International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 07 | July -2017 www.irjet.net p-ISSN: 2395-0072

STUDY OF PROPERTIES OF POLYPROPYLENE-NATURAL FIBER COMPOSITE

RAKESH KUMAR GUPTA[1], MOHD ZIAULHAQ[2]

[1]*M.Tech Scholar, Mech. Engg. Deptt., Azad Institute of Engineering & Technology,Lucknow,Uttar Pradesh,India*
[2]*Asst.Prof.-Mechanical Engg. Deptt., Azad Institute of Engineering & Technology,Lucknow Uttar Pradesh.India*

Abstract : *Recently, Jute, coir fibre is being used as a reinforcement material in the development of reinforced plastics for various engineering applications. Its biodegradability, low cost, and moderate mechanical properties make it a preferable reinforcement material in the development of polymer matrix composites. Therefore, Jute, coir fibre reinforced composites have replaced the most widely used synthetic fibre (glass, kevlar) reinforced composites in many applications. In the present experimental endeavour, Jute coir fibre-polypropylene reinforced composites were prepared using hot press technique process. The weight percentage of the fibre reinforcement was varied as 5, 10 , 15 and 20%. The effect of the weight percentage of the Jute, coir fibre reinforcement was investigated experimentally on the mechanical properties of the developed composites. Jute and coir fibers were utilized at a ratio of (1:1) during composite manufacturing. Tensile, flexural, impact and hardness tests were conducted for mechanical characterization. The results reveal that, the mechanical properties of polypropylene based composites are substantially improved on account of the addition of the Jute fibre reinforcement. It has also been observed that the significance of the enhancement of the mechanical properties increased as the weight percentage of the Jute, coir fibre reinforcement increased up to 20%. Tensile, flexural, impact and hardness tests were conducted for mechanical characterization. Tensile test of composite showed a decreasing trend of tensile strength and increasing trend of the Young's modulus with increasing fiber content. During flexural, impact and hardness tests, the flexural strength, flexural modulus, impact strength and hardness were found to be increased with increasing fiber loading. Based on the fiber loading used in this study, 20% fiber reinforced composite resulted the best set of mechanical properties.*

Keywords: Mechanical Properties; Coir, Jute, Polypropylene, Hybrid Composite

1. INTRODUCTION

Technological development mostly depends on advancements in the field of engineering materials. Conversely, in any field of endeavour, the final hurdle, facing constant advancements, is with materials. Composite materials in this regard represent nothing less than a giant step in the ever constant effort toward optimization in materials,Chawla (1998). Currently, the lightweight of composites that allows for lower fuel consumption has increased their use in a broad range of applications, including in the aerospace, automotive, and rail sectors. In the aerospace industry, the current emphasis on fuel efficiency favors the use of polymer matrix composites (PMCs) instead of aluminum and its alloys. Also, the production of a new class of aircraft - micro-jets – has called for an extensive use of lightweight composites. In the automotive industry, manufacturers are recognizing the advantages of weight reduction, parts consolidation, and design freedom that PMCs afford,Mazumdar (2002);Brostow*et al.* (2010).

So far, most of the PMC materials used in different sectors are principally fabricated using thermosetting matrices. However, thermosets have inherent

disadvantages such as brittleness, long cure cycles, and difficult to repair and recycle damaged parts. These limitations led to the development of the thermoplastic matrix composite system. Compared with thermosets, composites fabricated from thermoplastic materials typically have more shelf life, greater strain to failure, rapid consolidation, excellent chemical resistance, better damping characteristics, low noise emission, and are repairable. Polypropylene (PP) is one of the most extensively used thermoplastic in industry due to its high chemical and wear resistance, low cost, easy process-ability and excellent mechanical properties, Mukhopadhyay and Srikanta (2008); Chand and Dwivedi (2006). Natural fibres become superior alternatives of synthetic fibres as reinforcements for polymeric composites due to their high flexural modulus and impact strength. In addition, natural fibers are environmentally friendly, biodegradable, abundantly available, renewable with low density and cheap. The biodegradability of natural fibres can contribute to a healthy ecosystem while their low cost and high performance fulfils the economic benefits of industries. Applications of natural fiber based polymeric composites are found in such products as housing construction materials, furniture, and automotive parts,Larbig*et al.*(1998);Eleiche and Amin(1986);Nirmal*et al.* (2010); El-Tayeb(2008). Pineapple leaf, oil palm fibre, hemp, sisal, Jute, kapok, rice husk, bamboo, and wood are some of the natural fibres most commonly used as reinforcement materials in polymer composites, Gujjala*et al.* (2013).Among all the plant fibres, Jute appears to be the most useful, and inexpensive fiber, that can be moulded to different shapes,Zaman*et al.*(2010). However, it has a downside that may pale these advantages: Jute fibre shares the major weakness of all natural fibres such as low thermal resistance, hygroscopic in nature, inherent polarity, less dimensional stability, and anisotropic fibre properties. These disadvantages cause in weak fibre-resin interaction,Khan*et al.*(2013).

