EXPERIMENTAL INVESTIGATION ON THE TENSILE BEHAVIOUR OF JUTE- KEVLAR REINFORCED EPOXY WITH NANOCLAY PARTICLES

Bhanupratap R[1], H C Chittappa[2]
[1]Research Scholar, Department of Mechanical Engineering, UVCE, Bengaluru, INDIA
[2]Associate Professor, Department of Mechanical Engineering, UVCE, Bengaluru, INDIA

Abstract

In recent years, the industries are focussing their attention towards the development of sustainable composites. Researchers are working on fabrication of new composite materials to enhance the applicability of these materials. Particularly in polymer composites, laminated composites are most interesting for their properties. In view of this, the new polymer hybrid composite is developed in which the jute and kevlar fibre is reinforced to the epoxy resin with the application of nanoclay and studied its morpholoical behaviour. The results of the study show that the incorporation of nanoclay has exhibited the significant improvement in the tensile behaviour of composites. The optimum loading of clay was found to be at 3 wt% where the improvement in tensile property was seen.

Keywords: Jute; kevlar; nanoclay; epoxy, laminate, hand lay up technique, hybrid composite

I. INTRODUCTION

In the past few decades the research and engineering interest has been shifting from monolithic materials to natural reinforced materials like wood, jute, hemp,sisal, bone etc. Cellulose fibres are found in jute in lignin matrix. composite material has the main advantage of formability into more complex shapes than their metallic components. Use of composite material reduces the number of parts making up a given component and also reduces the need for fasteners and joints which may otherwise weaken the component. There is a siginificant growth in the use of natural composite in the automative and decking markets over past one decade. Sustainability, green chemistry and industrial ecology are driving the automobile industry to seek alternative, eco friendly materials for automative applications. Materials from renewable resources are sought to replace not onlythe reinforcement element but also the matrix plane of the composite materials, to overcome the sustainability issues associated with using synthetic materials in composites. The use of natural fibres with polymers based on renewable resources resolve many issue related to environment. The natural fibres such as jute have recieved considerable attention as an environmental friendly alternative for the use of synthetic fibres. and used as reinforced plastics (FRP) which have been widely accepted as materials for structural applications.[1] Girisha et al [2] worked on E glass, jute and epoxy and found that there were indications by the incorporation of both fibres, the polyester resin stabilised mechanical mechanical properties than epoxy resin. Ahmeda et al [3] worked on E glass, jute and polyester and found that the properties of jute composites can be considerably improved by incorporation of glass fibre as extreme glass plies. Sanjay et al [4] worked on E-Glass, jute and epoxy and found that the impact, flexure and laminar shear strength of the laminate L4 are more than the L1, L2 and L3. Margoto et al [5] worked on polypropylene [PP] and jute and found that the tensile and flexural tests showed increase in some mechanical properties of the composites such as strength values, maximum tension and deformation mainly for composites PP matrix with two layers of fabric jute in flexural test as compared to PP matrix without fabric jute. The main reason for the interest in FRP is due to their high stiffness to weight ratio and high strength to weight ratio as compared to conventional materials.[6] In modern plastics, reinforcement of any inorganic or organic particles is the most common method to improve the properties of the polymer. In particular, polymer clay is an interesting and very promising research area due to cost effective and their ease of their availabilty form natural resources.[7]. N O Warbhe et al[8] revealed that incorporation of kevlar to jute composites has enhanced the mechanical properties of resulting hybrid composites. Fiber reinforced composite materials are demanded by the industry because of their high specific stiffness and strength, especially for applications where weight reduction is critical. By using composites, weight of a structure can be reduced significantly. Nanoparticles are presently considered to be high potential filler materials for the improvement of the mechanical and physical properties. The nanometric size, leading to the huge specific surface areas (SSA) of up to more than 1000 m2/g, and their unique properties have caused intensive research activities in the field of natural and engineering sciences [9]. Their mechanical properties with electrical and thermal properties make them interesting materials for the use as fillers in polymers and open up new perspectives for multi-functional materials. An efficient exploitation of the properties of the nanoparticales in order to improve the material performance are generally related to the degree of dispersion, impregnation with matrix and to the interfacial adhesion [10]. The advantage of the nano scaled particles compared to the micro scaled fillers is their enormous surface area, which can act as interface for stress-transfer. However, a high SSA causes the formation of agglomerates. The agglomerates of the nanocomposite are difficult to separate and to infiltrate with the matrix [11]. Hence an effort is carried out to fabricate the nanocomposite by simple hand lay up technique and the influence over tensile property of jute, kevlar fibre reinforced epoxy resin are studied.

