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Investigations on Mechanical and Water Absorption Behaviour of Woven Banana - Cotton Fiber Reinforced Epoxy Composite with Addition of Nanoclay

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Abstract

This work investigates water absorption, hardness, tensile and flexural behaviours of woven banana-cotton fiberreinforced epoxy composites with addition of Nanoclay are studied, which is used for the purpose of decoration parts for constructions, inner parts and brake shoe for automobile andboat. The mat form of fibersis reinforced with epoxy resin in different volume ratio which varies between 10-40% Volume fractions (V_f) of fiber. The experimental values shows that the tensile and flexural properties of woven banana-cotton fiber reinforced composite increases with increase in fiber content and 30% Volume fractions (V_f) of fiber contained composite gives the maximum tensile and flexural strength. The water absorption test shows less percentage of water gain at 30% Volume fractions (V_f) of fiber composite. The 40% Volume fractions (V_f) of fiber contained composite gives the maximum hardness. The experiment shows 30% Volume fraction (V_f) of the composite achieves better performance compare with other different Volume fractions (V_f) of the woven banana-cotton fiberreinforced epoxy composite.The Montmorillonite (MNT) nanoclay is added in percentage compositions of 1%, 3%, 5% and 7% respectively in 30% Volume fraction (V_f) of woven banana-cotton fiber reinforced with epoxy composite. SEM analysis is done to investigate the distribution of the nanoclay within the form matrix. The experimental results are shows that the 5% weight ratio ofnanoclay composite gives better performance when compared with other different percentage composition of composite. The maximum tensile and flexural strength is obtained at 5% weight ratio ofnanoclay containing

composite.The water absorption test shows less percentage of water gain at 5% weight ratio ofnanoclay specimen. The 7% weight ratio of nanoclaycontaining composite gives the maximum hardness. Finally, the experimental evidence also shows that the nanoclay added specimen yields better results.

Keywords: Natural fibers, SEM, composite, nanoclay,Compression molding.

Introduction

Polymer matrix composites (PMCs) as the name indicates consist of a polymer resin as the matrix, filled with other materials. This type of composites is easy to produce with minimum cost and have better performances. A composite material is combinations of two are more materials that give a unique combination of properties. One of the material is made up of stiff, long fibres and the other is made up of a binder or 'matrix' which holds the fibres in place. More recently natural fibers have been used along with plastic materials. The natural fibers are extracted from the naturaly available plants. The availability of natural fibers such as Jute, Coir, Bamboo, Banana, Sisal, Pineapple etc. to rise the development of natural fibre composite. In the field of automation and structural engineering this type of natural fiber composites are readily used. Goulart et.al (1) Natural fibers are readily used as reinforcement in polymer matrix composites .The use of coupling agent with polymeric matrix are discussed and evaluated. The thermo kinetic mixer is used to mix the palm fiber with the polymeric matrix with speed rate of 5250 rpm, in which fiber were responsible for 5% of weight in the composition. Result shows that, when compared with pure polymer the addition of coupling agent in the composite lead to increased flexible strength and modulus. M. Boopalan et.al (2) the addition of banana fiber with raw jute has yielded agreeable results. The jute was hybridized with the banana fiber to yield better mechanical properties such as tensile, impact flexural, thermal etc., Different weight ratio of jute and banana fiber were taken and mixed with the epoxy by moulding to form the required composite. Cross plied jute and banana fiber were incorporated with the resin aid in the preparation of the composites. The Morphological analysis has also been done using Scanning electron microscopy (SEM).T.P Sathish kumar et al. (3) a more recent development in the field of natural fiber is the use of snake grass which are obtained from natural grass plant by natural grass plant using manual process. In this work the isophthallic polyester resin is used in the production of the composite. Various mechanical tests carried out shows that the Increase in volume fraction increases the tensile, flexural and modulus of the composite. T.P. Mohan et al. (4) the addition MNT nanoclay with the epoxy reduces the water absorption of the polymer matrix. The water absorption of 5% of MNT nanoclay filled composite is three times lower than nanoclay unfilled composites.

