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Analysis of Free Vibration Characteristic of Hybrid Polymer Composite Material

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***Abstract*— Composites are the choice in the present decade due to their incredible dominance in so many features. Few of them are great strength to weight ratio and stiffness to weight ratio and high temperature enduring competence. The present study aims at learning the mechanical behavior of hybrid Synthetic fiber composites. They are used in a variety of engineering applications such as airplane wings, helicopter blades, sports equipment's, medical instruments and turbine blades. Carbon and E-Glass fibers are used as reinforcement, Epoxy resin used as matrix. Specimens were cut from the fabricated laminate according to the ASTM standards for different experiments. After that experiment is performed under Universal testing machine (UTM). Flexural strength & Tensile strength were observed and compared to base values of epoxy polymer to perceive the change in strength.**

An important element in the dynamic analysis of composite beams is the computation of their natural frequencies and mode shapes. It is important because composite beam structures often operate in complex environmental conditions and are frequently exposed to a variety of dynamic excitations. Free vibration analysis was carried out for identifying the natural frequencies. A dynamic analysis is carried out which involves finding of natural frequencies and mode shapes for different stacking sequences. Finally, the non-dimensional natural frequencies of the beam are calculated by using ANSYS model of corresponding composite beam.

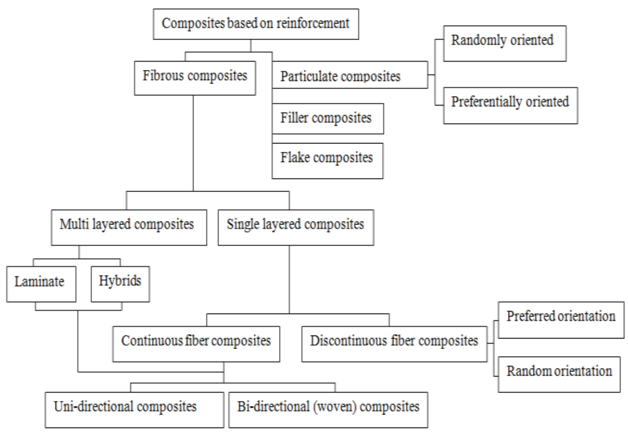
***Keywords*— Carbon and E-Glass Fibers, Epoxy, ANASYS software**

1. INTRODUTION

A composite is a material consisting of two or more materials that are synthetically made, dissimilar to one that develops naturally. A composite material, also, must include chemically different constituent phases which are separated by a clear interface. Although, most metallic alloys and many ceramics have multiple phases, they not fit this definition because they materialize as a result of natural phenomena. Numerous composite materials are comprised of just two phases; one is known as the matrix, which continuously surrounds the other constituent, which is called the dispersed phase. The properties of the component phases (i.e., volume fraction, shape and size of particles, distribution, and orientation) define the properties of the composite.

Considering the type and the shape of reinforcement used in fabricating the final material, composites can be classified in three main categories as shown in figure below, consisting of particle reinforced, fiber-reinforced, and structural composites. Each group includes a minimum of two subdivisions. Equiaxed dispersed phase is the main characteristic of particle-reinforced composites (i.e., particle dimensions are nearly the same in all directions); whereas, the dispersed phase of fiber reinforced composites, has the geometry of a fiber (i.e., a large length-to-diameter ratio). Structural composites are mixtures of composites and homogeneous material.

Classification based on reinforcement:



As a comparison between composites and metals, the composites materials are some advantages as:

- Light weight
- High specific stiffness and strength
- Easy moldable to complex forms
- Easy bondable
- Good dumping
- Low electrical conductivity and thermal expansion
- Good fatigue resistance
- Part consolidation due to lower overall system costs Low radar visibility
- Internal energy storage and release

Such as disadvantages of composites are the followings:

- Cost of materials
- Long development time
- Difficulty manufacturing
- Fasteners
- Low ductility
- Temperature limits
- Solvent or moister attack
- Hidden damages and damage susceptibility

Hybrid Composite

Hybrid composites are more advanced composites as compared to conventional FRP composites. Hybrids can have more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing and multiple matrix phases. They have better flexibility as compared to other fiber reinforced composites. Normally it contains a high modulus fiber with low modulus fiber.