II. MATERIALS

In this study, the natural fibre jute is obtained from the jute cottage, Bengaluru, Synthetic fibre Kevlar is obtained from Hindoostan Composites, Mumbai, Epoxy resin (LY556) and a room temperature curing hardner (HY 951) is obtained from the local source, Nanoclay i.e Montmorillonite is obtained from Sigma Aldrich Bengaluru.

III. PROCESSING

The base resin was heated in the oil bath, maintained at a constant temperature of 60deg. Nanoclay at different proportions was added slowly to the resin and then stirring was done mechanically for 2 hours. After stirring, modified epoxy solution was mixed with the hardener and stirring up to 20 mins was done. Finally the mixture was applied to the fibre sheet on both sides using hand lay up and left over night for drying. The laminas were cured under ambient temperature to get the shape as that of the mould cavity. Finally the samples were cut as per ASTM standards.

IV. RESULTS AND DISCUSSION

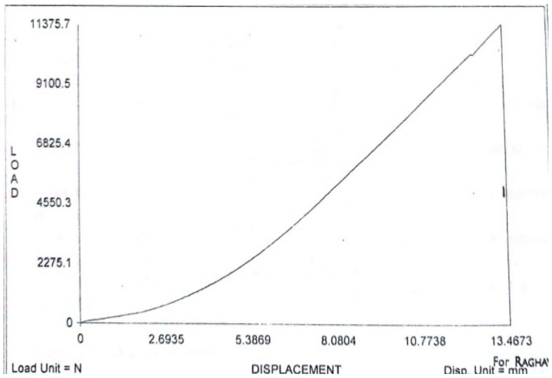
The material is cut into the dimensions as per ASTM: D638 standard 216 × 19 × 3 mm3. The tensile strength of the specimen is determined using the tensometer. The samples were tested at a cross head speed of 2mm/min. It determines the overall strength of the given object. In a tensile test, the object is fitted between two grippers at either end, then slowly pulled apart until it breaks. Tensile test provides vital information related to a composites durability which includes ultimate load, tensile strength and tensile modulus. The following results were obtained.

Table 1. Laminate designations without and with nanoclay

Laminates	Compositions	Laminates	Nanoclay	Compositions
L1	J+J+J+J	L5	1%	J+J+J+J
L2	J+K+J+J+J	L6	2%	J+K+J+J+J
L3	J+K+J+K+J+K+J	L7	3%	J+K+J+K+J+K+J
L4	J+K+K+J+K+J+K+K+J	L8	4%	J+K+K+J+K+J+K+K+J

Table 2. Tensile strength values of jute kevlar hybrid composite without nanoclay

Specimen code	Ultimate load(KN)	Tensile strength(N/mm2)	Elasticity modulus (GPa)
L1	2.35	50.807	17.148
L2	4.10	64.347	23.281
L3	8.01	117.637	32.502
L4	11.25	126.652	34.023