2. MATERIALS AND EXPERIMENTAL DETAILS

2.1 Materials

A commercial grade polypropylene (PP), coir and jute were used in this study. All of them were collected from the local market. The (fig.1) was write in colour and granular in from having a melting point of 160^{0}C. jute fiber was extracted from coconut and also the. The die use to prepare composite was made of aluminium.

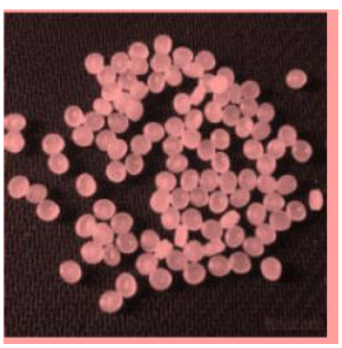


Fig.1 Image of Polypropylene(PP) Granules.

2.2 Manufacturing of Composites

Hybrid composite of polypropylene matrix and varying amount of coir and jute fiber were manufactured using hot press technique in a 2.54cm X 18.8cm X 0.8cm die as mentioned in the previous section. A hydraulic type machine having maximum load of 35kN and maximum temperature of 300^{0}C was utilised. The fiber loading was varied at 5, 10,15, and 20 wt% with the ration of jute to coir of 1:1. Fiber went cut to 3-5mm length. Firstly required amount of fiber and PP were weighed in a balance. Then to allow the removal of moisture, fiber and polypropylene were dried in an oven80^{0}for 20 minutes before preparing each composite. in some case they were mixed properly in a container by applying heat from a hot plate. The application of heat (much below the melting point of PP) during mixing enable the fiber to adhere with the PP granules. Since no additional adhesive had been used. The fiber and PP mixture was then placed inside the die. The fiber matrix mixture was allowed to press at 30kN pressure. The temperature was initially raised to 160^{o}C and hold there for around 12-15 minutes, after that the temperature was raised to (180-185)^{0}C depending on the thickness required. The die was cooled to room temperature, pressure was released and the composite were withdrawn from the die. Since compression temperature was higher than the melting point of PP (160^{0}C), the matrix melted but the fiber (melting point>220^{0}C), the matrix melted but the fiber (melting point>220^{0}C) remained intact.

2.3 Mechanical Properties Testing

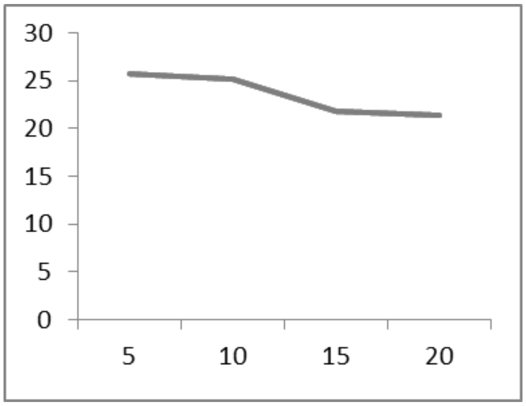
Tensile, Impact and hardness tested were carried out. In each case ,five sample were tested and average values were reported. Tensile tests were conducted according to ASTM D 638-01 using a universal testing machine at a crosshead speed of 4mm/min. Each test was continued until tensile failure. Static flexural test were carried out according to ASTM D 790-00 using the same Testing machine mentioned above at same crosshead speed . The dynamic charpy impact test of the composite was conducted using an impact tester MT 3016 according to ASTM D 6110-97. The hardness of the composite of was measured using a shore hardness testing machine.

3. RESULTS AND DISCUSSION

This chapter presents the mechanical properties of the Jute , Coir filled Polypropylene composites. .prepared for this present investigation. Details of processing of these 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, flexural strength, impact strength and hardness has been studied and discussed. The interpretation of the results and the comparison among various composite samples are also presented.

