International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 02 Issue: 02 | May-2015 www.irjet.net p-ISSN: 2395-0072

Effect of Nano Silicon Dioxide on the Fatigue Behavior Analysis of Jute/Epoxy Laminated Composites: A Review

Anupam Mondal[1],Dr Kiran Kumar.P[2],Prof T. Madhusudhan[3]

[1]*Mechanical Department, M.Tech student, Machine Design, SJBIT, Bangalore, India.*

[2]*Mechanical Department, Professor, SJBIT, Bangalore, India.*

[3]*Mechanical Department, H.O.D, SJBIT, Bangalore, India.*

---***---

Abstract- *Now-a-days natural fiber reinforced polymer composite are used both in industrial and fundamental research over manmade and synthetic fibers due to environment related issues. The present work is undertaken to study the effect of filler material on the fatigue behavior of natural fiber reinforced laminates. Among various fibers, jute is most widely used natural fiber due to its advantages like easy availability, low density, low production cost and satisfactory mechanical properties. Epoxy resin is used because of its better fatigue resistance. Bending fatigue test to be carry out to determine the strength of the laminates at different loading conditions. Specimens after tests needs to be observed under SEM for damage analysis. Results are presented in the form of S–N curves, showing the variation of the fatigue strength as a function of the specimen orientation. The experimental data, obtained from fatigue tests having different fiber orientation with or without filler material has to be compared and verified with FEA.*

Key Words: Composite materials, Fatigue analysis, nano silicon dioxide, Woven fibers, Natural fibers,SEM, FEA.

1. INTRODUCTION

A composite material consists of two or more distinctly different materials combined together which are insoluble with each other and differ in form or in chemical composition also. Fiber reinforced composite materials consists of fibers of significant strength and stiffness embedded in a matrix with distinct boundaries between them .Both fibers and matrix maintain their physical and chemical identities ,yet their combination performs a function which cannot be done by each constituent acting singly. Fibers of fiber reinforced plastic may be short or continuous. It appears obvious that FRP having continuous fibers is indeed more efficient. Composite materials are classified into four broad categories has been done according to the matrix used, they are polymer matrix composites, metal matrix composites, ceramic matrix composites and carbon- carbon composites. Polymer matrix composites are made of thermoplastic or thermoset resins reinforced with fibers such as glass, carbon or boron. Metal matrix composites of a matrix of metals or alloys reinforced with metal fibers such as boron or carbon. Ceramic matrix composites consists of ceramic matrices reinforced with ceramic fibers such as silicon carbide, alumina or silicon nitride. Carbon/carbon composites consists of graphite carbon matrix reinforced with graphite fibers.

1.1 Fiber

Based on the fibers the composites may be classified as natural and synthetic fibers. Natural fibers are gaining importance due to some unique characteristics such as low cost, easy availability and environmental friendly materials. Jute fibre is extensively obtained from two herbaceous annual plants, white Corchorus Capsularis (white jute) are available in Asia and Corchorus olitorius (Tossa jute) are available in Africa. Next to cotton, jute is the second most common natural fibre, cultivated in the world and extensively grown in countries like Bangladesh, China, India, Indonesia and Brazil. The jute plant grows nearly from 8-10 feets in height and has no branches. The stem of the jute plant is covered with thick bark, which contains the fibres. In 2-3 months' time, the plants grow up and then are cut, tied up in bundles and kept under water for several days for fermentation. Due to fermentation the stems rot and the fibres become loose and came out from the bark easily. Then the cultivators peel off the fibers from the bark, wash them very carefully and dry them in the sun.

1.2 Resin

The family of epoxy resins contains some of the highest performance resins available at this time. The main term epoxy resins describes a class of thermosetting resins prepared by the ring-opening polymerization of compounds containing an average of more than one epoxy group per molecule. Epoxy resins traditionally are made by reacting epichlorohydrin with bis-phenol A, which are linear polymers that cross-link, forming thermosetting resins basically by the reaction with the hardeners.

© 2015, IRJET.NET- All Rights Reserved

The curing agent for the epoxy resins usually is amine. During the curing process no volatile by-products are generated.
During curing, epoxy resins undergoes three basic reactions:
1. Epoxy groups are rearranged and they form direct links between themselves.
2. Aromatic and aliphatic hydroxyls links up to the epoxy groups.
3. Cross-linking takes place with the curing agent through various radical groups.

1.3 Fatigue in composite materials

Composite materials exhibits complex failure mechanisms under both static and fatigue loading because of anisotropic characteristics in their strength and stiffness. Fatigue causes a large damage throughout the specimen volume, that leads to failure from general degradation of the material instead of a predominant single crack.
Matrix cracking, delamination of laminates, fiber breakage and interfacial debonding are the basic failure mechanism in composite materials. The different failure modes combined with the complex stress fields, anisotropies, and non-linear behavior of composites severely limit our ability to understand the true nature of fatigue.