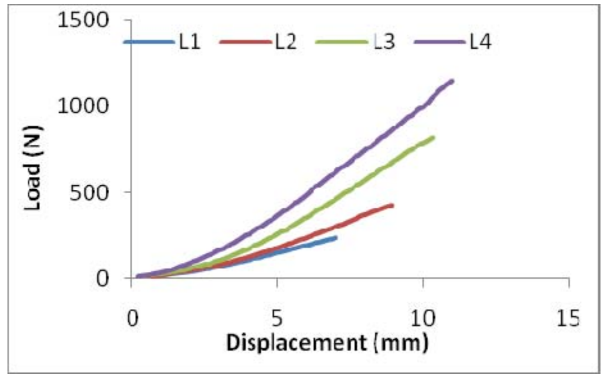
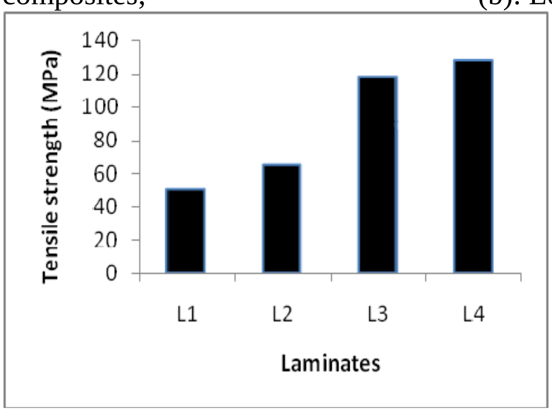
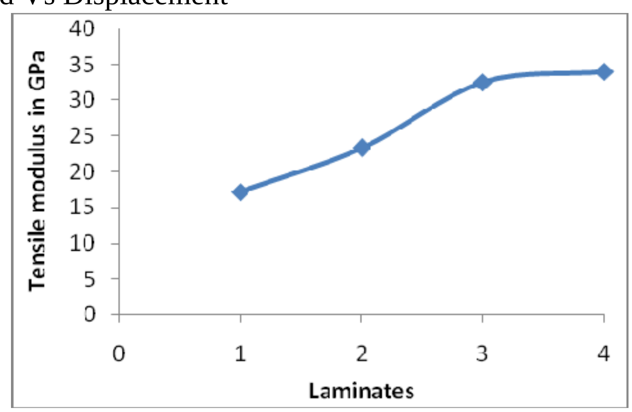


Fig 1: (a) Sample graph obtained from tensometer for load vs displacement for jute-kevlar epoxy composites; (b): Load Vs Displacement





Fig(c): Tensile Strength Vs Laminate ; Fig(d): Tensile Modulus Vs Laminates

TABLE 3. Tensile strength values of jute kevlar hybrid composite without nanoclay

Specimen code	Ultimate load(KN)	Tensile strength(N/mm2)	Elasticity modulus (GPa)
L5	2.660	53.492	19.725
L6	3.909	67.028	24.178
L7	10.571	134.592	38.328
L8	8.119	129.124	37.052