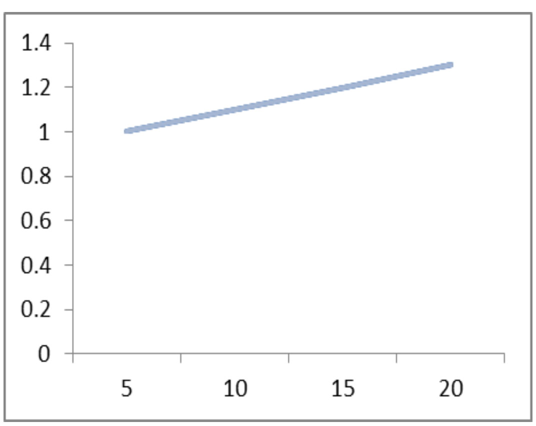
3.1 Tensile Strength

Tensile properties of the composite sample were measured for each fiber constant (5 10 15 and 20 %) with the help of stress / strain curve. The tensile strength of raw coir and jute fiber reinforced hybrid polypropylene composite at different fiber loading is shown in fig.2.The tensile strength decreased with an increase in fiber loading. As the fiber loading increased. The interfacialarea between the fiber and matrix increased. Which was weak because of worsening bonding between cellulose based hydrophilic filler (jute and coir) and hydrophobic matrix. The onsequently decreased the tensile strength,the same trend was also observed byOther researchers [15]-[18].



Fiber %
Fig. 2.Variation of tensile strength at different fiber content.

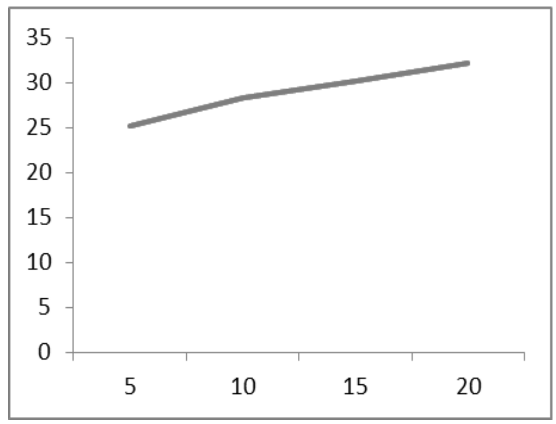
The Young's modulus values of Jute, coir fiber reinforced polypropylene composites for different fiber loading are shown in "Fig.3". It is observed that the Young's modulus increased with an increase in fiber loading [6] [9] . This is because with an increase in fiber content, the brittleness of the composite increased and stress/strain curves becomes steeper. Poor interfacial bonding creates partially separated micro spaces which obstruct stress propagation between the fiber and the matrix [17]. As the fiber loading increases, the obstruction increases, which in turn increased the stiffness.



Fiber %
Fig. 3. Variation of Young's modulus at different fiber content.

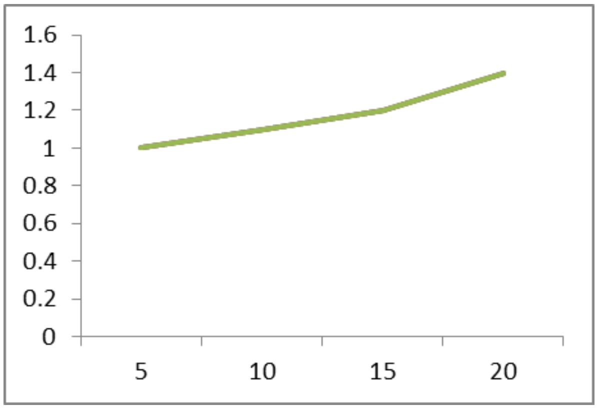
3.2 Flexural Properties

Flexural properties (Flexural strength and flexural modulus) were measured for samples of each fiber content (5, 10, 15 and 20 wt %) with the help of flexural stress/strain curves and respective equations. The flexural strength of raw coir and jute fiber reinforced hybrid polypropylene composites at different fiber loading, is shown in "Fig. 4". The flexural strength increased with an increase in fiber loading which was in agreement with the findings by other researchers [8 9 16] . This may be due to the favourable entanglement of the polymer chain with the filler which has overcome the weak filler matrix adhesion with increasing filler content [18] .



Fiber %
Fig. 4. Variation of flexural strength.