Thus the various works done in this field shows that the natural fibers can be readily used in the preparation of natural composites that can be easily fabricated using compression moulding process.

Experiments

A. Material Description

1. *Fiber materials*-The banana fiber and cotton fiber are extracted and spinnedto form a mat and it is called as woven banana-cotton fiber.
2. *Epoxy resin*- The LY 556 grade epoxy resin and HY 951 gradehardener arecommercially available and is used for the investigation in ratio of 10:1.
3. *Nanoclay*- Nanoclay means nanoparticlate mineral silicates in layer. Depending on its size and composition, they are classifying into different types of nanoclay such as kaolinite, bentonite, montmorillonite, etc., The MNTnanoclay is commercially available. The size of MNTnanoclay obtained is 164 nm.

B.Composite Preparation

The composites were prepared using compression moulding process. Using this process the specimens were prepared at a temperature 110°C and pressure 30 $kg/m^3$for 2hrs.Totally eight type of specimens were prepared out of which, four specimens were prepared with Volume fractions (V_f) of 10%, 20%, 30% and 40% of fiber content and another four specimens were prepared with various weight ratios of 1%, 3%, 5% and 7% of Montmorillonite (MNT) nanoclay.The nanoclay was mixed with epoxy resin using magnetic stirrer at 1300rpm for about 2hrs.

C. Tensile Testing of the Composite

The Tensile test was conducted for the composite specimen using the electronic tensometer setup to obtain the tensile properties. The dog-bone specimens of the composites were prepared according to the ASTM D 638 standards. The specimens were machined to a standard size of 165 mm × 13 mm × 4 mm for 100 mm gauge length. For this testing, the load cell of 5 kN was utilized in the tensometer with the same cross head speed of 20 mm/min.

D.Flexural Testing of the Composite

Three point flexural testing was conducted on the specimens according to the ASTM D 790 standards using the spring mass testing machine. The specimens were machined for the dimensions of 125 mm ×12 mm ×4 mm. The span to the depth ratio of the specimen was considered as 16:1. For the testing, Load cell of 6 kN was utilized with the cross head speed of 10 mm/min.

E. Hardness Testing of the Composite

The shore-D hardness testing machine is used to test the hardness of the natural composite materials.

F. Water Absorption Behaviourof the Composite

Water absorption behaviour of the composite was tested in an environment of salt water at room temperature 23ºC. The test was carried out as per ASTM 570-98.The specimens were machined for the dimensions of 125 mm ×12 mm ×4 mm.

The amount of water absorption in the composite was determined using the following equation:

% of Weight gain (W) = [(W_2-W_1)/ (W_2)] ×100

W_1, W2are the weight of samples before and after immersion in salt water respectively.

G. SEM Analysis of the Composite

Scanning electron microscopy (SEM) analyse the surface finishing of materials. Scanning electron microscopy (SEM) measures the size and arrangements of Montmorillonite (MNT) nanoclay in the material. The specimens were machined for the dimensions of 10mm ×10 mm.

Result and Discussion

A. Woven Banana-Cotton Fiber Reinforced Epoxy Composite

1. *Tensile Test Result for Woven Banana-Cotton Fiber Reinforced Epoxy Composite*

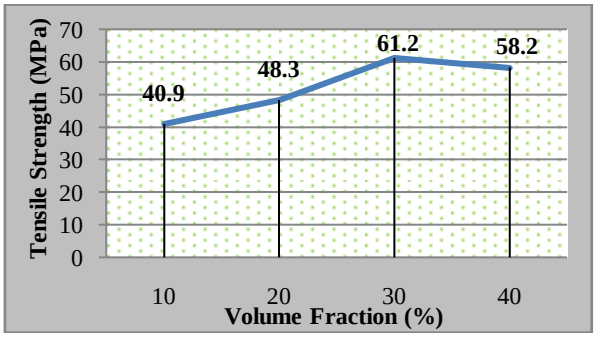

Figure 1: Tensile strength of composite

From the graph (Fig 1) obtained it is evident that the 30% Volume fraction (V_f) of fiber gives the maximum tensile strength of 61.2 MPa is obtained and it get decreases after that. Also at 10% Volume fraction (V_f) of fiber gives the minimum of 40.9MPa is obtained.

