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Investigation on Dynamic Behaviour of Hybrid Sisal/Bagasse Fiber Reinforced Epoxy Composites

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Abstract*— The present study deals with transverse vibration analysis of hybrid sisal-bagasse fabric reinforced epoxy composites. The hybrid sisal-bagasse composite are prepared by hand lay-up technique using treated sisal and bagasse as reinforced materials and commercially available epoxy resin as a matrix material. Hybrid sisal-bagasse fabric reinforced epoxy composite having aspect ratio of 0.83 with 5 layers of cloth for hybrid sisal-bagasse composite with fiber direction orientation at [+90°/+45°/0°/-45°/-90°] composite is prepared. In the analysis, a frequency domain model is used along with Frequency Response Function (FRF) measurements obtained from the plate. These measurements are made using a Fast Fourier Technique (FFT) based spectrum analyzer. Natural frequency, damping factor and mode shapes are obtained from the composites.

***Keywords*—Transverse vibration; matrix material; mode shapes; Frequency Response Function; damping factor; Natural frequency**

I. Introduction

In recent years, the natural fiber reinforced composites have attracted substantial importance as a potential structural material. The attractive features of the natural fibers like jute, sisal, coir and banana have been their low cost, light weight, high specific modulus, renewability and biodegradability. Even though the basic concepts of composite materials were known from ancient times, the development of advanced composite materials such as boron epoxy, Kevlar epoxy, glass epoxy, carbon epoxy, etc., suitable for modern engineering applications has received attention only in recent past [1].Non-conventional fibers such as jute, sisal, coir, banana, palm fibers etc., are extracted from stem/leaf/fruit of plants. Among all these fibers, jute and sisal have an advantage over other fibers [2]. Sisal fibers are available in the fiber form. Bagasse is the fibrous matter that remains after sugarcane or sorghum stalks are crushed to extract their juice. It is used as a biofuel and in the manufacture of pulp and building materials. These fibers posses moderate strength and stiffness. Easy availability of these reinforced materials, availability of only a few mechanical properties of these fibers induced the interest and curiosity to take up this work.

The objective of the present work is to determine the damping factor and mode shapes for a cantilevered Rectangular symmetric plate of hybrid sisal-bagasse fabric reinforced epoxy composite with fiber orientation [+90°/+45°/0°/-45°/-90°] using a Fast Fourier Technique (FFT) based spectrum analyzer.

II. EXPERIMENTATION

The hybrid sisal-bagasse composite are prepared by hand lay-up technique using treated sisal and bagasse as reinforced materials and commercially available epoxy resin as a matrix material. Hybrid sisal-bagasse fabric reinforced epoxy composite having dimensions 300x300x3.8 mm is as shown in Fig. 1

Fig .1: Hybrid sisal-bagasse composite

Block diagram of experimental set up and Experimental setup is as shown in Fig.2. & Fig. 3 respectively.

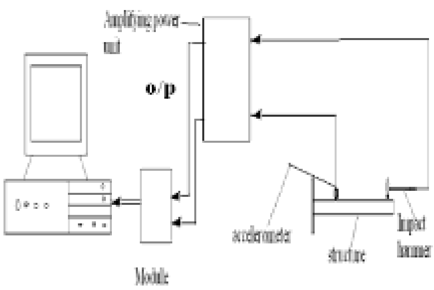

Fig. 2: Block diagram of experimental set up

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Fig. 3: Experimental set up

A grid of 7x6 (42 points) measurement points are marked over the surface of the composite .The composite is then clamped on test fixture and an impulse technique was used to excite the structure by impact hammer with force transducer built in to the tip to register the force input. The excitation signal is fed to the analyzer through amplifier unit. A piezoelectric accelerometer stuck on the desired measuring point of the specimen senses the resulting vibration response. The accelerometer signals were conditioned in the charge amplifier and fed to the analyzer. The analyzer in conjunction with Fast Fourier Transform (FFT) gives mathematical relation between time and Frequency Response Spectrum (FRS) and coherence functions are registered in the selected frequency range. At each grid point five measurements were made and their average was obtained. The output data of all 42 measurements was used as an input data for LABVIEW- 2009 package to identify response frequencies. From the response frequencies natural frequencies, damping factor and mode shapes were obtained and animated [3].

Table 1 and Table 2 shows the modal properties of sisal composite and hybrid sisal-bagasse composite and that are obtained using experimentation.

