IOSR Journal of Engineering (IOSRJEN) www.iosrjen.org
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 07, Issue 10 (October. 2017), ||V2|| PP 30-35

Experimental Investigation And Comparative Analysis Of Mechanical Properties Of Rice Straw Fiber Composites

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Abstract: World is as of now concentrating on alternate material sources that are environment agreeable and biodegradable in nature. Because of the expanding natural concerns, bio composite produced out of regular fiber and polymeric resin, is one of the late advancements in the business and constitutes the present extent of experimental work. The purpose of this research work is to evaluate and comparative study of the mechanical properties of laminates prepared of different composition of rice straw (RS), an agricultural waste and natural fiber, and Polypropylene. The mechanical properties evaluated are tensile strength, flexural strength and impact strength. The density of each of the laminates and water absorption properties are also evaluated. Six laminates of banana and Polypropylene of dimension 64 x 12 x 9 mm3 is fabricated by Hot pressing at a temperature of 210°C and at pressure of 1100 kgf/cm^2. All the six specimens were developed for each weight fraction of corn fibre composites. Specimens were cut from the fabricated laminate according to the ASTM standard for different experiments for tensile test, flexural text and impact test. The incorporation of Rice Straw Fiber into the polypropylene matrix has resulted in a moderate improvement in the tensile, bending and impact properties of the composites. This work describes the mechanical behavior of RS fiber reinforced polymer composite with the references to the impact of fiber loading and volume of fiber on the properties of composites. Based on tensile, flexural and impact properties, 20% fiber weight fraction is the optimum value for Rice Straw fiber reinforced polypropylene composites.

Keywords: Natural Fiber, Rice straw, Composites, Strength.

Date of Submission: 22-08-2017 Date of acceptance: 09-11-2017

I. INTRODUCTION

Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form. A typical composite material is a system of materials composing of two or more materials on a macroscopic scale.

A composite material is composed of reinforcement embedded in a matrix. The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new combined material exhibits better strength than would each individual material.

Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The composite properties may be the volume fraction sum of the properties of the constituents or the constituents may interact in a synergistic way resulting in improved or better properties. Apart from the nature of the constituent materials, the geometry of the reinforcement influences the properties of the composite to a great extent. The concentration distribution and orientation of the reinforcement also affect the properties.

Concentration determines the contribution of a single constituent to the overall properties of the composites. It is not only the single most important parameter influencing the properties of the composites, but also an easily controllable manufacturing variable used to alter its properties. The orientation of the reinforcement affects the isotropy of the system

II. LITERATURE SURVEY

Jute is a fibre obtained from the various species of Corchorus [1]. Jute fibre reinforced plastic composites have been investigated for their performance. The physical properties of Jute reinforced thermo sets, and influence of surface treatment and environment on them are studied [2]. Thermoplastics, bipod degradable Polyester [3], Polypropylene [4], Polyethylene [5] etc. are reinforced with Jute fibre. The resultant composites are tested for mechanical, hygroscopic, thermal and electrical properties.

It was found that 24 wt % of such MAPP being used in the composite formulation, the mechanical properties of the composites such as tensile modulus, the tensile strength and the impact strength all increased significantly [6].

The banana fibres are suitable for manufacturing strings, ropes, cords, cables, packing fabrics as well as mats and rugs. The impact strength have been found to be higher in malefic-anhydride treated fibre composites than the untreated fibre composites.Banana fibre composites shoe increment in impact strength up to 45 % fibre content only thereafter it decreases. MA treated fibre composites show higher impact strength than the respective untreated fibre composites. The order of impact strength is same in both MA treated and untreated respective fibre composites [7].

Tests were conducted and it was found that impact strength gave the maximum value for 40 mm fibre length [8]. Incorporation of 40 % untreated fibres gave a 34 % increase in impact strength.

The mechanical properties of composites consisting of high density Polyethylene (HDPE) and oil palm fibrous wastes that is empty fruit bunch (EFB) have been investigated and impact strength decreases with increase in filler loading [9].