2. *Flexural Test Result for Woven Banana-Cotton Fiber Reinforced Epoxy Composite*

From the graph (Fig 2) obtained it is evident that the 30% of Volume fractions (V_f) composite gives the maximum flexural strength of 104.8 MPa is obtained and it gets decreases after that. Also the 10% of Volume fractions (V_f) of fiber is the minimum of 55.6 MPa is obtained.

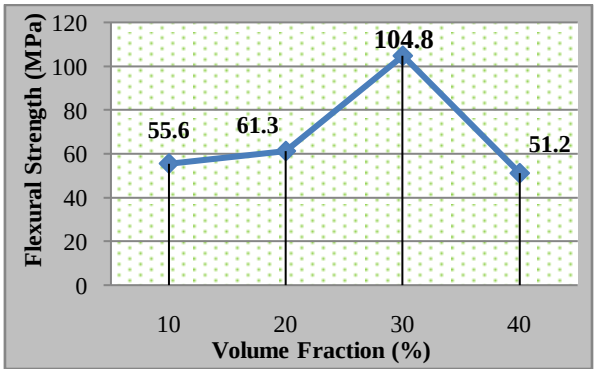

Figure 2: Flexural Strength of Composite

3. *Hardness Test Result for Woven Banana-Cotton Fiber Reinforced Epoxy Composite*

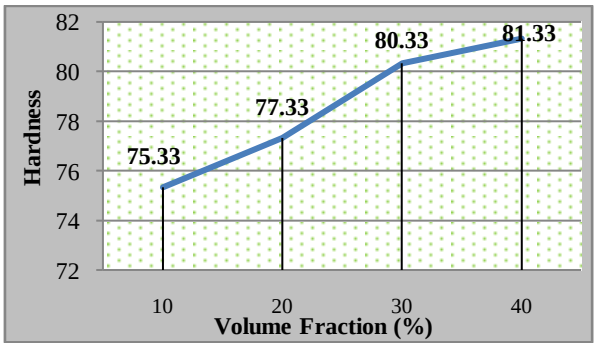

Figure 3: Hardness of Composite

From the graph (Fig 3) obtained it is evident that 40% Volume fractions (V_f) of fiber gives the maximum hardness strength of 81.33 of shore-D value is obtained. Also at 10% Volume fractions (V_f) of fiber gives the minimum of 75.33 of shore-D value is obtained.

1. *Water Absorption Test Results for Woven Banana-Cotton Fiber Reinforced Epoxy Composite*

The specimens are immersed in salt water for 24, 48, 72 and 96 hours after which the initial and final weights were calculated. The Percentage of weight gain were calculated from the formula which is given below,

% of Weight gain (W) = $[(W_2-W_1)/(W_2)] \times 100$

W_1, W2 are weight of the samples before and after immersion in water respectively.

From the Table 1 shows that the 30% volume fraction is obtaining better result compare with other results in water absorption test.

Table 1: Water Absorption without Nanoclay Composite

Time of Immersion (h)	Volume Fraction of Fiber (%)	Initial Weight (g)	Final Weight (g)	Weight Gain (%)
24	10	6.242	6.245	0.04
	20	6.851	6.855	0.05
	30	9.483	9.487	0.04
	40	8.173	8.178	0.06
48	10	6.242	6.248	0.09
	20	6.851	6.85	0.10
	30	9.483	9.491	0.08
	40	8.173	8.185	0.14
72	10	6.242	6.252	0.15
	20	6.851	6.862	0.16
	30	9.483	9.498	0.15
	40	8.173	8.191	0.21
96	10	6.242	6.257	0.23
	20	6.851	6.868	0.24
	30	9.483	9.501	0.18
	40	8.173	8.193	0.24

B. Woven Banana-Cotton Fiber Reinforced Epoxy Composite with Addition of Nanoclay

1) *SEM Analysis for Woven Banana-Cotton Fiber Reinforced Epoxy Composite with Addition of Nanoclay*