Natural frequency

If a system, after an initial disturbance, is left to vibrate on its own, the frequency with which it oscillates without external forces is known as its natural frequency. As will be seen later, a vibratory system having n degrees of freedom will have, in general, n distinct natural frequencies of vibration

Mechanical Vibrations

Vibrations are oscillations in mechanical dynamic systems. Although any system can oscillate when it is forced to do so externally, the term "vibration" in mechanical engineering is often reserved for systems that can oscillate freely without applied forces.

2. MATERIAL AND EXPERIMENTAL DETAILS

The following section will elaborate in detail the experimental procedure carried out during the course of our project work.

The steps involved are

1. Specimen Fabrication (Fabrication of FRP).
   - By Hand Lay-Up method.
   - Cutting of Laminates into samples of desired dimensions.
2. Tensile test
3. Flexural test (3-Point Bend test).
4. Natural Frequency analysis is done by using ANASYS SOFTWAER.

2.1 Raw Materials

Raw materials used in this experimental work are

(i) Synthetic fibers
- Glass fiber
- Carbon fiber

(ii) Epoxy resin
(iii)Hardener

2.2 Fabrication of Composite Material

There are so many methods to prepare the composite material like Compressive Molding and Vacuum Molding and Extrusion method and hand lay-up technique. So i choice the hand lay-up technique

2.2.1 Hand Lay-Up Technique

The fiber piles were cut to size from the jute fiber cloth. The appropriate numbers of fiber plies were taken two for each. Then the fibers were weighed and accordingly the resin and hardeners were weighed. Epoxy and hardener were mixed by using glass rod in a bowl. Care was taken to avoid formation of bubbles. Because the air bubbles were trapped in matrix may result failure in the material. The subsequent fabrication process consisted of first putting a releasing film on the mould surface. Next a polymer coating was applied on the sheets. Then fiber ply of one kind was put and proper rolling was done. Then resin was again applied, next to it fiber ply of another kind was put and rolled. Rolling was done using cylindrical mild steel rod. This procedure was repeated until eight alternating fibers have been laid. On the top of the last ply a polymer coating is done which serves to ensure a god surface finish. Finally a releasing sheet was put on the top; a light rolling was carried out. Then a 20 kgf weight was applied on the composite. It was left for 72 hrs to allow sufficient time for curing and subsequent hardening.

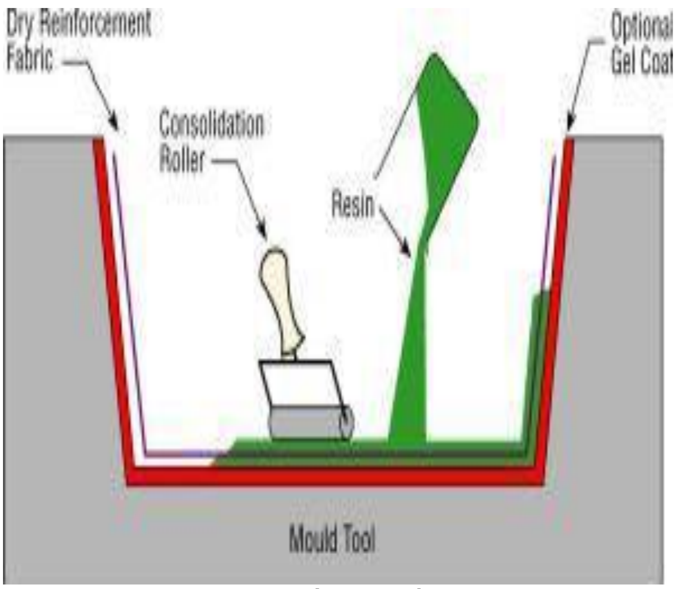


FIG 2.1 Hand Lay-up techniqu

2.2.2 Preparation of Test Specimens:

A jig saw machine was used to cut each laminate into smaller pieces, for Tensile, Flexural and impact test specimens.

The characterization of the composites reveals that the % weight of fibers is having significant effect on the mechanical properties of composites. All the mechanical testing methods that were carried out were based on American Standard Testing Methods (ASTM).

There are four tests performed, namely Tensile Test (ASTM D638), Flexural Test (ASTM D256),respectively.