Epoxy resins were chemically modified with carboxyl terminated Polyethylene glycol adulate (CTPEGA). It was observed that impact strength gradually increases with increasing CTPEGA concentration attain a maximum and then decrease [10].

It was observed that the composites filled with larger sized filler showed higher impact strengths [11]. Epolyene (E-43) was observed to improve impact strength of the composites [12].

Flax fibres with different moisture content were used as reinforcement inPolypropylene matrix with malice anhydride grafted polypropylene couplingagent. It was observed that by decreasing moisture content of fibre impact strengthcan be improved but using PPGMA as coupling agent impact strength is decreased [13].

The transverse perforation impact behavior of flax material reinforced polypropylene (PP) composites provided with additional discontinuous a cellulose(L) and discontinuous glass fibre (G) material was investigated and found that the resistanceto perforation impact of the PP/Flax composite was strongly improved by the hybridizationwith L and G fibres. [14].

It was found that the woven flax fibre results in composites with better impact strengths than the woven jute fibres based composites. Impact properties such as loss energy and damping index were found to be almost linearly dependent on void content and impact energy [15].

It was found that both Izod and charpy Impact tests reflect that the composites with bleached silvers have higher impact strengths, in comparison to composites with control silvers[16].

The notched Impact energy where the performance of the wet formed composite exceeded the melt-blended composite [17]. It was found that the impact properties were moderately increased for those composites with fibre loadings up to 45 %.

Acetylated EFB (empty fruit bunch) and coir composites shown superior detention of impact properties after ageing in water up to 12 months [18]. The work of fracture of composites with 30 wt % fibre loading was found to be 168 % more than virgin PP. [19]

Annual crop fibres are a cheaper and more rapidly renewable source of cellulose-rich fibre [21] with a renewal time of one year as against at least thirty years for softwoods, and their full potential as a polymer reinforcement has yet to be achieved. However, annual crop fibres such as jute and by products such as sugar cane biogases [22] have been used as fibrous reinforcement in composites.

Sisal fibre reinforced polypropylene (SF/PP) composites was investigated [27]. Concerning injection molding of sisal fibre reinforced polypropylene (SF/PP) composites, the problems encountered are (i) increased melt flow viscosity as sisal fibres were introduced and (ii) poor interfacial bonding between sisal fibre and PP. Some studies [28] have indicated that malefic anhydride can serve as an effective compatibilizer for cellulosic fibre and polyolefin matrices. By using a malefic anhydride grafted polypropylene (MA-g- PP) as the compatibilizer for SF/PP composites, the melt blending torque could also be reduced.

A pre-impregnation technique for the injection molding of sisal fibre reinforced polypropylene (PP/SF) composites was introduced [29].

The natural composite materials have more elastic strain energy storage capacity and high strength capacity and high strength to weight ratio compared to metals. The jute can replace the existing steel in the leaf springs [30].

III. PROBLEM STATEMENT

Natural fibres have played a significant role in human civilization since prehistoric times. The human beings depend on them for garments and other simple domestic uses as well as complex applications such as land dwellings and reed-built sailing craft etc. Modern technological innovations producing synthetic fibres with a wide selection of desirable properties by manipulations of the condensation of short-or-long-chain polymers compete with and in some cases, surpass the production of vegetable fibres in many countries.

The research has emphasized synthetic fibre innovations offered by an advancing technology. However, the research to improve the productivity, application and quality of natural fibres has comparatively lagged behind. Most of the natural reinforced composites are cheaper than synthetic fibre reinforced composites. It will be cost effective to replace the costly and scarce wood used for building construction and furniture, and help to conserve the forests and thereby protect the environment.

The proposed research work is intended to exploit the advantages of using natural fibres as reinforcement material in composites. The work provides basic understanding of the behaviour and response of new natural fibres and lightweight materials.

IV. FABRICATION OF COMPOSITE SPECIMEN

The culms of rice Straw were cut at their base and were dried in shade for a period of three weeks. The hollow cylindrical portion of culms was taken for extracting fibre and made into four strips peeling them in longitudinal direction. The extracted fiber was then chopped to a length of 3 mm.