The images are obtained using SEM shows that the surface finish gets increased as the nanoclay percentage increases, this is evident from the images given below,

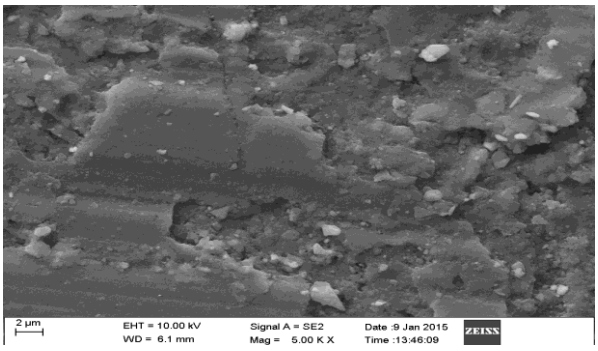

Figure 4: 0% of MNT Nanoclay composite

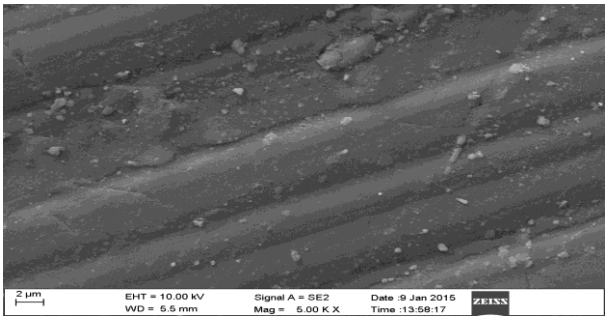

Figure 5: 1% of MNT Nanoclay Composite

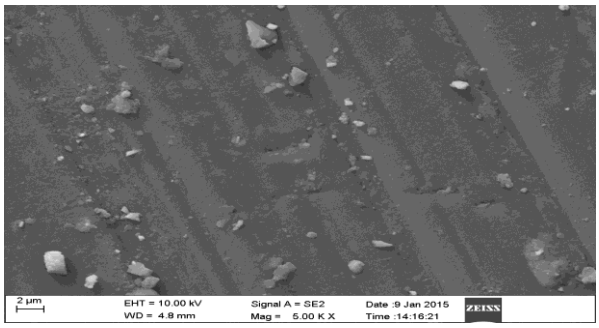

Figure 6: 3% of MNT Nanoclay Composite

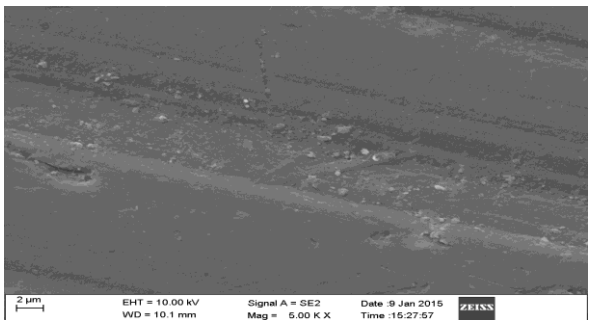

Figure 7: 5% of MNT Nanoclay Composite

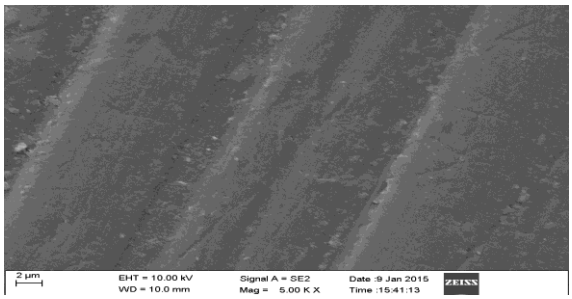

Figure 8: 7% of MNT Nanoclay Composite

2) Tensile Test Result for Woven Banana-Cotton Fiber Reinforced Epoxy Composite with Addition of Nanoclay