Table 2.1 Specimen Dimensions

S.No	Test Name	Astm Standard	Dimensions
1	Tensile test	D638-03	168X12.5X4
2	Flexural test	D256	100 X12.7X4
3	Natural Frequency	D175	200 X25X4

2.3 Tensile Test:

In a broad sense, tensile test is a measurement of the ability of a material to with stand forces that tend to pull it apart and to what extent the material stretches before breaking. The stiffness of a material which represented by tensile modulus can be determined from stress-strain diagram.

$$\text{Tensile strength} = \frac{\text{Force (load)}}{\text{Cross section area}}$$

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$$\text{Tensile strength at yield} = \frac{\text{Maximum load recorded}}{\text{Cross section area}}$$

$$\text{Tensile strength at break} = \frac{\text{Load recorded at break}}{\text{Cross section area}}$$

Fig 2.1 Tensometer

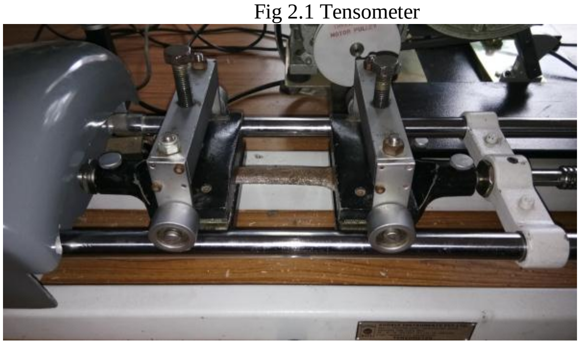
Fig 2.2 Sample Loaded Condition For Tensile Testing

2.4 Flexural Test: Flexural strength is the ability of the material to withstand bending forces applied perpendicular to its longitudinal axis. Sometime it is referred as cross breaking strength where maximum stress developed when a bar-shaped test piece, acting as a simple beam, is subjected to a bending force perpendicular to the bar. This stress decreased due to the flexural load is a combination of compressive and tensile stresses.

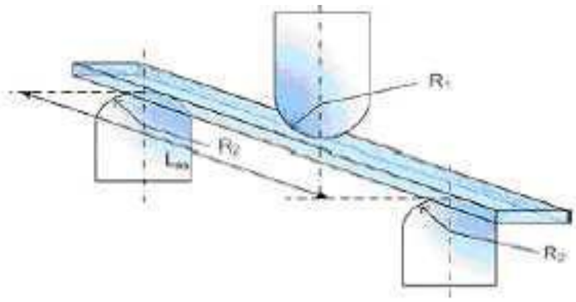
Fig 2.3 3-Point Bending Test Setup

Flexural Strength

$$\sigma_f = \frac{3PL}{2bd^2}$$

Where

σf = stress in the outer specimen at midpoint, MPa [psi]

P = load at a given point on the load deflection curve, N [lbf]

L = support span, mm

b = width of beam tested, mm

d = depth of beam tested, mm

Flexural Modulus

$$E_B = \frac{L^3 M}{4bd^3} \qquad (3.6)$$

Where

E_B = modulus of elasticity in bending, MPa

L = support span, mm

M = slope of the tangent to the initial straight line portion of the load deflection curve, N/mm of deflection

b = width of beam tested, mm

d = depth of beam tested, mm

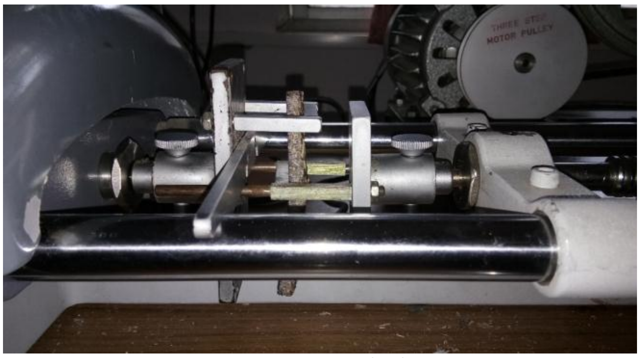
FIG 2.4 Experimental set Up for flexural testing


FIG 2.5 Sample loaded condition for flexural testing

2.5 Ansys:

ANSYS is a large-scale multipurpose finite element program developed and maintained by ANSYS Inc. to analyze a wide spectrum of problems encountered in engineering mechanics.