TABLE I
MODAL PROPERTIES OF SISAL COMPOSITE
DIMENSION: 300X300X3.8 MM
ASPECT RATIO: 0.83

Mode No.	Frequency (f) (Hz)	Damping Factor (ξ) %
1	24.35	3.20
2	45.50	2.09
3	129.07	0.53
4	165.51	1.19

TABLE III
MODAL PROPERTIES OF HYBRID SISAL-BAGASSE COMPOSITE DIMENSION: 300X300X3.8 MM
ASPECT RATIO: 0.83

Mode No.	Frequency (f) (Hz)	Damping Factor (ξ) %
1	24.009	3.547
2	47.804	3.682
3	129.448	2.166
4	147.595	2.087

III. RESULTS AND DISCUSSIONS

A hybrid sisal-bagasse fabric reinforced epoxy composite having dimensions 300x300x3.8 mm were tested for input frequency of 250 Hz to obtain modal properties. The structural testing, analysis and reporting (LAB VIEW-2009) software which uses frequency response function (FRF) method to identify the modal parameters of a structure is used. As explained, in this method, FRF measurements are made with an FFT analyzer and transferred to the lab view system for processing and curve fitting. Table 1 shows the modal frequency and the damping factor of Hybrid Sisal-bagasse composite.

Fixed excitation is used here to obtain the response at various points on the specimen and results are also obtained at all points. Each peak from left to right shown in Fig.4 relates to corresponding mode shapes from 1 to 4 of hybrid sisal-bagasse composite. The first four experimental mode shapes obtained for hybrid sisal- bagasse composite plates are given in Fig.5.

The mode shapes give the information of dynamic behavior of composite under various natural frequencies. The mode-1 is called as fundamental mode in bending, mode-2 is in twisting and the rest of the modes are under combination of bending and twisting [8]. The average damping factor obtained for fundamental frequency of hybrid sisal-bagasse composite is 1.15 times greater than the sisal composite. However, the damping factors of hybrid sisal-bagasse reinforced epoxy composites are higher than that of conventional composites and monolithic materials.

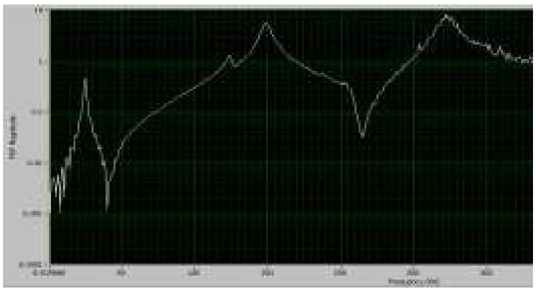
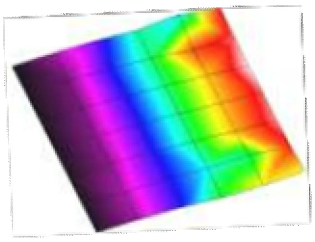
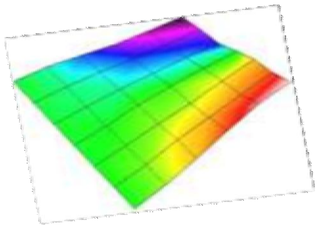


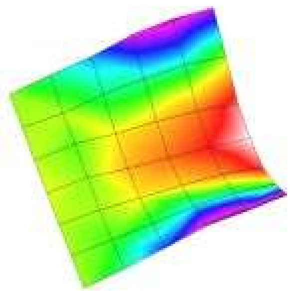
Fig.4: Magnitude – frequency response of hybrid sisal-bagasse composite.



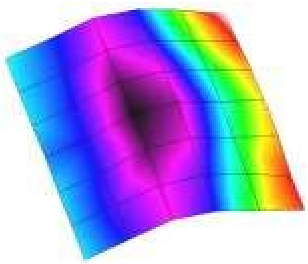
Mode : 1
Frequency : 24.009
Damping factor : 3.547



Mode : 2
Frequency : 47.804
Damping factor : 3.682



Mode : 3
Frequency : 129.448
Damping factor :2.166



Mode : 4
Frequency : 147.596
Damping factor : 2.087

Fig.5: Modal shapes of hybrid sisal-bagasse composite.

III.1 Comparison Between the Experimental Results of Sisal and Hybrid Reinforced Composite.

From table 1 and table 2 it can be observed that the average damping factor obtained for fundamental frequency of hybrid sisal-bagasse composite (3.682%) is 1.15 times higher than that of sisal composite (3.20%).The variation in damping factor is due to difference in flexural stiffness of hybrid sisal-bagasse composite and sisal composite and changes in the fiber angle that yields to different dynamic behavior of the composite.

IV. CONCLUSIONS

The main emphasis of the present work is on development, testing and characterization of hybrid sisal-bagasse fabric reinforced epoxy composites to know their suitability and adaptability for various structural applications. Experimentally determined the natural frequency and mode shapes for hybrid sisal-bagasse composite by using Fast Fourier Technique (FFT) analyser.

a) The average damping factor obtained for fundamental frequency of hybrid sisal-bagasse composite (3.681%) is 1.15 times higher than that of sisal composite (3.19%). The variation in damping factor may be due to difference in flexural stiffness of hybrid sisal-bagasse composite and bagasse composite and changes in the fiber angle yields to different dynamic behavior of the composite.

b) Hybrid sisal-bagasse fabric reinforced epoxy composites possess good damping factor as compared to conventional composites. Therefore, these composites can be used as vibration absorbing materials in certain applications such as automobile industries, for house construction roofing material and for indoor applications.

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