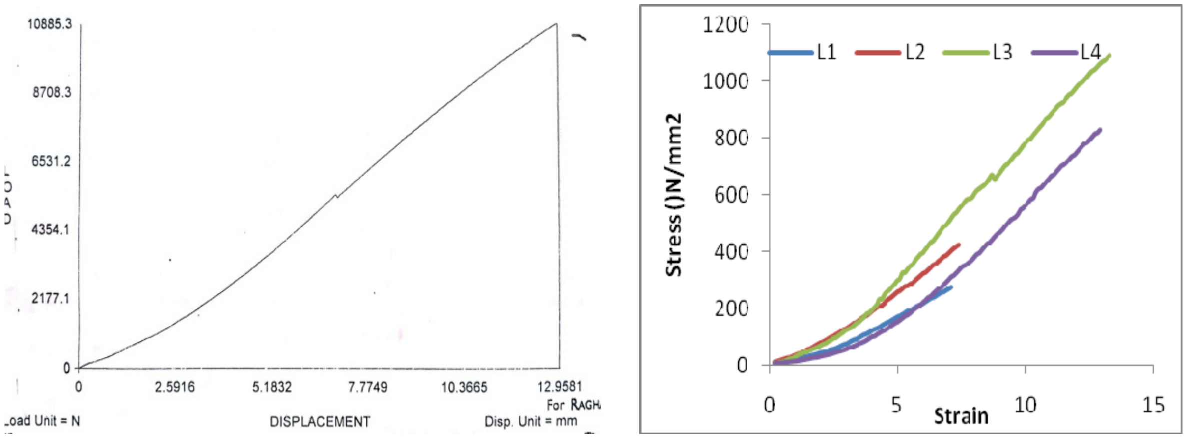
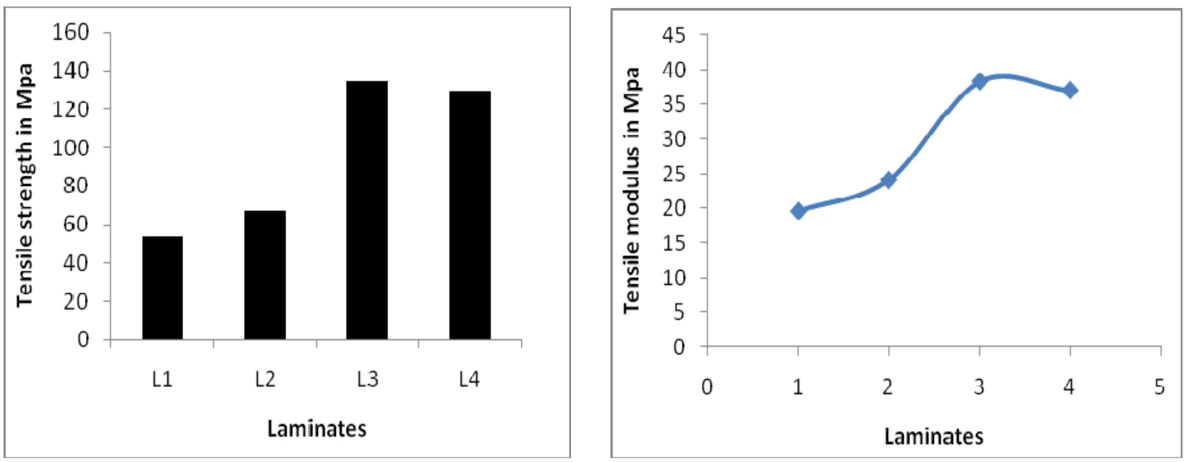


Fig 2 (a): Sample graph obtained from tensometer for load vs displacement for jute-kevlar-nanoclay composite; Fig (b):Load Vs Displacement For Jute-Kevlar-Nanoclay Composite



Fig(c): Tensile Strength Vs Laminates For Jute-Kevlar-Nanoclay Composite; Fig(d): Tensile Modulus Vs Laminates

V. SCANNING ELECTRON MICROSCOPY (SEM) ANALYSIS

The surface charecteristics of the composite material used for the investigation is studied through Scanning electron microscopy. The cross sectional view of the fabricated composite material consisting of jute, kevlar composite and jute, kevlar, nanoclay composite are presented in fig 3a and 3b. Scanning electron microscopy (SEM) images are taken to observe the interfacial properties, internal cracks and internal structure of the fractured surfaces of the composite materials. All the specimens are coated with conducting material before observing the surfaces through SEM. The scanning electron image observed for the jute, kevlar composite and jute, kevlar composite material of 3wt% nanoclay subjected to tensile test is presented in fig c and d. It is often not possible to see the individual nanoclay particles mixed in polymer matrix using SEM. However the surface properties observed in specimens is an indication of the uniformity of the nanoclay dispersion. It can be seen that for a laminated composite without nanoparticles exhibited as smooth fracture surface where resin seperates from the failure surface that shows the weak bonding between jute-kevlar fibre and epoxy matrix. In contrast, the laminated composite with nanoparticles of 3wt% nanoclay showed rough fracture as the matrix is completely stacked to the fibres at the failure surface, which represents the improvement of adhesion between the matrix and the fibres at the presence of nanoparticles. The issue can increase the toughness and strength of fibre reinforced resin. However the brittle nature of the resin can reduce the mobility and increase the modulus and strength. But it was not the case for 4 wt% as they tended to break apart before the peak, which meant they were brittle.