2. LITERATURE REVIEW

The fibers used in composite materials are glass, aramid, carbon, all are synthetic fibers. The use of natural fibers is increasing due to its unique properties. They are easily available at less cost compared to the synthetic fibers. Epoxies are best known for their excellent adhesive property, chemical and heat resistance, mechanical properties, and outstanding electrical insulating properties and low curing contraction. The chemical resistance of epoxies is excellent against basic solutions. Epoxies are little more expensive than polyesters, and also takes longer time to cure, but the extended range of properties make them the cost/performance choice for many critical applications. This is a best choice for products where strength and toughness are much more considered,as the material offers both outstanding flexural and tensile modulus The following are some of the review of journal papers based on study of fatigue behavior of both natural and synthetic fiber.

J.A.M Ferreira,et al [3] had studied of the fatigue behavior of bi-directional woven cloth mixture of E-Glass fibers and polypropylene fibers thermoplastic composites. The fiber volume distribution and strain rate of laminated composites with different lay-up orientation.

C. Belekacemi, et al [4], focuses on the quasi- static mechanical and fatigue of a jute/polyester composite laminates with stacking sequence of 0/90. Tensile test and fatigue tests are performed.in tensile test a linear proportion up to 20 MPa and a non-linear portion to rupture stress max of 47 MPa, followed by elongation of 2.08% with a break elongation of 2.50%.

Davi S. de Vasconcellous,et al[5], had studied the comparison of two different stacking sequence (0/90) and (+45/-45) of woven hemp fiber reinforced with epoxy resin laminated composites. At First the tensile-tensile fatigue tests are performed on specimens till rupture and later the damage specimens are observed under combined techniques like optical microscope and X-ray micro topography observations, temperature fields measurements by infrared cameras and acoustic emission monitoring. The results give a complete description of fatigue damage mechanisms and a damage scenario during fatigue tests.

P.Amuthakkannan, et al [6], had studied the effect of fiber length and fiber content of short basalt fiber on the mechanical properties was investigated. Specimens which are prepared with different fiber length are subjected to tensile strength, flexural strength and impact strength test and later the failure of the composites were examined with the help of scanning electron microscope.

Md Rashnal Hossain, et al [7], had studied the longitudinal tensile strength of jute/epoxy composites having jute fiber stacking sequence (0/0/0),(0/+45/-45/0) and (0/90/90/0). Further it is concluded that the tensile properties of the composites are strongly dependent on the tensile strength of jute fiber.

K.N. Bharath [8] had studied tensile and moisture absorption properties of randomly distributed areca fiber and maize powder reinforced urea formaldehyde composites. Composites were prepared by hydraulic hot press at 150 degree celcius. The tests were conducted according to ASTM standards. The tensile tests were conducted to investigate strength of the composite and moisture absorption test to investigate the moisture absorption resistance property.

G Rathnakar, et al [9], had determined the effect of fiber orientation on the flexural strength of woven glass fiber reinforced and woven graphite fiber reinforced laminated composite having orientation 0/90 and 0/45 with varying thickness ranges from 2mm to 4 mm. Both Specimens shows brittle failure and the flexural strength of laminates with 0/45 shows greater flexural strength than the laminates with 0/90 orientation. Graphite fiber reinforced laminated composites with 0/45 orientation have higher flexural strength than glass fiber reinforced laminated composites with same fiber orientation.

Andrew Makeev, et al [10], generated S-N curve based on custom short beam shear fatigue tests. The custom short beams test configuration ensure a consistent interlaminar shear failure mode. Test data sets used to

© 2015, IRJET.NET- All Rights Reserved

develop the fatigue properties, include approx. 20 glass/epoxy and 30 carbon/epoxy components. All the tests were run in load control at 0.1 load ratio to better understand the material behavior under cyclic loading.

Ya.B Unigovski, et al [11], had studied the effects of thermal cycling on low-cycle fatigue behavior of carbon-epoxy laminate were investigated in a purely bending mode at strain ratios of -1 and 0.1. It is found that a very small increase in the plastic strain amplitude catastrophically shortens the fatigue life N of the composite determined as a number of cycles corresponding to 0.9 of the initial force. The preliminary thermal cycling of the composite at the temperature varied from 180°C to −195.8°C shortens N values in comparison to the reference at small strains.

Ramesh K, et al [12], had studied the effect of modified epoxy matrix by Al_2O_3, SiO_2 and TiO_2 micro particles in glass fiber/epoxy composite to improve the mechanical properties. The composites are fabricated by hand lay-up method. It is observed that the mechanical properties like flexural strength, flexural modulus and ILSS are more in case of SiO_2 modified epoxy composite compare to other micro modifiers due to smaller particle size of silica compare to others modifiers. Alumina modified epoxy composite increases the hardness and impact energy compare to other modifiers.

P.N.B Reis, et al [13], had studied the dog bone shape specimens cut out from carbon epoxy laminates with load line aligned with one of the fiber directions. Tests were done at room temperature with load control with frequency of 10 Hz. Fatigue behavior was studied for different stress ratios and for variable amplitude block loading. Improved by addition of suitable reinforcement (filler) materials. Among the most common filler materials are glass fibers, graphite, carbon and bronze.

