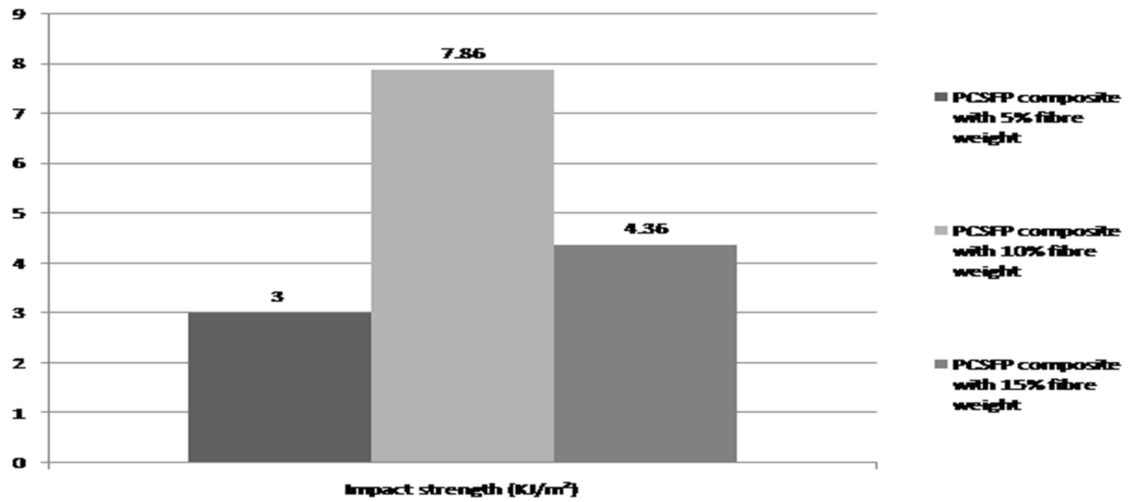

Fig. 4.Impact properties of PCSFP composites at different fibre weight percents (constant fibre length (10 mm)).

This maximum performance was produced by 10% (optimum fibre weight percent) weight of fibre PCSFP composites. Seenivasan et al. [8] found the impact strength of randomly oriented short Sansevieria cylindrica fibre/ polyester composites to be 3.5 J/cm2

6. Conclusion

Two major conclusions were drawn from the test results. First, the tensile, flexural and impact properties of randomly oriented PCSFP composites were found to be dependent on the fibre weight percent, indicating a optimum fibre weight percent 10%, respectively. Second, the tensile strength and modulus of PCSFP composites were around 11.86 MPa and 0.7 GPa, respectively. The elongation at break 5.03%. Flexural tests revealed that the flexural strength was approximately 76.44 MPa,and the flexural modulus was 7.9 GPa. The impact strength was estimated to be around 7.86 KJ/cm2.

7. ACKNOWLEDGEMENT

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