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Free Vibration Behaviour of Glass Fiber Reinforced Polymer Composite

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Abstract: This paper mainly presents free vibration analysis of glass fiber reinforced composite. Glass fibers were treated with sodium hydroxide and hydrochloric acid solutions respectively. Hand lay-up method has been used to fabricate the composite specimen. Glass fiber reinforced polymer composites has been done by experimental method and FEM analysis for free vibration characteristics. Results indicated that the natural frequency of NaoH treated glass fiber reinforced composite shows better results than HCL treated and untreated glass fiber reinforced composites. At the same time the result shows that the damping ratio of the HCL treated glass fiber reinforced composite is higher than the untreated and NaoH treated glass fiber reinforced composite.

Key words: Glass Fiber Reinforced Composite · Mechanical Testing · Damping · Frequency

INTRODUCTION

Polymer matrix composite (PMC) is a composite having any one of its constituents in nano dimension. Due to multifunctional features such as high specific strength, flame resistance, water barrier resistance and chemical resistance associated with PNC finds application in defence sector, aerospace and automobile industries. This motivates several researchers to focus on different research issues associated with PMC.

Experimental study was carried out to investigate the mechanical properties such as tensile strength and modulus of polypropylene/glass fiber composite materials prepared using injection molding and compression molding. Results show that the tensile strength decreased with the increasing of glass fiber loadings which are attributed to the absence of adhesion between polypropylene and electrical type glass (E-glass) due to the difference in polarity between polypropylene and the hydroxyl groups on the fiber surface. In terms of fiber length, the samples prepared by using a 12 mm fiber showed higher tensile modulus and strength particularly at higher fiber loadings compared to samples prepared by using 3 mm or 6 mm fiber length [1]. Basalt and glass fibers were treated with sodium hydroxide and hydrochloric acid solutions respectively for different periods of time. Both the mass loss ratio and the strength maintenance ratio of the fibers were examined after the treatment. The morphologies of the fiber surfaces were characterized using scanning electron microscopy and their compositions were analyzed using energy dispersive X-ray spectroscopy. For the basalt fibers, the acid resistance was much better than the alkali resistance. Nevertheless, for the glass fibers, the acid resistance was nearly the same as the alkali resistance. Based on the experimental results, possible corrosion mechanisms are addressed [2]. Dynamic young's modulus and damping factors were measured for Kevlar 49 fiber reinforced composite experimentally. Kevlar fibres have high stiffness and damping than glass and yet they costs lesser than graphite fibres. The dynamic properties measured in the experiments described here are important for successful design of dynamically loaded components made of such a material [3]. The resonance technique was used for determining the stiffness and damping factors for composite or composite structures. The resonance frequencies of a material or a system are function of its electrical properties, dimensions and mass. Pultruded GRP composites and optical fibre cables were investigated. The damping properties were determined by both a free exponential decay curve and half-peak bandwidth methods. The measured elasticity of optical cables was found to be in good agreement with the derived theoretical value [4].

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Table 1: shows the properties of E-Glass fiber.

Property	Value
Tensile strength	3.1-3.8 GPa
Elastic modulus	72.5-75.5 GPa
Elongation at break	4.7 %
Density	2.54-2.57 g/cm³

Table 2: Shows the properties of vinyl ester

Property	Value
Viscosity at 25°C, CPS	300 - 400
Specific gravity at 25°C gm/ml	1.05 - 1.06
Acid value, mg KOH/gm	6 - 10
Volatile content, %	40 - 45
Gel time at 25°C, minutes*	25 - 30
Peak exotherm, °C**	160 - 170

Experimental Procedure: E-Glass fiber has been used as reinforcement. Vinyl ester resin is used as matrix, procured from Vasivibala resins (P) Ltd, Chennai, India. One weight percentage of Methyl Ethyl Ketone Peroxide (MEKP) and Cobalt Naphthenate has been used as catalyst and accelerator respectively for room temperature curing as per the manufacturer data.