Steps of Anasys

2.5.1 Material Models

ANSYS allows several different material models like:

· Linear elastic material models (isotropic, orthotropic, and anisotropic).

· Non-linear material models (hyper elastic, multi linear elastic, inelastic and Viscoelastic)

· Heat transfer material models (isotropic and orthotropic)

· Temperature dependent material properties andCreep material models.

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1. Loads

The word loads in ANSYS terminology includes boundary conditions and externally or internally applied forcing functions, as illustrated in Loads. Examples of loads in different disciplines are:

Structural: displacements, forces, pressures, temperatures (for thermal strain),Gravity.

Thermal: temperatures, heat flow rates, convections, internal heat generation Infinite surface.

Magnetic: manetic potentials, magnetic flux, magnetic current segments,source current density, infinite surface.

Electric: electric potentials (voltage), electric current, electric charges, charge Densities, infinite surface

Fluid: velocities, pressures Loads are divided into six categories: DOF constraints, forces (concentrated loads), surface loads, body loads, inertia loads, and coupled field loads.

2.5.2 Analysis Types

The following types of analysis are possible using ANSYS

· Structural Analysis: Static Analysis, Modal Analysis, Harmonic Analysis, Transient Dynamic Analysis, Spectrum Analysis, Buckling Analysis, Explicit Dynamic Analysis, Fracture mechanics, and Beam Analysis.

· Thermal Analysis: Steady-state thermal analysis, transient thermal analysis.

· CFD (Computational Fluid Dynamics) Analysis: Laminar or turbulent, Thermal or adiabatic, Free surface, Compressible or incompressible, Newtonian or Non-Newtonian, Multiple species transport.

Several types of Electromagnetic field analysis and Coupled field analysis.

2.5.3 Post Processing

Post processing means reviewing the results of an analysis. It is probably the most important step in the analysis, because you are trying to understand how the applied loads effect your design, how good your finite element mesh is, and so on Two postprocessors are available to review your results.

2.5.4 Modeling of Solid Element

Modeling solid element named SOLID 45 is taken. It is the element which is having a higher order 3-D, 8-node element. The element is defined by 8 nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities. It also has mixed formulation capability for simulating deformations of nearly incompressible elastoplastic materials, and fully incompressible hyper elastic materials

3. RESULT AND DISCUSSION

MECHANICAL CHARACTERISTICS OF COMPOSITES:

The properties of the Carbon /E-Glass fiber reinforced epoxy hybrid composites with different orientation of fiber under this investigation are presented in below Tables &figures respectively. Details of processing of these composites and the tests conducted on them have been described in the previous chapter.

The mechanical properties of synthetic fiber reinforced composites are largely depends on the chemical, structural composition, fiber type and soil conditions and also on atmospheric conditions at the time of fabrication of the specimens.

The results of various characterization tests are reported here. This includes evaluation of tensile strength, flexural strength, natural frequency. Has been studied and discussed.

Based on the tabulated results, various graphs are plotted and presented in figs 4.1 to 4.3 for different orientation composites.

Table 3.1: The Tensile properties of Carbon/E-glass hybrid composite

Sample Id	Load in N	Elongation in Mm	Young's modules MPa
T_1	5530	4.5	4253.84
T_2	6099	4.3	4879.2
T_3	3520	2.3	5415.38
T_4	5850	3.9	5086.95
T_5	6570	4.1	5475.1
T_6	8080	4.3	6464

The above table shows the load and elongation and young's modules values of composites with different orientations. Compare the all values with each other composites.

T_6 was having higher value of load capacity 8080N and elongation 4.3mm and young's modules is 6464 MPa.

