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EXPERIMENTAL STUDY OF DYNAMIC BEHAVIOUR OF HYBRID JUTE/SISAL FIBRE REINFORCED POLYESTER COMPOSITES

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Abstract: The present study deals with transverse vibration analysis of hybrid jute-sisal fabric reinforced polyester composites. The hybrid jute-sisal laminate are prepared by hand lay-up technique using untreated woven jute and sisal as reinforced materials and commercially available polyester resin as a matrix material. A cantilevered rectangular symmetric plate of hybrid jute-sisal fabric reinforced polyester composite having aspect ratio of 0.83 with 5 layers of cloth for hybrid jute-sisal laminate with fibre direction orientation at [+90°/+45°/0°/-45°/-90°] laminate 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 laminates.

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

1. INTRODUCTION

In recent years, the natural fibre reinforced composites have attracted substantial importance as a potential structural material. The attractive features of the natural fibres 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 fibres such as jute, sisal, coir, banana, palm fibres etc., are extracted from stem/leaf/fruit of plants. Among all these fibres, jute and sisal have an advantage over other fibres [2]. Jute is available both in fibre/strand and mat form, and sisal fibres are available in the fibre form. These fibres 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 jute-sisal fabric reinforced polyester composite with fibre orientation at [+90°/+45°/0°/-45°/-90°] using a Fast Fourier Technique (FFT) based spectrum analyzer.

2. EXPERIMENTATION

The hybrid jute-sisal laminate are prepared by hand lay-up technique using untreated woven jute and sisal as reinforced materials and commercially available polyester resin as a matrix material. A cantilevered rectangular symmetric plate of hybrid jute-sisal fabric reinforced polyester composite having dimensions 300x300x3.8 mm is as shown in Fig. 1.

Fig .1: Hybrid jute-sisal laminate

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

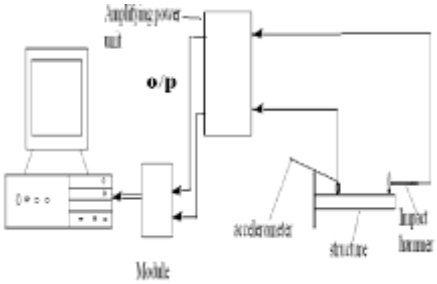

Fig. 2: Block diagram of experimental set up

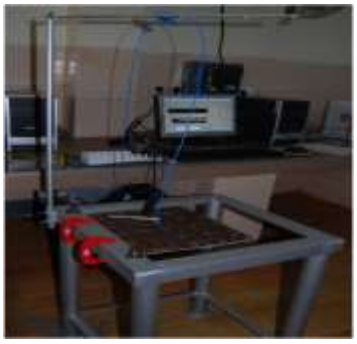

Fig. 3: Experimental set up

A grid of 7x6 (42 points) measurement points are marked over the surface of the laminate .The laminate 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 jute laminate and hybrid jute-sisal laminate and that are obtained using experimentation.

Table 1: Modal properties of jute laminate [7]

Dimension: 300x300x3.8 mm

Aspect ratio: 0.83

Mode No.	Frequency (f) (Hz)	Damping Factor (ξ) %
1	24.34	3.19
2	45.49	2.08
3	129.06	0.52
4	165.50	1.18

Table 2: Modal properties of hybrid jute-sisal laminate

Dimension: 300x300x3.8 mm

Aspect ratio: 0.83

Mode No.	Frequency (f) (Hz)	Damping Factor (ξ) %
1	24.008	3.546
2	47.803	3.681
3	129.447	2.165
4	147.595	2.086

3. RESULTS AND DISCUSSION

A cantilever test plates of hybrid jute-sisal fabric reinforced polyester 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 Jute-Sisal laminate. 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 jute-sisal laminate. The first four experimental mode shapes obtained for hybrid jute-sisal laminate plates are given in Fig.5.

The mode shapes give the information of dynamic behavior of laminate 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 jute-sisal laminate is 1.15 times greater than the jute laminate. However, the damping factors of hybrid jute-sisal reinforced polyester composites are higher than that of conventional composites and monolithic materials.

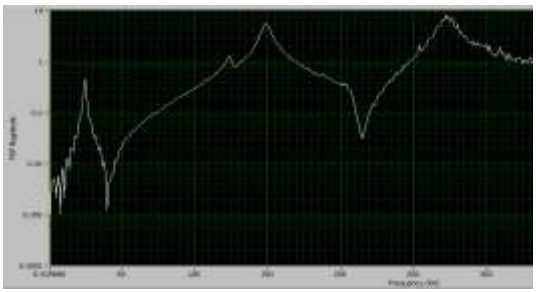

Fig.4: Magnitude – frequency response of hybrid jute-sisal laminate

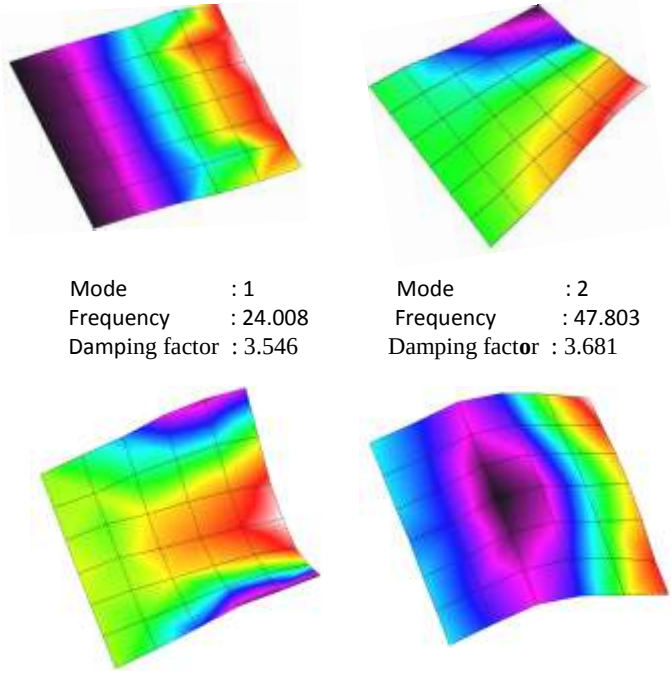

Fig. 5: Mode shapes of hybrid jute-sisal laminate

3.1Comparison Between the Experimental Results of Jute and Hybrid Reinforced Composite Laminate.

From table 1 and table 2 it can be observed that the average damping factor obtained for fundamental frequency of hybrid jute-sisal laminate (3.681%) is 1.15 times higher than that of jute laminate (3.19%).The variation in damping factor is due to difference in flexural stiffness of hybrid jute-sisal laminate and jute laminate and changes in the fibre angle that yields to different dynamic behavior of the composite laminate.

4. CONCLUSION

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

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

b) Hybrid jute-sisal fabric reinforced polyester 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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