Proper proportion of fibres (0, 5, 10, 15, 20 and 25%) by weight and polypropylene pellets were then properly mixed to get a homogeneous mixture. The mixture was then placed in a 2tonne plastic hydraulic plastic Injection Moulding Machine. At a temperature of 210° C and at pressure of 100N/mm^2, all the five specimens were developed for each weight fraction of fibre composites. Percentage of fiber in the composite is maintained by its weight fraction.

Test specimens with different weight fractions starting from 5% to 25% with regular intervals are made to standardize the results of testing. Five specimens are prepared for each weight fraction.

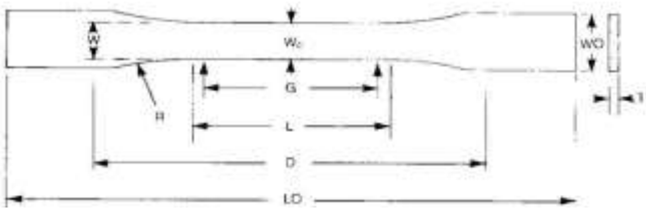


Fig 1a: Tensile test Specimen as Per ASTM Standards

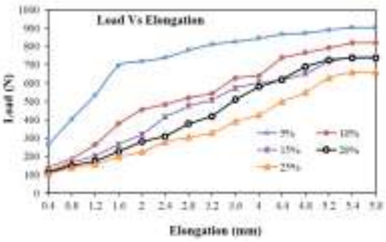
Fig 1b Injection Moulding Machine

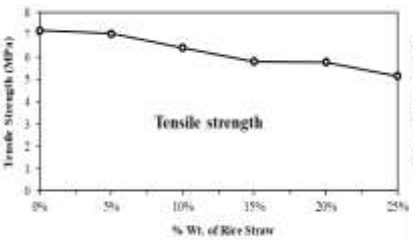
V. EXPERIMENTAL PROCEDURE

An Electronic tensometer of 2 ton capacity is used to find the tensile strength of composites. Its capacity can be changed by load cells of 20Kg, 200Kg & 2000 Kg. A load cell of 2000 Kg. is used for testing composites. Self-aligned quick grip chuck is used to hold composite specimens. A digital micrometer is used to measure the thickness and width of composites. The gauge length, thickness and width are measured with 0.001 mm least count digital micrometer. The specimen was held in fixed grip and the movable grip is manually moved until the specimen is held firmly without slackness. The movable chuck is further moved such that the load indicator just starts giving indication of loading on the specimen. At that instant the extension meter is adjusted to read zero, when the load on the specimen is zero. Starting from zero, at every 0.5 mm extension the load indicated are noted until the specimen breaks. Three point bend tests are performed in accordance with ASTM D790M test method to measure flexural properties. The samples are tested for each composition. The three point bend test requires less material for each test and eliminates the need to accurately determine the center point deflection with test equipment. n Izod / Charpy impact test machine was used to test the impact properties of composite specimens. Standard test method, ASTM D256-97, for impact properties of fibre reinforced composites has been used to test the unidirectional composite specimens. A V-notch is provided with a sharp file having an included angle of 450 at the centre of the specimen, and at 900 to the sample axis.

VI. RESULTS AND DISCUSSION

The composites are moulded with polypropylene resin matrix and reinforced with different weight fractions (0.5, 10, 15, 20, and 25 %) of Rice Straw fiber. Five specimens are prepared for each weight fraction and are tested as per the methods given in previous Chapter and the results are plotted in the graphs and discussed below. The results of tensile test for five specimens of Rice Straw PP composites for each weight fraction are shown in Fig.2. Average tensile strength and modulus are calculated. The tensile strength and tensile modulus of the pure polypropylene are 7.181 MPa and 1.33 GPa, respectively. They varies with addition of the Rice Straw as in Fig 6.2b, 6.3c. The flexural strength decreased with fiber loading up to 15% weight fraction of the fiber, and there was a increment after 15% fiber loaded composites. The bond between fiber and matrix often dictates whether the fiber will improve the properties of composites by transferring the applied load. The load transfer between matrix and fibers in a composite is not only determined by the intrinsic properties of the fiber and matrix, but also affected by the geometric parameters and fiber arrangement within the matrix such as fiber distribution. Figure shows the Flexural Modulus as a function of % weight fraction of the fiber for rice straw fiber composites.