T_1- Carbon Uni-Direction T_2- Carbon and E-Glass Bi-Direction T_3- Carbon Bi-Direction

T_4- E-Glass Bi-Direction T_5- E-Glass Uni-Direction T_6- Carbon and E-Glass Uni-Direction

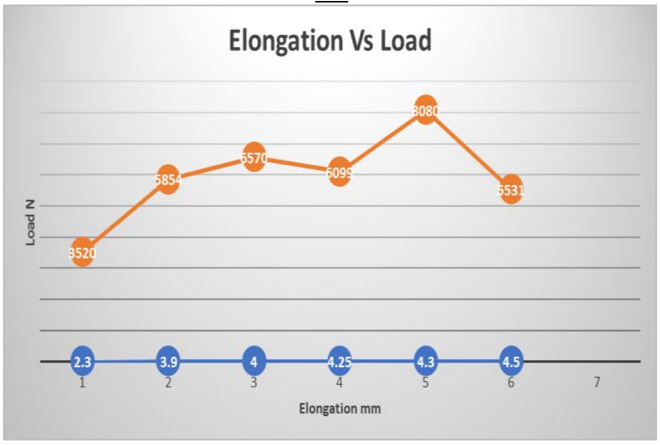

Fig 3.1

The results indicated that elongation and load of carbon/E-glass hybrid composite. It is evident that the highest tensile strength and highest elongation was found. This can be attributed that hybridization effect as both fibers contributed higher strength and elongation of the hybrid composite.

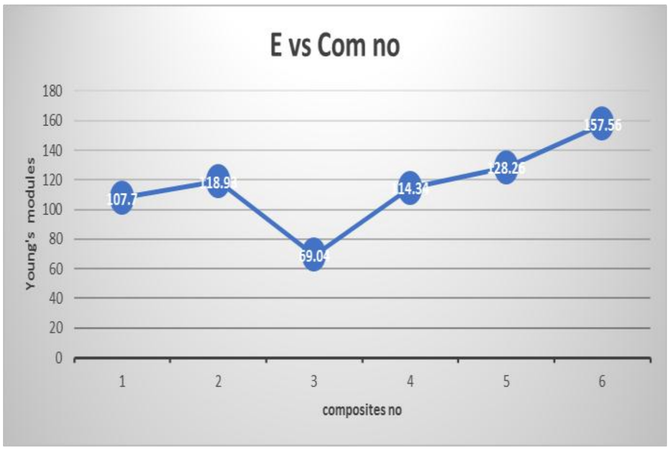

Fig 3.2

Here the graph drawn between the Young's modules and composites. The T_6 was having the highest Young's modules value as compared to other.

Table - 3.2: The flexural properties of Carbon/E-glass hybrid composite

Sample Id	Load in N	Elongation in Mm	Flexural Modulus (Mpa)
F_1	950	5.3	55134.75
F_2	320	6.6	14913.64
F_3	150	9.0	5126.56
F_4	1030	13.9	22792.92
F_5	1390	8.6	49715.75
F_6	1520	5.7	82025.03

The above table shows the load and elongation and flexural modules values of composites with different orientations. Compare the all values with each other composites.

F_6 was having higher value of load capacity 1520N and elongation 5.7mm and flexural modules is 82025.03 Mpa.

F_1- Carbon Uni-Direction F_2- Carbon and E-Glass Bi-Direction F_3- Carbon Bi-Direction

F_4- E-Glass Bi-Direction F_5- E-Glass Uni-Direction F_6- Carbon and E-Glass Uni-Direction

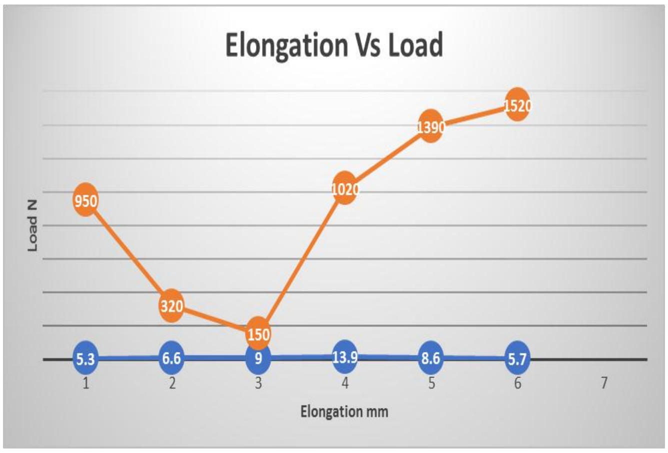

Fig 3.3

The results indicated that elongation and load of carbon/E-glass hybrid composite. It is evident that the highest load and highest elongation was found. This can be attributed that hybridization effect as both fibers contributed higher strength and elongation of the hybrid composite.

