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Study Of Mechanical Behavoir Of Composite Material By Vibration Analysis

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***Abstract:** In present time there is an increasing need for an alternative material to conventional materials. Growing interest in using environmentally friendly materials brings natural fiber made the composite material in focus. They are strong, lightweight, cheap and biodegradable. But one needs to check whether its properties satisfy that of existing material. The target of the study is to experimentally justify biaxial fiber composite as a promising alternate material. The polymer composite samples are made with natural/synthetic fiber as reinforcement and a synthetic resin as matrix material. To find its natural frequency and damping of the composite materials, vibration test is carried out. ANOVA technique is used to find the level of the parameter.*

***Keywords:** Natural Fiber, Composite Material, Natural Frequency, ANOVA etc.*

I. INTRODUCTION

Industrialization is a major concern throughout the globe. It is a growing threat to nature due to the use of non-biodegradable artificial materials whose remains are not easily disposable and non-renewable. Engineers are shifting their focus toward the design of an alternate material that is compatible and less harmful to the environment. Various industries and engineering application show increase in development of green composite material. This has lead to the development of natural fiber polymer matrix composite.

The composite material is a combination of two materials (matrix and reinforcement) having a distinct boundary, which when combined provides superior property than the parent materials. The resin (matrix) protects the fiber (reinforcement) from unsuitable external/ environmental conditions and bonds together for effective transfer of applied load.

Natural fiber composite is made with natural fiber as reinforcement and natural/ synthetic resin as matrix [34]. Examples of natural fiber are jute, hemp, cotton, bamboo, sisal, coir, banana, flax, etc.

Natural fiber made polymer composites are replacing synthetic fiber due to higher specific properties. Natural fiber has low density, high stiffness, and specific strength. They are easily available, partially recyclable, environment-friendly and cheaper. They can be manufactured with ease but they have a high level of moisture absorption capacity, low thermal resistance, poor dimensional stability and the insufficient adhesion between untreated fibers and the polymer matrix may act as a major restriction on the successful use of natural fibers in many applications.

Composite materials find a vast field of applications such as automobile, aerospace, railway coaches, consumer products, building construction, etc.

II. LITERATURE REVIEW

The metamorphosis of composite material has succeeded most of the conventional material in aerospace industry, sporting goods industry, automotive industry and home appliance industry. Fiber reinforced material have been widely successful in hundreds of application where there was a necessity of high strength materials. The composite material has a better combination of properties that can be comprehended by the amalgamation of a matrix phase and dispersed phase than is possible with the conventional metal alloys, ceramics, and polymeric materials. The composite material can be customized to converge the specific requisite of stiffness and strength by adjusting alternate layers of fibers, binders, and orientation. The composite material is appropriate for structural application where strength and stiffness ratios are considered. It is very important to carry out the vibration analysis of composite structures to understand its behavior in the real application because if the frequency of any load variation matches the resonant frequency then it may lead to the failure of the structure. A number of research scholars have given many pivotal ideas in the field of vibration analysis in last few decades.

Natural fibers are complex mixtures of organic materials and as a result, thermal treatment leads to a variety of changes in the microstructures. The thermal stability of natural fiber can be determined by thermogravimetric analysis [1][2]. The matrix phase plays a crucial role in the performance of fiber reinforced composites. In composites the specification is different because it involves resin, curing agents, promoters, catalysts, activators, hardeners etc [3]. The properties of natural fiber reinforced composites depend on a number of parameters such as fiber volume fraction, the aspect ratio of fibers, stress transfer at the interface and orientations. The various studies on natural fiber involve the study of mechanical properties as a function of fiber content, the effect of various treatments of fibers and external additive agents [4][5][6][7]. Fiber reinforced composites have aroused great focus in industrial application due to their high strength and stiffness. Conventional vacuum infusion process has been used to manufacture large fiber reinforced composites. The vacuum is used to draw the resin in and air out to reduce the chance of voids in the laminated plates [8]. However, even despite additional attachments such as bleeders, breathers etc evacuated air cannot be effectively removed from the resin used in the process. On the other hand pressure gradients that develop during the infusion causes a thickness gradient across the part which adversely affect the fiber volume fraction, void content and mechanical behavior [9]. Voids are detrimental to particular matrix dominated mechanical properties of composites, including interlaminar shear, compressive and flexural strengths [10]. One of the most important parameters in our research is the fiber orientation. It affects the surface integrity of the fiber reinforced composites [11]. The application of natural fiber is motivated by a combination of environmental sustainability, cost effectiveness, and biodegradable nature [12]. The use of natural fiber as reinforcement in the structural application is rapidly taking place mainly in the automotive sector. Some renewable fibers that researchers have used are jute, sisal, hemp, coir etc [13]. Damping is of prime importance in the study of composite structures vibration behavior. However, the properties of composite materials have not yet been completely identified [14]. To examine the effect of delaminating length on the frequency of the composite beam in the linear beam, it is important to be aware of the possibility of entering the nonlinear elastic behavior domain [15].