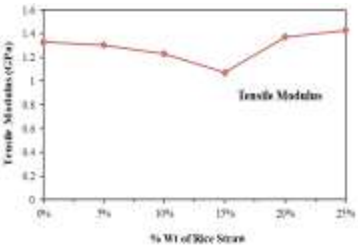
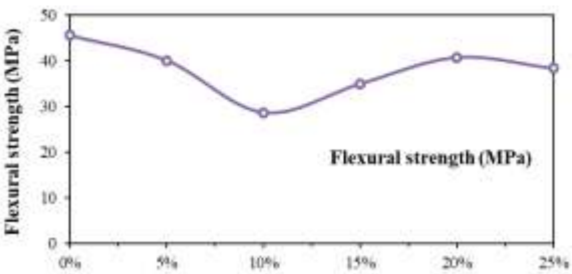


Fig 2 a Fig 2 b Fig 2 c

Fig .2 (a) Load Vs Elongation for mixture of Rice Straw /PP composites. (b) Tensile strength Vs Percentage Weight of Rice Straw
(c) Tensile Modulus Vs Percentage Weight of Rice Straw



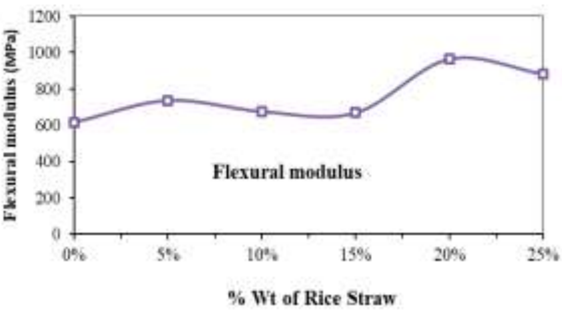


Fig 3 a Fig 3 b

Fig 3 a. Flexural strength Vs Percentage Weight of Rice Straw b. Flexural Modulus Vs Percentage Weight of Rice Straw

The Impact Strength of the pure polypropylene is 26.7 J/m. The average impact strength of five specimens at different fiber weight fraction for Rice Straw reinforced polypropylene composites is shown in Fig.4. It is observed that the impact strength decreases with the increase in the fiber content up to 15% weight fraction of fibers and then increases. The energy dissipation mechanisms operating during impact fracture are matrix and fiber fracture, fiber-matrix debonding and fiber pull out. Fiber fracture dissipates lesser energy compared to fiber pull out and is the common mechanism of fracture in fiber reinforced composites.

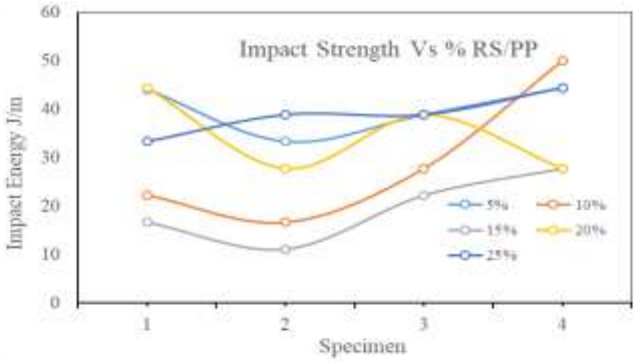


Fig 4: Variation of Impact Strength in % Rice Straw /PP composites.