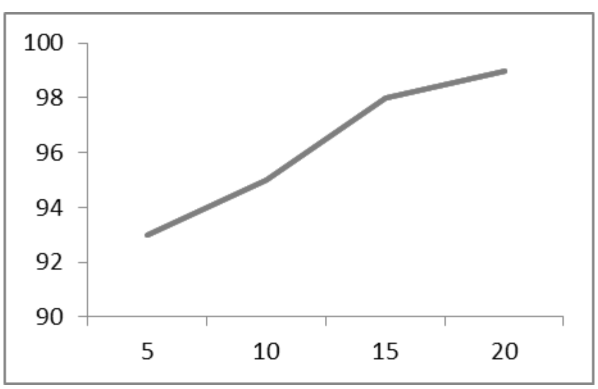
The flexural modulus values of raw coir and jute fiber reinforced hybrid polypropylene composites at different fiber loading is shown in "Fig. 5" the flexural modulus increased with an increase in fiber loading [6]-[8],[16]. Since both coir and jute are high modulus material, higher fiber concentration demands higher stress for the same deformation [18]. So the incorporation of the filler (rigid coir and jute) into the soft polypropylene matrix results into the increase in the modulus.



Fiber %
Fig. 5. Variation of flexural modulus at different fiber content.

3.3 Impact Strength

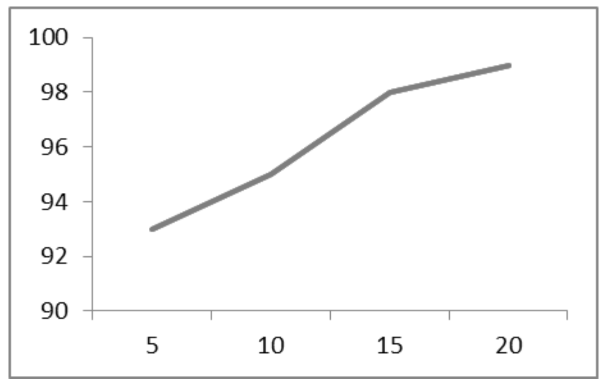
Variation of the Charpy impact strength with fiber loading for coir and jute fiber reinforced hybrid composite is shown in Fig. 6". Impact strength increased with fiber loading [10],[15], [17], [19]. Impact strength of a material provides information regarding the energy required to break a specimen of given dimension, the magnitude of which reflects the materials ability to resist a sudden impact. The impact strength of the fiber reinforced polymeric composites depends on the nature of the fiber, polymer and fiber–matrix interfacial bonding [20]. As presented in the figure, impact strength of all composites increased with fiber loading. This result suggests that the fiber was capable of absorbing energy because of favourable entanglement of fiber and matrix. Fiber pull out is found to be an important energy dissipation mechanism in fiber reinforced composites [21]. One of the factors of impact failure of a composite is fiber pull out. With the increase in fiber loading , stronger force is required to pull out the fiber . This in turn increased the impact strength.



Fiber %
Fig. 6. Represents Variation of different fiber content.

3.4 Hardness test

Hardness of the composite depends on distribution of of the filler into matrix [2] [15]. Usually presence of a more flexible matrix causes the resultant composite to exhibit lower hardness. As shown in fig. 7 , incorporation of fiber into the PP matrix has reduced the flexibility of the matrix resulting in more rigid composite. Due to the increase of stiffness of respective composite the hardness of jute , coir hybrid PP composite showed a Slight increasing trend with an increasing in the fiber content [2]. Better dispersion of the filler into the matrix with minimization of void between the matrix and the filler also enhance hardness[22].



Fiber %
Fig.7. Represents Variation of hardness at different fiber content

4. CONCLUSION

In the present work, jute and coir hybrid fiber reinforced PP composites were manufactured using hot press machine. The level of fiber loading was varied at 5, 10, 15 and 20 wt% with jute coir ratio of 1:1. The tensile

strength of the composites decreased with an increase in fiber loading. Whereas, the Young's modulus increased with fiber loading. Flexural strength, flexural modulus, charpy impact strength and average hardness values increased with an increase in fiber loading. Scanning electron microscopic analysis indicated strongest adhesion between the fiber and matrix when 20% fiber was reinforced into polypropylene polymer. As a result 20% fiber composite yielded the best set of mechanical properties compared to other composites. Basically these composite can be further modified by treatment of the fiber and improving fiber matrix interbonding.

REFERENCE

[1] T. W. Chou, Micro Structural Design of Fiber Composite, University of Delaware, USA, pp. 231-284.

[2] H. G. B. Premalal, H. Ismail and A. Baharin, "Comparison of the mechanical properties of rice husk powder filled polypropylene composites with talc filled polypropylene composites", Poly. Test., Vol. 21, pp. 833-839, 2002.

[3] C. J. Wolf, Encyclopedia of Chemical Technology, Vol. 7, UK, 1998.