III. METHODOLOGY

1. Material

The materials used in this experiment are a natural fiber, glass fiber as reinforcement and resin as a matrix. The natural fibers used are jute, hemp, sisal. Epoxy resin, Vinyl ester and GP (general purpose) with a certain proportion of promoter, catalyst, and hardener were used as the resin.

2. Fabrication method

2.1 Fiber

In the present paper, natural fiber sheets were used as reinforcing material due to its favorable properties. Initially, the specimen is prepared with a dimension 400mm*50mm, glass fiber, natural fiber (jute, hemp, sisal).

Fig 1.

2.2 Matrix

1-2% (promoter+ catalyst+ hardener) was added to Vinyl ester.
The hardener was blended with Epoxy resin in a ratio of 10:1.
1% (catalyst+ hardener) was added to GP.

2.3 Specimen preparation

Taguchi’s design/ method (orthogonal array) is product/ process optimization method which is based on steps to find the best among the control factors to achieve higher signal: noise ratio. Each row and column in the array represent a specific/ control factor.

Three factors of matrix and reinforcement (X, Y, and Z) and three values/ levels of each factor (1, 2, and 3) were considered for the preparation of composite specimen.

The design of experiment (DOE) procedure according to Taguchi is as follows:
1) Identifying the Product / Process objective.
2) Determining the noise factor i.e. design parameters affecting the product characteristics.
3) Identification of response variables & control factors and their levels.
4) Selection of the orthogonal array matrix.
5) Conducting the matrix experiments.
6) Analysis of the data and prediction of optimum level.

Accordingly, 9 specimens of the different combination were prepared.

It can be tabulated as:

Specimen 1	X_1	Y_1	Z_1
Specimen 2	X_1	Y_2	Z_2
Specimen 3	X_1	Y_3	Z_3
Specimen 4	X_2	Y_1	Z_2
Specimen 5	X_2	Y_2	Z_3
Specimen 6	X_2	Y_3	Z_1
Specimen 7	X_3	Y_1	Z_3
Specimen 8	X_3	Y_2	Z_1
Specimen 9	X_3	Y_3	Z_2

Where,
X_1= Jute, Y_1= Vinyl ester, Z_1= 0 layer,
X_2= Sisal, Y_2= Epoxy resin, Z_2= middle layer,
X_3= Hemp, Y_3= GP, Z3=2, 4 layer.

Hand lay-up method was used for the preparation of samples.

Fig 2.

After preparing the specimens they are put in a vacuum bag for some time then heated in the oven.

Fig 3.

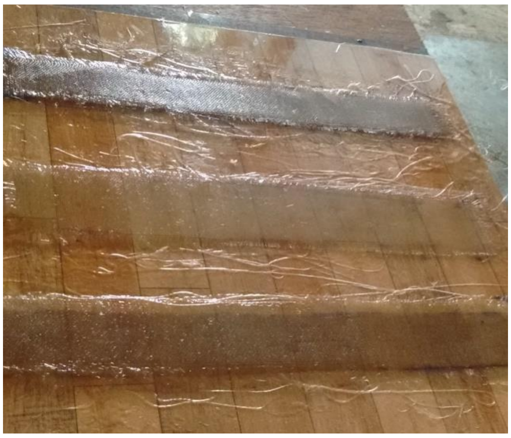

Fig 4.

For a duration of 3 hours the specimens containing Vinyl ester (i.e. specimen 1, 4, 7) were heated at 90 degree Celsius, that containing Epoxy resin (i.e. specimen 2, 5, 8) were heated at 100 degree Celsius and specimens containing GP (i.e. specimen 3, 6, 9) were heated at 70-80 degree Celsius.

After taking out the samples from the oven, they are keeping at room temperature for some time. Finally, they are cut to the required dimension of 350mm*25mm.

Fig 5.

Fig 6.