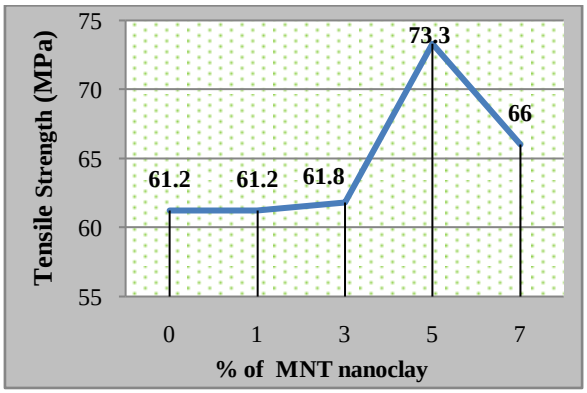

Figure 9: Tensile Strength of Nanoclay Composite

From the graph (Fig 9) obtained it is evident that the 5% of MNT nanoclay gives the maximum tensile strength of 73.3 MPa is obtained and it gets decreases after that. Also at 0% of MNT nanoclay is the minimum strength of 61.2 MPa is obtained.

3) Flexural Test Result for Woven Banana-Cotton Fiber Reinforced Epoxy Composite with Addition of Nanoclay

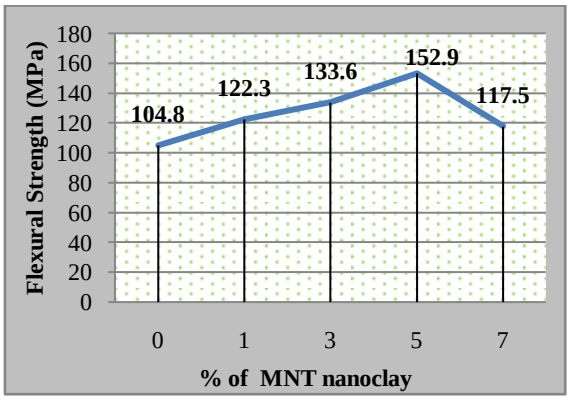

Figure 10: Flexural Strength of Nanoclay Composite

From the graph (Fig 10) obtained it is evident that the 5% of MNT nanoclay composite gives the maximum flexural strength of 152.9 MPa is obtained and it gets decreases after that. Also the 0% of MNT nanoclay is the minimum of 104.8 MPa is obtained.

4) Hardness Test Result for Woven Banana-Cotton Fiber Reinforced Epoxy Composite with Addition of Nanoclay

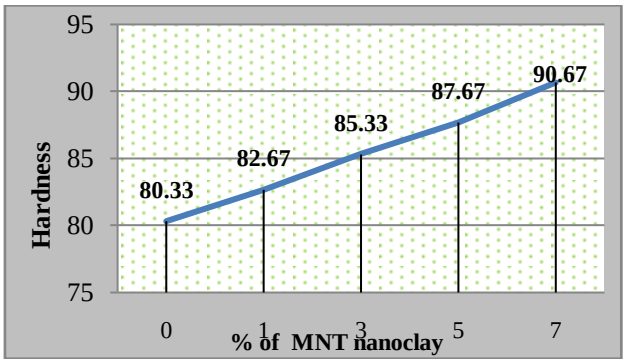

Figure 11: Hardness Strength of Nanoclay Composite

From the graph (Fig 11) obtained it is evident that the 7% of MNT nanoclay composite is give the maximum hardness strength of 90.67 of shore-D value is obtained. Also at 0% of MNT nanoclay is give the minimum of 80.33 of shore-D value is obtained.

Table 2: Water Absorption with Nanoclay Composite

Time Of Immersion (h)	MNT Nanoclay (%)	Initial Weight (g)	Final Weight (g)	Weight Gain (%)
	0	9.483	9.487	0.04
	1	11.662	11.668	0.05
	3	10.346	10.350	0.03
24	5	10.168	10.177	0.08
	7	10.679	10.689	0.09
	0	9.483	9.491	0.08
	1	11.662	11.674	0.10
	3	10.346	10.357	0.10
48	5	10.168	10.181	0.12
	7	10.679	10.701	0.20
	0	9.483	9.498	0.15
	1	11.662	11.688	0.22
	3	10.346	10.364	0.17
72	5	10.168	10.184	0.15
	7	10.679	10.706	0.25
	0	9.483	9.501	0.18
	1	11.662	11.691	0.24
	3	10.346	10.372	0.25
96	5	10.168	10.192	0.23
	7	10.679	10.711	0.29