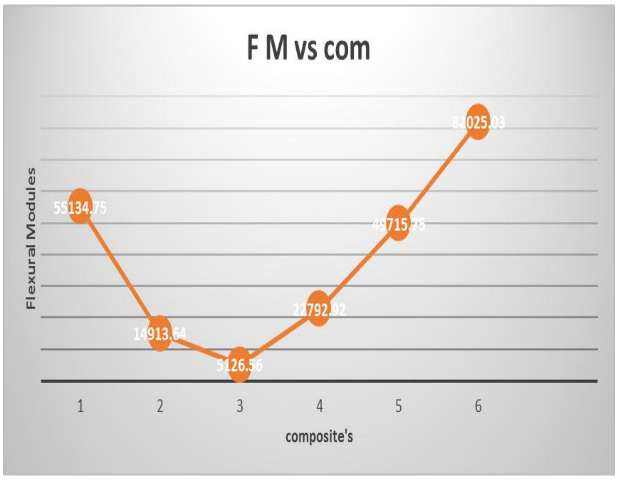

Fig 3.4

Here the graph drawn between the Flexural modules and composites. The F_6 was having the highest Flexural modules value as compared to other.

Table - 3.3: The Natural Frequency of Carbon/E-glass hybrid composite

Sample Id	Natural Frequency Hz
Fr_1	113.58
Fr_2	80.67
Fr_3	89.56
Fr_4	54.371
Fr_5	76.01
Fr_6	120.40

The above table shows the natural frequencyvalues of composites with different orientations. Compare the all values with each other composites.

Fr_6 was having higher value of Natural Frequency value 120.40 Hz among other composite.

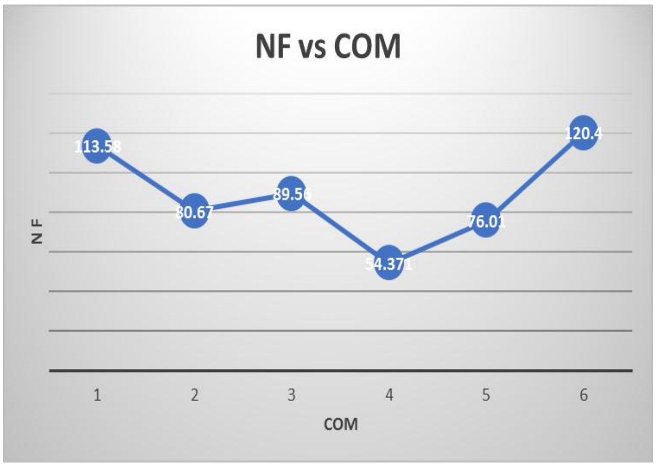

Fig 3.5

Here the graph drawn between the Natural Frequency and composites. The Fr_6 was having the highest Natural Frequency value as compared to other.

4. CONCLUSION

The following are the conclusions Based on the experimental and analytical observations of Carbon & E-Glass grass reinforced hybrid Synthetic fiber composite.

- Among all the specimens the properties of Carbon&E-Glass Uni-Direction hybrid composite have young's modules 157.56 Mpa and maximum elongation 4.3mm and ultimate load 8080 N.
- Among all the specimens the properties of Carbon&E-Glass Uni-Direction hybrid composite have Flexural modules 82025.03 Mpa and maximum elongation 5.3mm and ultimate load 1520 N.
- Among all the specimens the properties of Carbon&E-Glass Uni-Direction hybrid composite have maximum Natural Frequency 120.40 Hz by using ANASY software.
- By increasing the weight percentage of Carbon and E-Glass fiber, the mechanical properties also increase up to certain limit. Further, addition causes them to decrease due to poor interfacial bonding between fiber and matrix.
- Due to the high density of proposed synthetic fibers compared to the Natural fibers (Broom, corie fibers, etc...), the composites can be regarded as a useful engineering materials in light weight applications.
- Compared the all specimens with each other the Carbon&E-Glass Uni-Direction Hybrid Composite shows better results.