3. Vibration test

Vibration test is carried out, considering the samples as a cantilever beam. It is a non-destructive and highly repetitive test in determining the dynamic behavior of the specimens. Frequency and damping are computed from the experiment.
Fig shown below is the experimental setup of our testing.

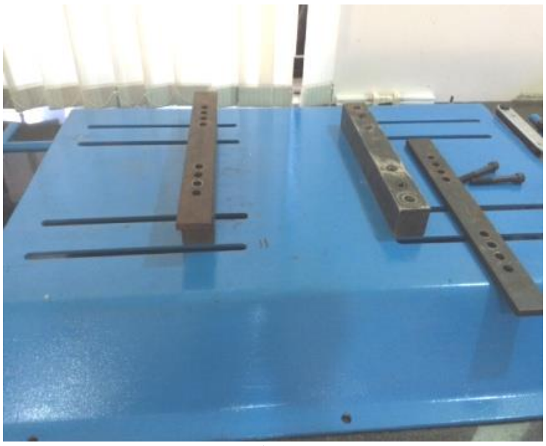

Fig 7.

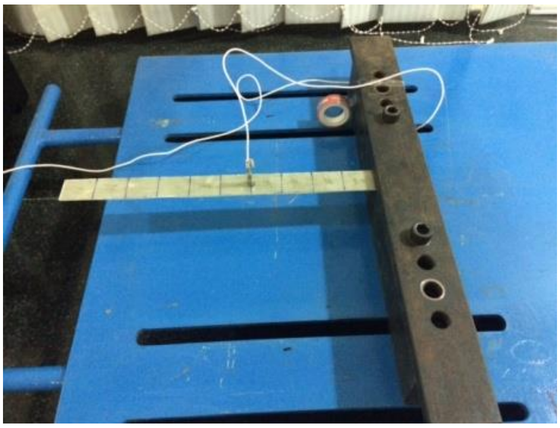

Fig 8.

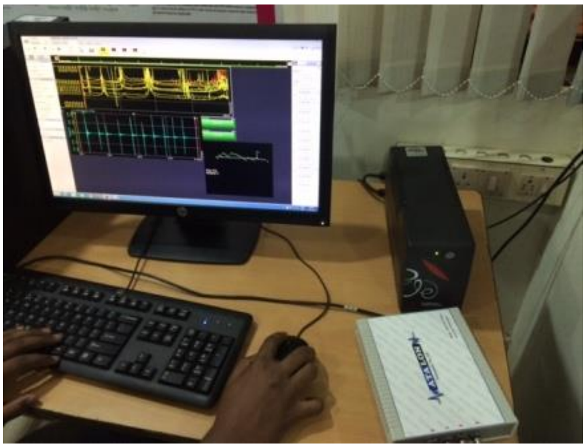

Fig 9.

Fig 10.

Dew soft: data acquisition (DAQ) and Impact Hammer

IV. RESULTS AND DISCUSSIONS

We have obtained the result by conducting vibration test using Dew soft: Data acquisition (DAQ), test and measurement solutions.

Specimen	N.F	Frequency (Hz)	Damping
1	1	8.6644	0.0070441
	2	44.536	-0.021013
	3	148.03	0.0273
2	1	11.713	-0.018639
	2	66.883	0.010023
	3	203.42	0.025579
3	1	11.437	-0.11504
	2	64.686	0.025203
	3	198.82	0.023071
4	1	13.904	0.037652
	2	83.219	0.03125
	3	252.43	0.013335
5	1	14.827	-0.019329
	2	82.02	-0.022709
	3	253.3	0.019729
6	1	7.8421	0.1239
	2	39.51	0.028392
	3	125.11	0.042188
7	1	14.488	-0.1815
	2	77.16	0.01796
	3	238.12	0.027512
8	1	7.1319	-0.044939
	2	40.031	0.013923
	3	125.16	0.022097
9	1	9.566	-0.8303
	2	48.623	0.018864
	3	150.72	0.028692

CONCLUSION

The cantilever beam with the static loading of the composite material under vibration testing provides quick response for pre-load as well as end displacement properties with the fundamental frequency and damping ratio. Transverse vibration techniques were applied as it is a non-destructive evaluation. During observation, it is revealed that if we increase the fiber volume fraction% of the composite material then it will lead to increase the damping factor of the material. Another important parameter we have observed is Humidity. Although it is an environmental but it affects the fiber composition during the fabrication. Natural as well as synthetic fiber absorbs moisture from the atmosphere it leads to the degradation of matrix strength and stiffness properties. It also increases the strain component in the matrix material.

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