5) *Water Absorption Test for Woven Banana-Cotton Fiber Reinforced Epoxy Composite with Addition of Nanoclay*

The specimens are immersed in salt water for 24, 48, 72 and 96 hours after which the initial and final weights were calculated. The Percentage of weight gain were calculated from the formula which is given below,

$$\% \text{ of Weight gain } (W) = [(W_2 - W_1)/ (W_2)] \times 100$$

W_1, W2 are weight of the samples before and after immersion in water respectively.

From the Table 2 shows that the 5% weight ratio of MNT nanoclay is obtaining better result compare with other results in water absorption test.

C. Comparison of Woven Banana-Cotton Fiber Reinforced Epoxy with and without Addition Nanoclay Composite Results.

1) Comparison of Tensile test result for Woven banana-cotton fiber reinforced epoxy with and without addition of Nanoclay composite

From (Fig 12) the tensile test results obtained, a comparative study shows that the woven banana-cotton fiber reinforced epoxy composite with addition of nanoclay specimen gives superior result then the woven banana-cotton fiber reinforced epoxy composite.

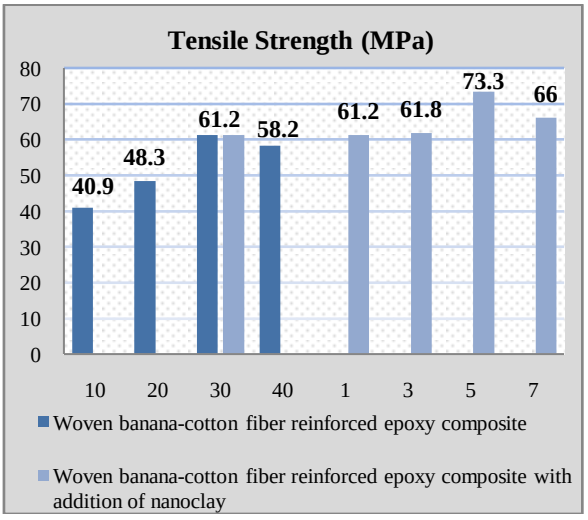

Figure 12: Comparisons of Tensile Test Results

2) Comparison of Flexural Test Results For Woven Banana-Cotton Fiber Reinforced Epoxy with And without Addition of Nanoclay Composite

From (Fig 13) the flexural test results obtained, a comparative study shows that the woven banana-cotton fiber reinforced epoxy composite with addition of nanoclay specimen gives superior result then the woven banana-cotton fiber reinforced epoxy composite.

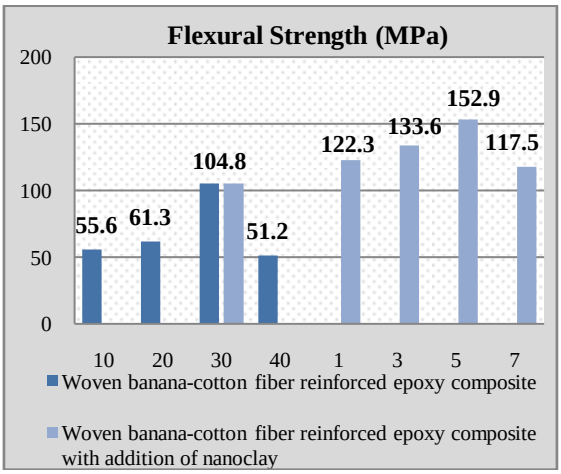

Figure 13: Comparison of flexural test results

3) Comparison of Hardness Test Results For Woven Banana-Cotton Fiber Reinforced Epoxy with and without Addition of Nanoclay Composite

From (Fig 14) the hardness test results obtained, a comparative study shows that the woven banana-cotton fiber reinforced epoxy composite with addition of nanoclay specimen gives superior result then the woven banana-cotton fiber reinforced epoxy composite.