Xiangming Zhou, et al [14], did research on fracture and impact properties of short discrete jute fiber reinforced cementious composites. Fracture properties impact resistance flexural and splitting tensile tests were done at an interval of 7, 14 and 28 days. Different combination of JFRCC with GGBS/PC is compared with PFA/PC matrix and results are compared.

C.M Manjunatha, et al [15], studied the effect of nano silica particles on the fatigue behaviour of glass fiber reinforced epoxy laminate. Fatigue life of GFRC increased by 3-4 times by the addition of 10% of nano silica particles. Addition of nano silica particles result in the less matrix cracking and reduced crack growth rate due to particle debonding and plastic void growth mechanism.

3. CONCLUSIONS

The reviews show that there is lot of research work going on in natural fibers due to the increasing demand of the environmental friendly composite materials. The following may be concluded based on this review.

1. The stress-strain curves obtained in the laminates showed a non-linear behaviour for all stress levels.
2. The fatigue strength was strongly influenced by the layer design. The +45°/0°/ÿ45° and +30°/30°/0° laminates have similar fatigue strength and about 1.8 less than that of the 0° laminate.[1]
3. The tensile ultimate strength obtained for woven balanced bidirectional laminated carbon/epoxy composites is significantly higher (about 69%) than the compressive ultimate strength.
4. The secant modulus during fatigue life shows a significant loss, indicating the creation of damage.
5. Small increase in the plastic strain amplitude $\Delta\varepsilon p$ catastrophically shortens the fatigue life of the composite.
6. Smaller strains corresponded to the high-cycle fatigue region, thermal cycling of the composite shortens its fatigue life.
7. Addition of filler materials increases the mechanical properties of the composites.

ACKNOWLEDGEMENT

The authors sincerely thank and acknowledge the support provided by the principal and management of SJBIT Bangalore.

REFERENCES

[1]Mudhujit Mokhopadhyay, Mechanics of composite materials and structures university press,2008,2009.2012,2013.

[2]Gurit,E,Guide to Composites, gurit@gurit.com,www.gurit.com.

[3]J.A.M Ferreira,J.D.M Costa, P.N.B Reis. " Static and fatigue behaviour of glass fiber reinforced polypropylene composites, Elsevier Theoretical and Applied Fracture Mechanics 31 (1999).

[4]C.Belekacemi,B.Bezzazi,Quasi static mechanical characterization and fatigue of a composite laminates, Pelagia Research Library Advances in Applied Science Research, 2014,5(3):328-335

[5]Davi S.de Vasconcellous, Fabienne Touchard, Laurence Chocinski-Arnault,"Tension Tension fatigue behaviour of woven hemp fiber reinforced epoxy composite: A

© 2015, IRJET.NET- All Rights Reserved

multi instrumented damage analysis. HAL Id: hal-00796853.

[6]P.Amuthakkannan, V.Manikandan, J.T winowlin Jappes, M.Uthayakumar. Effect of fiber length and fiber content on the mechanical properties of short basalt fiber reinforced polymer matrix composites. Materials Physics and Mechanics 16 (2013)107-117

[7]Md Rashnal Hossain, Ignaas Vespoest.Tensile behavior of environment friendly jute epoxy laminated composite. Elsevier, Procedia Engineering 56 (2013) 782 – 788

[8]Ramesh K Nayak,Alina Dash, B.C Ray Effect of epoxy modifiers on mechanical performance of Epoxy/Glass fiber hybrid composites, Elsevier, Procedia Materials Science 6 (2014) 1359 – 1364

[9]G. Rathnakar, Dr. H.k Shivanand,Fiber Orientation and its influence on the flexural strength of glass and graphite fiber reinforced polymer composite.IJIRSET, Vol. 2, Issue 3, March 2013

[10]Andrew Makeev,Interlaminar shear fatigue behavior of glass/epoxy and carbon/epoxy composites, Elsevier, Composites ScienceandTechnology80(2013)93–100

[11]Ya.B. Unigovski,EM. Gutman.Low cycle fatigue of thermally cycled carbon-epoxy composites. Journal of Metals, Materials and Minerals, Vol.22 No.1 pp. 21-30, 2012

[12]KN Bharat,AM Ramesh,Moisture absorption characteristics of Areca/Maize

BIOGRAPHIES

Anupam Mondal, completed his BE in mechanical engineering from PESCE, Mandya karnataka and currently pursuing his M.Tech in Machine Design from SJBIT Bangalore, Karnataka. His area of interest is in composite materials and design of machine elements.
Emailid:anupammech@yahoo.in

Dr. Kiran Kumar P, is having 18 years of experience in industry and academics. He has published many journal papers and also presented paper in various national and internationl conferences. His area of interest includes radiation curing of materials and polymer composites and design of experiments .Presently he is working as a professor at SJBIT, Bangalore.

Prof. T Madhusudhan is a faculty serving as a head of the department of mechanical engineering department SJBIT, has a vast experience in engineering academics. His special interest are automobile systems, polymer composites, renewable energy sources and dynamics of machine.

© 2015, IRJET.NET- All Rights Reserved