Future Scope of Work

There is a wide scope for future scholars to explore this area of research. This work can be further extended to study other aspects of Carbon/E-Glass hybrid synthetic fiber reinforced composites.

The present investigation is limited to the finding of mechanical properties only. It can be extended to

- In the present investigation, study of Carbon/E-Glass fiber with orientation of fiber only. This can be further enhanced to 50 % fiber content and 50 % matrix through other fabrication techniques.
- Optimization studies.
- Water absorption studies.
- Experimental results can be compared with FTT.
- The work can be extended with various types of alkali treatments of fibers.

REFERENCES

[1] N. Nayak, S. Meher , and S. K. Sahu. Experimental and Numerical Study on Vibration and Buckling Characteristics of Glass-Carbon/Epoxy Hybrid Composite Plates, Elsevier, 2013.volo.1 888-895.

[2] C. Kyriazoglou, F.J. Guild, Finite element prediction of damping of composite GFRP and CFRP laminates – a hybrid formulation – vibration damping experiments and Rayleigh damping. Department of Mechanical Engineering, University of Bristol, Bristol BS8 1TR, UK .Composites Science and Technology 67 (2007) 2643–2654.

[3] J. Alexander and B. S. M. Augustine, Free Vibration and Damping Characteristics of GFRP and BFRP Laminated Composites at Various Boundary Conditions. Indian Journal of Science and Technology, Vol 8(12), DOI: 10.17485/ijst/2015/v8i12/54208, June 2015.

[4] P.S.Senthil Kumar, Karthik.K, Raja.T, Vibration Damping Characteristics of Hybrid Polymer Matrix Composite. International Journal of Mechanical & Mechatronics Engineering IJMME-IJENS Vol:15 No:01. , 153101-8282-IJMME-IJENS February 2015 IJENS.

[5] V. Tita, J. de Carvalho and J. Lirani Theoretical and Experimental Dynamic Analysis of Fiber Reinforced Composite Beams. Presented at COBEM 99 – 15th Brazilian Congress of Mechanical Engineering. 22-26 November 1999, São Paulo. SP. Brazil. Vol. XXV, No. 3, July-September 2003.

[6] E.Salin, Y.Liu, M.Vippola. Vibration damping properties of steel/rubber/composite hybrid structures. Composite Structures, Vol. 94, 2012, pp. 3327–3335.

[7] Kaushic Govindaraj, Suresh Balasubramaniam, Fabrication And Fabrication And Evaluation Evaluation Evaluation Of Mechanical Mechanical Mechanical Behaviour In Hybrid Behaviour In Hybrid Polymer Matrix Composites. Volume 1, Issue 7, Nov - Dec, 2014, ISSN (E): 2347-5900 ISSN (P): 2347-6079.

[8] Delphine Carponcin, Eric Dantras, Guilhem Michon , Jany Dandurand , Gwenaëlle Aridon d , Franck Levallois, Laurent Cadiergues, Colette Lacabanne, New hybrid polymer nanocomposites for passive vibration damping by incorporation of carbon nanotubes and lead zirconate titanate particles. (2015) Journal of NonCrystalline Solids, vol. 409. pp. 20-26. ISSN 0022-3093.

[9] B. S. Ben , B. A. Ben , Adarsh K , K. A. Vikram and Ch.Ratnam, Damping measurement in composite materials using combined finite element and frequency response method. International Journal of Engineering Science Invention (IJESI) ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org ‖ PP.89-97.

[10] P.Prabaharan GRACERAJ, Gopalan VENKATACHALAM, C. Pandi VELAN, A. Gautham SHANKAR , R. Chandan BYRAL. Analysis of mechanical behaviour of hybrid fiber (jute-gongura) reinforced hybrid polymer matrix composites. U.P.B. Sci. Bull., Series D, Vol. 78, Iss. 3, 2016 ISSN 1454-2358.

[11] Jyothish J Nair , Aji Augustine , Mahesh B Davanageri. Wear characteristics and vibration analysis of shell powder filled glass fiber reinforced epoxy composite laminates. eISSN: 2319-1163 | p ISSN: 2321-7308, Volume: 05 Issue: 11 | Nov-2016.