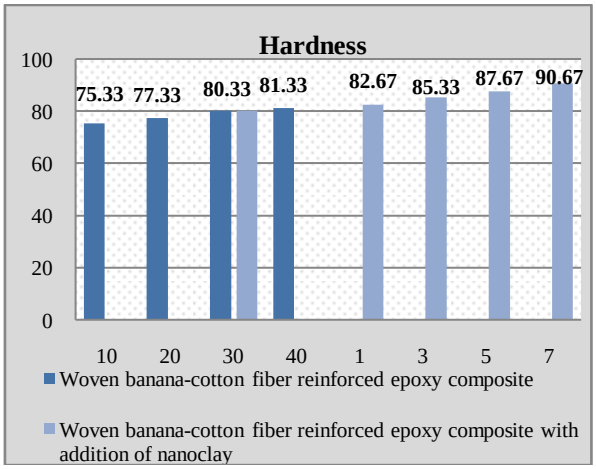

Figure 14: Comparisons of Hardness Test Results

4) Comparison of Water Absorption Test Results for Woven Banana-Cotton Fiber Reinforced Epoxy with and without Addition of Nanoclay Composite

A comparative study of water absorption test results shows that the less amount of water is absorbed in woven banana-cotton fiber reinforced epoxy composite specimen compare with the woven banana-cotton fiber reinforced epoxy composite with addition of nanoclay specimen.

Conclusion

Thus the natural fiber composites were fabricated using compression moulding process and the samples are generated using epoxy as reinforcement and with percentage addition of nanoclay. The results show that the superior mechanical and water absorption properties are obtained at 30% Volume fraction (V_f) of woven banana-cotton fiber reinforced epoxy composite. And With addition of nanoclay, the superior mechanical and water absorption properties are obtained at 5% of weight ratio of MNT nanoclay. These composites can be readily used in the application of boat, decoration parts for constructions, interior parts and brake shoe for automobile etc., finally the experimental evidence also shows that the nanoclay added specimen yields better results.

References

[1] Goulart, S.A.S., Oliveira, T.A., Teixeira, A.,Miléo, P.C.,Mulinari, D.R., 2011, Mechanical Behaviour of Polypropylene Reinforced Palm Fibers Composites, Procedia Engineering 10, pp. 2034–2039.

[2] Boopalan, M., Niranjanaa, M., Umapathy, M.J., 2013, Study on the mechanical properties and thermal properties of juteand banana fiber reinforced epoxy hybrid composites, Composites: Part B 51, pp. 54–57.

[3] Sathishkumar, T.P., Navaneethakrishnan, P., Shankar, S., 2012, Tensile and flexural properties of snake grass natural fiber reinforced isophthallic polyester composites, Composites Science and Technology 72, pp. 1183–1190.

[4] Mohan, T.P.,Kanny, K., 2011, Water barrier properties of nanoclay filled sisal fibre reinforced epoxy composites, Composites: Part A42, pp. 385–393.

[5] Verma. D., Gope. P.C., Maheshwari. M.K., Sharma. R.K., 2012, Bagasse Fiber Composites: A Review, J. Mater. And Environ. Sci. 3(6), pp. 1079-1092.

[6] Verma, D.,Gope, P.C.,Shandilya, A., Gupta, A., Maheshwari, M.K., 2013, Coir Fibre Reinforcement and Application in Polymer Composites: A Review, J. Mater. Environ. Sci. 4 (2), pp. 263-276.

[7] Venkateshwaran, N., Elayaperumal, A.,Sathiya, G.K., 2012, Prediction of tensile properties of hybrid-natural fiber composites, Composites: Part B 43, pp. 793–796.

[8] Venkateshwaran, N., Elayaperumal, A., Alavudeen, A., Thiruchitrambalam, M., 2011, Mechanical and water absorption behaviour of banana/sisal reinforced hybrid composites, Materials and Design 32, pp. 4017–4021.

[9] Mo-lin Chan, Kin-tak Lau, Tsun-tat Wong, Mei-poHo, David Hui, 2012, Mechanism of reinforcement in a nanoclay/polymer composite, Composites: Part B 42, pp. 1708–1712.