VII. CONCLUSION

The incorporation of Rice Straw Fiber into the polypropylene matrix has resulted in a moderate improvement in the tensile, bending and impact properties of the composites. It has been observed that the pure polypropylene has got a tensile strength of 7.181MPa and there is a decrease in tensile strength for increase in the weight fraction of rice straw fiber PP matrix.

The tensile modulus of pure polypropylene is 1.33 GPa. It is observed that the tensile modulus decreases up to a fiber weight fraction of 20% and a maximum tensile modulus of 1.42 GPa is obtained at 25% of rice straw/PP composites

The flexural strength for pure polypropylene is 45.53 MPa and the maximum flexural strength of the rice straw fiber polypropylene composite is 40.71 MPa occurring at 20% fiber fraction.

The flexural modulus of pure polypropylene is 615.65 MPa and is observed that the maximum flexural modulus of the rice straw fiber polypropylene composite is 963.34 MPa occurring at 20% fiber fraction.

The impact strength of pure polypropylene is 26.66J/m and the Impact strength of 34.71 J/m is noted at 20 weight % of rice straw fiber PP composite

Based on tensile, flexural and impact properties, 20% fiber weight fraction is the optimum value for Rice Straw 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 Rice Straw as filler to the matrix.

VIII. CONCLUSION

The future work will investigate the performance of other lower cost resin systems, particularly polypropylene resins. There may be chance of improvement in the mechanical properties of Rice Straw composites by chemical treatment of fibers and by changing the length of the fibers. Other natural fibers can be explored and tested for mechanical properties of those fiber polypropylene composites.

REFERENCES

[1] Vithal Babu V and G. N. Nagar, "Survey on Indian‟s export potential of polymer of Palmyra fiber and allied products in UK, USA and Japan," Indian Institute of Foreign Trade, New Delhi, 1972, pp73-75.

[2] Samir Abdul Azim M, "Palm tree fronds for concrete roof reinforcement", Concrete International, The American Concrete Institute Magazine, Vol 14, n 12, 1992.

[3] Cook D. J, "Concrete and cement composites reinforced with natural fibers", Proceedings of Symposium on Fibrous Cements, London, April 1980.

[4] Samir Abdul-Azim M, "Development of prototype structure for low - cost and energy efficient house by utilizing palm tree fronds", Building and Environment, Vol 32, n 4, 1997, pp 373-380.

[5] Olfat Y. Mansour, El-Hady B. A, Ibrahim S. K and Goda M, "Lignocellulose -Polymer composites. V", Polymer - Plastics Technology and Engineering, Vol 40, n 3, 2001, pp311-320.

[6] S. Mishra, J.B.Naik, Y.P.Patil,"The compatibility effect of Maleic anhydride on swelling and mechanical properties of plant fiber reinforced novolac composites", Composite science and technology 60(2000) 1729-1735.

[7] Z.A.Mohd Ishak, A.Aminullah, H.Ismael, H.D.Rozman, "Effect of silage based coupling agents and acrylic acid based compatibilisers on mechanical properties of oil palm empty fruit bench filled high density polyethylene composites" Journal of applied polymer science vol 68, 2189-2203 (1988).

[8] D.Ratha. A. B .Samui and B.C.Chakraborthy, Flexibility improvement of Epoxy resin by chemical modification", 2004 society of chemical industry poly int 0959-8103/20004.

[9] Zaini M.J, Fuad M.Y.A, Ismail.Z, Mansor. M. S, Mustafah.J, "Effect of filler content and size on the mechanical properties of polypropylene oil palm wood flour composites". Polymer international v40 n 1 may 1996 p 51-55.

[10] Rozman.H.D, Lai.C.Y, Ismail.H, Mohd Ishak.Z.A, "Effect of coupling agents on the mechanical and physical properties of oil palm empty fruit bunch poly propylene composites", Polymer international v 49 n 11 nov 2000 p 1273-1278.

[11] Pothan Laly.A, Thomas Sabu, Neelakantham N.R, "Short banana fiber reinforced Polyester composites: Mechanical, Failure and aging characteristics", Journal of Reinforced plastics and composites v 16 n 8 1997. p 744-765

[12] Hargitai.H, Racz.I, "Influence of water on properties of cellulose fiber reinforced polypropylene composites", International journal of polymeric materials v 47 n 4 2000 p 667-674.

