Evaluation of Free Vibrational Behavior of Sisal Mat / PVC / Sisal Mat Sandwich Polyester Composites

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***Abstract*— Sandwich composites are fabricated by using two external skins (faces) and a Polyvinyl chloride (PVC) as core material (C). In this experiment the composites with core are fabricated by using vacuum infusion technique. The composites are made-up by catalyzed unsaturated isophthalic polyester resin (VBR 4503) is used to inject into the porous cavity between the impermeable foam core and the external faces. The composite sandwich structure is made up of woven sisal mat (S) with PVC foam core. The layering pattern followed in sandwich structure is Sisal Mat/PVC/Sisal Mat. The key purpose of this experiment is to know the dynamic characteristics /free vibrational behaviors such as natural frequency and damping of sandwich structure. The vibration behaviors have been studied by impact hammer technique. Further the specimen was subjected to density test.**

Keywords—Sisal mat, PVC sandwich, impact hammer technique, natural frequency, damping.

I. INTRODUCTION

Sandwich composites are prepared by two thin face sheets like a woven type of fibers and a low density and thick core foam. Since the sandwich composites are having good specific strength-to-weight ratio, these are commonly used in many fields such as automobile industries, aircraft industries, civil and various experiments have been conducted by many researchers and also they studied about mechanical properties of composites [1-3]. Tagarielli et al [4] studied the different types of flexural property of sandwich composites. The conditions are fully clamped and simply supported beam types. Styles et al [5] fabricated a sandwich composite by using aluminum foam core. They experimented about the flexural loadings and the effect of foam core thickness. Shi Cheng et al [6] explored the free vibration analysis of polymer honeycomb structures by using beam theory. The same results compared with experimental results for validity. Frostig et al [7] explored the free vibration of sandwich specimens. They used compressible and incompressible core also they compared the results with analytical methods i.e. finite element methods. Mehdi Afshin [8] investigated the damping and vibration analysis of sandwich composites. The face skins are cross-ply layup and follows first-order shear deformation assumption and the centre foam is considered as a liner visco elastic medium. Apart from the experimental works, many classical theories also found in text books [9-11]. Rao et al. [12] investigated the vibration and damping behavior of composite structures. In the composite structure, they were embedded visco elastic layers.

In the present study, the dynamic behaviors such as natural frequency and damping behaviors of sandwich panels were studied experimentally. The sandwich panel was made up of using woven sisal fiber and PVC foam core. The sandwich composite consists of Sisal fiber mat/ PVC/Sisal fiber mat. Apart from the dynamic characteristics, density also studied.

II. EXPERIMENTAL DETAILS

A. Materials

Sisal weaved fiber (shown in fig. 1) used in this study was purchased from Shiva Exports, Tirunelveli, India. Unsaturated isothalic polyester resin, initiator and accelerator were supplied by Vasivibala resins private limited, Chennai, Tamilnadu, India. The properties of a sisal fiber are shown in Table 1.

TABLE. 1 Properties of sisal fiber

Fiber	Sisal
Cellulose (%)	65-70
Hemicellulose (%)	12
Lignin (%)	9.9
Moisture content (%)	10
Density (g/cc)	1.450
Micofibrillar Angle (°)	20
Tensile strength (MPa)	68
Young’s modulus(GPa)	3.8

B. Fabrication of Composites

The sandwich composite was fabricated (shown in fig. 2) by using Vacuum assisted Infusion technique. Initially the surface of the produced composite area was cleaned and wax was applied. According to the layering sequence the woven sisal fiber mat on two extremities and PVC in the core position were layered over the area of the cleaned surface.

III. VIBRATION TESTING

A. Experimental set-up for Modal Analysis

Fig. 1 shows the experimental setup used for conducting the free vibration analysis of sandwich composite specimens using as Impact hammer. At the end of the rectangular specimen (200mm×20mm×3mm), the accelerometer (Kistler model 8778A500) is fixed with the help of using wax [28]. For obtaining higher frequencies, the modally tuned impact hammer with sharp hardened tip (Kistler model 9722A500) was selected. Data acquisition system (DEWE 43, Dewetron Corp., Austria) (DAS) and ICP conditioner (MSIBRACC) was used to record the displacement signal, which is obtained from the accelerometer. A personal computer also used to record the outputs from the specimens. Further two adaptors were used to record the output signal. In which one adaptor used to receive the accelerometer signal. Then one more accelerometer gauging the magnitude of the response by the hammer from the specimens.

B. Damping factor

To study the vibration characteristics of the sandwich composites, damping is essential. The half-power band width method was used to find the damping coefficient values of composites through the Frequency Response Function curves attained from the FFT analyzer. The damping values were calculated from the Equation 1.

$$\zeta = \Delta\omega / 2\omega n \qquad (1)$$

Where: ζ–Damping coefficient,

Δω – Bandwidth, and ωn –Natural frequency.