It was because when the nanoclay weight percentage increased, the mixture itself became too viscous, sluggish and more void formations in the samples of high wt%. The more the nanoclay the more viscous of the clay-resin mixture. Thus the nanoclay particles with 3 wt% improve the nanocomposite by acting as rigid connector between the fibre and matrix

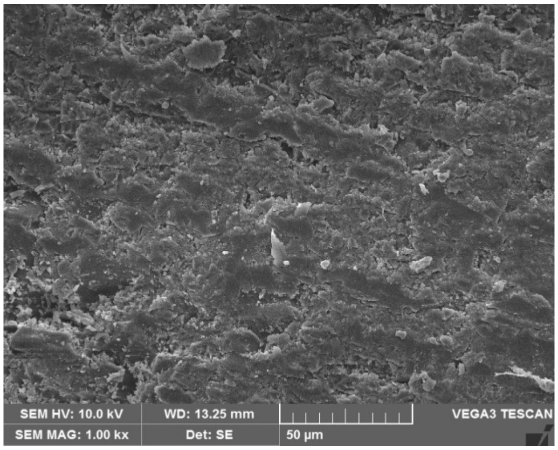
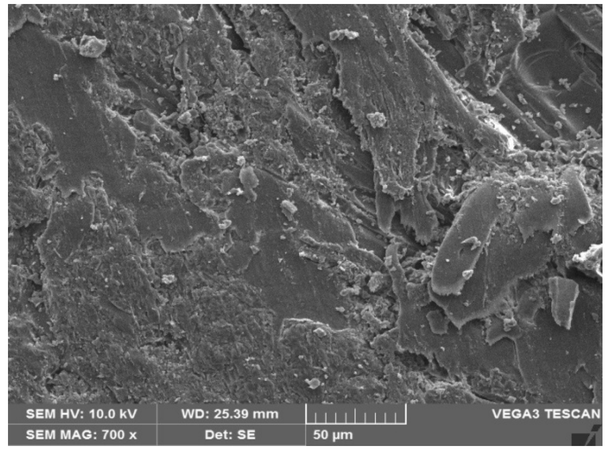
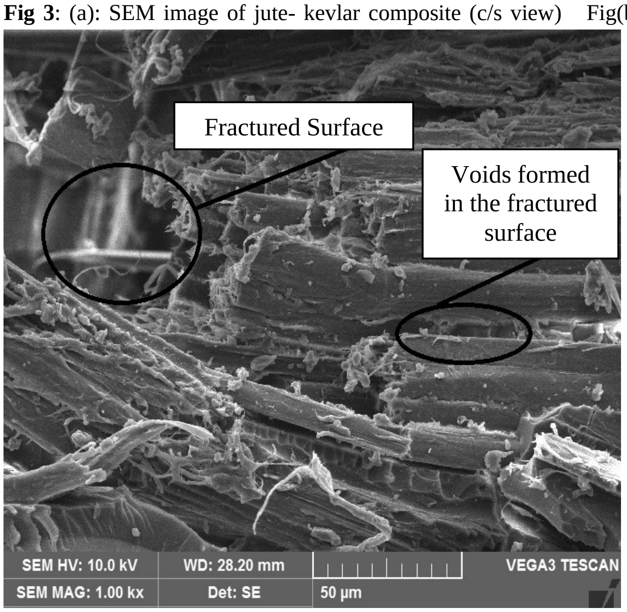


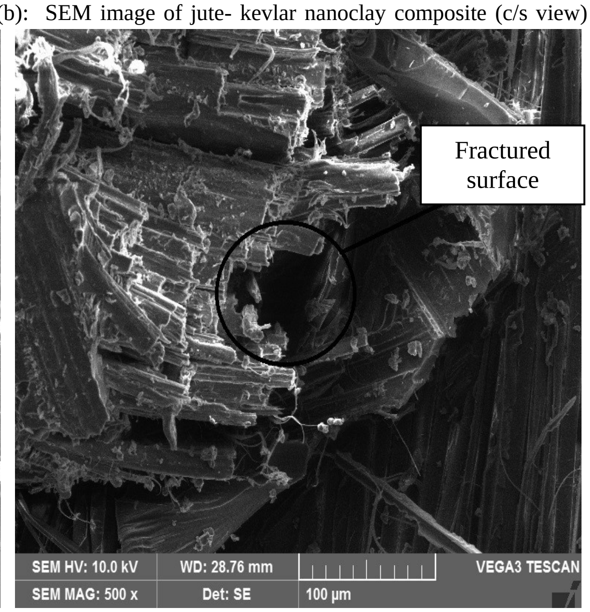
Fig 3: (a): SEM image of jute- kevlar composite (c/s view)