[13] Benevolenski O.I, Karger-Kocsis.J, Mieck.K.P, Reubmann.T, "Instrumented perforation impact response of poly propylene composites with hybrid reinforcement flax/glass and flax/ cellulose fibers", Journal of thermoplastics composite materials v 13 n 6 Nov 2000.

[14] Muenker Michael, Holtmann Robert, Michaeli Water, "Improvement of the fibre / matrix-adhesion of natural fibre reinforced polymers", International SAMPE symposium and exhibition (proceedings) v 43 n 2 1998.

[15] Sebe Gilles, Cetin Nihat.S, Hill Callum A.S, Hughes Mark, "RTM hemp fibre reinforced polyester composites", Applied composite materials v 7 n 5-6 Nov 2000 p 341-349.

[16] Mishra H.K, Dash B.N.Tripathy S.S, Padhi B.N, "Sudy of mechanical performance on jute epoxy composites", Polymer-plastics technology and Engineering n 39 n 1 2000. p 187-198.

[17] D.K.Miller, Appl.Polym.Symp,28(1975)21

[18] K.K.Chawala and A.C.Bastos, Mechanical behaviour of materials

[19] J.Harris, Eng. Mater.Des.14 (1971)583.

[20] E.C.Mcclaughlin, J.Mater. Sci.15 (1980) 886.

[21] Straw-reinforced polyester composites, Journal of material science 18(1983) P no.1549-1556

[22] http://www.blueplanetbiomes.org/elephant_grass.htm

[23] Drzal, L.T., Mohanty, A.K., Burgueño, R. and Misra, M. (2003). Biobased Structural Composite Materials for Housing and Infrastructure Applications:Opportunities and Challenges. Composite Science and Technology. 63: 129-140.

[24] Herrera-Franco, P.J. and Valadez-González, A. (2004).Mechanical Properties of Continuous Natural Fibre Reinforced Polymer Composites. Composites - Part A: Applied Science and Manufacturing. 35: 339-345

[25] Rozman, H.D., Tay, G.S., Kumar, R.N. A.Abubakar. H. Ismail and Mohd. Ishak, Z.A.(1999). Polypropylene Hybrid Composites: A preliminary Study on the Use of Glass and Coconut Fiber as Reinforcements in Polypropylene Composites. Polymer-Plastics Technology and Engineering. 38(5): 997-1011.

[26] Mubarak A. Khan and Idriss Ali, K.M. (1999). Characterization of Wood and Wood-Plastic Composite. Polymer-Plastic Technology and Engineering. 38(4): 753-765.

[27] H. A. Rijsdijk, M. Contant & A. A. J. M. Peijs, "Continuous glass fibre reinforced polypropylene composites: I. Influence of maleic anhydride modified polypropylene on mechanical properties". Composites Science and Technology. 48:161-172.

[28] Joseph K, Joseph P.J, Thomas S, "Effect of processing variables on the mechanical properties of sisal-fiber-reinforced polypropylene composites". Composites Science and Technology. 59: 1625-1640.

[29] Fung KL, Li RKY, Tjong SC. Interface modification on the properties of sisal fibre reinforced polypropylene composites. Journal of Applied Polymer Science.85:169-76.

[30] V R Kumar, R L Narayana, Ch Srinivia, "Analysis of Natural Fiber Composite Leaf Spring", IJLTET, vol:3, Issue: 1, Spetember 2013, pp: 182-191.

[31] Tjong SC, Xu Y, Meng YZ. Composites based on maleated polypropylene and methyl cellulosic fiber: Mechanical and thermal properties. Journal of Applied Polymer Science; 72:1647-1653.

[32] Li TQ, Ng CN, Li RKY. Impact behavior of sawdust/recycled-PP composites. Journal of Applied Polymer Science.81:1420-1428.

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