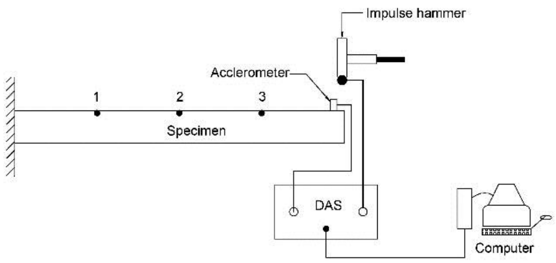

Fig. 1 Experimental setup for modal analysis

IV. RESULTS AND DISCUSSION

In sandwich composites, the natural frequency depends upon several reasons such as the name of the fiber used, length of the fiber used, woven or non-woven type, resin, density of the composite and etc. Hence the finding of natural frequency of fiber reinforced composites is not so easy to understand. In this present study, the first three modes (bending, twisting and second bending) of natural frequency of sandwich composites were studied to understand the behavior of sandwich composites. In this experiment the sandwich specimen was fixed like a cantilever beam i.e one end is fixed and the other end is free. In the free end of the sandwich composite, piezoelectric impact hammer was used to give the excitation. The name of the vibration is so called as free vibration (After given the initial excitation there is no continuous excitation applied). The force given at various places over the sandwich specimen. The response of the sandwich specimen was recorded by using an accelerometer at the free end of the specimen. The output of the free vibration test is frequency response function (FFT). The FFT curve has been shown in the fig. 4. The first three natural frequencies of sandwich composites are shown in figure 2. The natural frequencies are 85.45 Hz, 163.57 Hz, and 334.47 Hz (shown in fig. 2). It could be due to the face skins (sisal woven fibers) firmly bonded with the PVC and the stiffness of the foam core placed in between the face sheets. Further the thickness of the face skins is fixed or constant on both sides of the composite, the natural frequency gets increased when the thickness of the foam core is being increased or changed. The density of the PVC foam has observed as 0.214g/cc. It affects the natural frequency of the sandwich composite. It is observed that the natural frequency of the sandwich composite was decreased when the density of the foam increases [15]. Fig. 3 shows the damping of sandwich composites. It provides good damping compare to the other combinations of non-woven type of polymer composites. Due to the incorporation of PVC foam core in the sandwich structure, the damping was reached higher (shown in fig. 3).

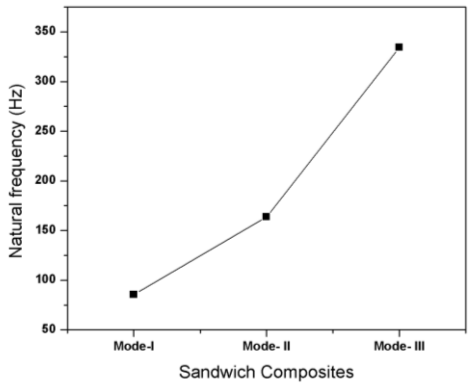

Fig. 2. Natural frequency of sandwich composites

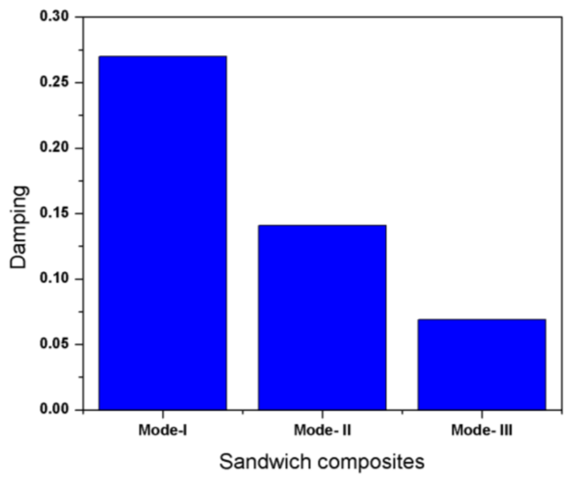

Fig. 3. Damping values of sandwich composites

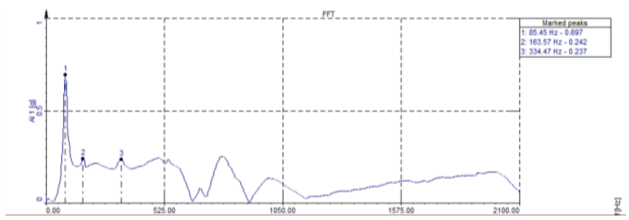

Fig. 4. Frequency Response Function of sandwich composites

IV. CONCLUSION

An experimental model to understand the vibration characteristics such as natural frequency and damping of sandwich composites was proposed. The following conclusion has been made from this present study.

1. The sandwich composite was fabricated by using woven sisal fiber and PVC. The pattern followed as Sisal woven fiber/ PVC/ Sisal woven fiber.
2. The sandwich composite was fabricated by using infusion technique.
3. The natural frequency and damping of the fabricated composites are 85.45 Hz, 163.57 Hz, 334.47 Hz and 0.270, 0.141, 0.069.
4. The density of the composite and thickness of the face skins and PVC influences the vibration behavior of sandwich composites.

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