Fig(b): SEM image of jute- kevlar nanoclay composite (c/s view)



Fig(c): SEM image of Laminate L4 after tensile test



Fig(d): SEM image of 3 wt% of Laminate L7 after tensile test

VI. CONCLUSION

The comparison between the tensile properties of the specimens with and without the addition of nanoclay has been studied. There is an increase in the tensile strength of the specimens that has the addition of clay in it. The clay adds some reinforcement to the fibres. The tensile properties determined exhibit the similar behaviour for each of the specimens with the addition of clay. Corresponding to this the tensile modulus increased with the increase in the fibre loading in the composites due to the reinforcement imparted by the fibres that allowed the greater stress transfer at the interface. It has been clearly seen that 3wt% nanoclay composite showed considerable increase in the tensile properties and further adding nanoclay at 4 wt% had increased the viscosity of the resin mix which leads to brittleness of the material. It has been suggested that clay-resin interactions leads to this[1]. Thus it is concluded that maximum properties are obtained from 3 wt% nanoclay composite. To ascertain their suitability for commercial applications, few more tests are to be carried out to evolve the mechanical properties of the composites.

AKNOWLEDGEMENTS

The author sincerely thank depeartment of mechanical engineering, UVCE for providing the support to carry out this research.

REFERENCES

1. K Deepak, SV Prabhakar Vattikutti, B Venkatesh, "Experimental Investigation of Jute Fibre Reinforced Nanoclay Composite", Procedia Materials Science 10 (2015) 238-242.
2. K G Girisha, K C Anil, Akash, "Mechanical properties of jute and hemp reinforced epoxy/polyester hybrid composite" IJRET ISSN(E):2321-8843:ISSN(P):2347-4599,Vol.2 Issue 4 Apr.2014
3. K Sabeel Ahmeda, S Vijayaranga, "Tensile, flexural and interlaminar shear properties of woven jute and jute glass fabric reinforced polyester composites", journal of materials processing technologies, 207[2008] 330-335, 2008
4. M R Sanjay, B Yogesha, "Tensile, flexural and interlaminar shear properties of woven jute and jute glass fabric reinforced polyester composites", journal of minerals and materials charecterisation and engineering, Vol 4, Pg no 15-25, Jan 2016
5. Olivia H Margoto, Virginia A Da S Moris, Jane M F.De Paiva, "Mechanical Properties Of Poly Propylene Matrix Composites With Jute Fibre Fabric", 10th International Conferance On Composites Science And Technology, Jan 2015
6. BH Manjunath, K Prahalad Rao, "Influence of fibre particles reinforcement on epxy composites", IJERA, Vol 3, issue3, May-June2013, pp1147-1151
7. TP Mohan, K Kanny, "Effects of synthetic and processing methods on dispersion charecteristics of nanoclay in polypropylene polymer matrix composites", Materials Sciences and Aplication, Scientific Research 2011,2,785-800.
8. N O Warbhe, Ramakanth Srivastava, P S Advani, " mechanical properties of kevlar, jute reinforced epoxy composite", IJIRSET, Vol 5, Issue 9, Sept 2016
9. Koo, J.H. (2006), "Polymer Nanocomposite, Processing, Characterization and Application", McGraw-Hill Companies, USA
10. Ragosta, G. (2005), "Epoxy-Silica Particulate Nanocomposite: Chemical Interactions, Reinforcement and Fracture Toughness", Polymer, 46, 10506-10516
11. Kurimoto M. et al. (2007). "Improvement of Dispersibility of Nano Fillers in Epoxy/Alumina Nanocomposite by Application of Ultrasonic Wave", Proceedings of International Symposium on Eco Topia Science, ISET.