[4] A. K. Rana, A. Mandal, B. C. Mitra, R. Jacobson, R. Rowell and A. N. Banerjee, , "Short jute fiber reinforced

polypropylene composite: Effect of compatibilizer", J. App. Poly. Sci., Vol. 69, pp. 329-338, 1998.

[5] M. M. Thwe and K. Liao, "Effects of environmental aging on the mechanical properties of bamboo-glass fiber reinforced polymer matrix hybrid composites", Comp. A, Vol. 33, pp. 43-52, 2002.

[6] H. S. Yang, H. J. Kim, J. Son, H. J. Park, B. J. Lee and T. S. Hwang, "Rice-husk flour filled polypropylene composites; mechanical and

morphological study", Comp. Stru., Vol. 63, pp. 305-312, 2004.

[7] C. W. Lou, C. W. Lin, C. H. Lei, K. H. Su, C. H. Hsu, Z. H. Liu and J. H. Lin, "PET/PP blends with bamboo charcoal to produce functional composites", J. Mat. Pro. Tech., Vol. 192-193, pp. 428-433, 2007.

[8] A. K. Rana, A. Mandal and S. Bandyopadhyay, "Short jute fiber reinforced polypropylene composites: effect of compatibilizer, impact modifier and fiber loading,", Comp. Sci. Tech., Vol. 63, pp. 801-806, 2003.

[9] S. Joseph, M. S. Sreekala, Z. Oommen, P. Koshy and S. Thomas, "A comparison of mechanical properties of phenol formaldehyde composites reinforced with banana fibers and glass fibers", Comp. Sci. Tech., Vol. 62, pp. 1857-1868, 2002.

[10] K. Ajay, S. S. Chauhan, J. M. Modak and M. Chanda, "Mechanical properties of wood-fiber reinforced polypropylene composites: effect of a novel compatibilizer with isocyanate functional group", Comp. A, Vol. 38, pp. 227-233, 2007.

[11] S. Biswas, Q. Ahsan, I. Verpoest and M. Hasan, "Effect of Span Length on the Tensile Properties of Natural Fibers", Advanced Materials Research, 2011, Vol. 264-265, pp. 445-450 .

[12] ASTM Standard D 638-01, Standard Test Methods for Tensile Properties of Plastics, Vol. 8, USA, 2002.

[13] ASTM Standard D 790-01, Standard Test Methods for Flexural of Unreinforced and Reinforced Plastics and Electrical Insulating Materials, Vol. 8, USA, 2002.

[14] ASTM Standard D 6110-97, Standard Test Methods for Determining the Charpy Impact Resistance of Notched Specimens of Plastics, Vol. 8, USA, 2002.

[15] Md. S. Jamil, I. Ahmed and I. Abdullah, "Effect of rice husk filler on the mechanical and thermal properties of liquid natural rubber compatibilized high-density polyethylene natural rubber blends", J. Poly. Res., Vol. 13, pp. 315-321, 2006.

[16] M. R. Rahman, M. M. Haque, M. N. Islam and M. Hasan, "Improvement of physico-mechanical properties of jute fiber reinforced polypropylene composites by post treatment", Comp. A, Vol. 39, pp. 1739-1747, 2008.

[17] H. S. Yang, H. J. Kim, J. Son, H. J. Park, B. J. Lee and T. S. Hwang, "Water absorption behavior and mechanical properties of lignocellulosic filler polyolefin biocomposites", Comp. Stru., Vol. 72, pp. 429-437, 2006.

[18] Md. R. Rahman, Md. M. Huque, Md. N. Islam and M. Hasan, "Mechanical properties of polypropylene composites reinforced with chemically treated abaca", Comp. A, Vol. 40, pp. 511-517, 2009.

[19] J. C. Lin, L. C. Chang, M. N. Nien and H. L. Ho, "Mechanical behaviour of various nano particle filled composites at low-velocity impact", Comp. Stru., Vol. 27, pp. 30-36, 2006.

[20] K. Jayaraman, "Manufacturing sisal-polypropylene composites with minimum fiber degradation", Vol. 63, pp. 367-374, 2003.

[21] P. V. Joseph, G. Mathew, K. Joseph, G. Groeninckx and S. A. Thomas, "Dynamic mechanical properties of short sisal fiber reinforced polypropylene composites", Comp. A, Vol. 34, pp. 275–290, 2003.

[22] S. Mishra, J. B. Naik, Y. P. Patil, "The compatibilising effect of maleic anhydrideon swelling and mechanical properties of plant-fiberreinforced novolac composites", Comp. Sci. Tech., Vol. 60, pp. 1729–1735, 2000.