MATERIALS AND METHODS

Hand Layup technique is the simplest form of fabrication technique in the field of composites. This method is used to fabricate simple and less volume of composites and is very cost effective. It also requires very less labour. The resin mixed with the hardener and catalyst and is mixed thoroughly with constant stirring. The mixture is wetted out or applied on the fiber lamina. Immediately the next lamina is placed on the previous lamina and again the mixture is applied on the same lamina. The process is repeated for required number of laminas and thus a laminate is fabricated. The laminate is then allowed to cure and a weight is applied on it for few hours. Thus the Hand Lay-up technique is a very simple fabrication process [5].

Experimental Setup for Modal Analysis: Figure shows experimental setup which has been carried out for modal analysis of glass fiber reinforced composites using impact hammer. The composite specimen having dimension of (200x20x3 mm) is clamped as a cantilever beam support upto a length of 30mm. The accelerometer is attached to the end of the rectangular specimen with wax. The sharp hardened tip impact hammer has been used for getting higher frequencies. The displacement signal from the accelerometer is directly recorded to the personal computer through data acquisition system (DEWE 43, Dewetron crop).

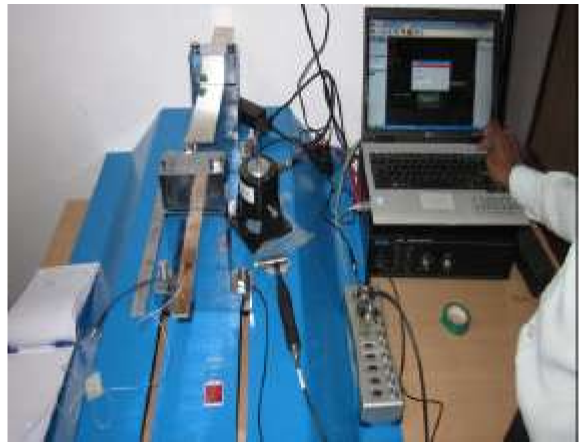

Fig. 1: Experimental setup for modal analysis of basalt fiber reinforced composite.

RESULT AND DISCUSSION

Test has been carried out on different specimens such as untreated, HCL treated and NaoH treated glass fiber reinforced composites. The composite specimen is clamped as cantilever beam support upto a length of 30mm. Then the specimen is excited using impact hammer on four equally spaced locations. The frequency response function curve was obtained directly from the software itself (DEWESOFT 7.0).

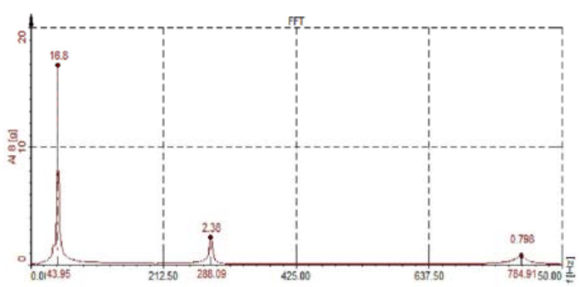

Fig. 2 shows the frequency response function curve for the untreated glass fiber reinforced composite obtained from the DEWESOFT 7.0.

Table 3: Shows the experimental value of natural frequency and damping factor for the glass fiber reinforced composites.

Mode		UTF	ATF	ALTF
1	Frequency	36.62	35.40	48.83
	Damping	0.04998	0.05172	0.03749
2	Frequency	229.49	225.83	290.53
	damping	0.01595	0.01622	0.01470
3	Frequency	612.79	617.68	803.22
	damping	0.00398	0.00988	0.00398

From the experimental results it is observed that the natural frequency of glass fiber reinforced composites increases after the alkali treatment and decreases after the acid treatment. The natural frequency of the alkali treated glass fiber reinforced composite is higher than the acid treated and untreated glass fiber reinforced composites.

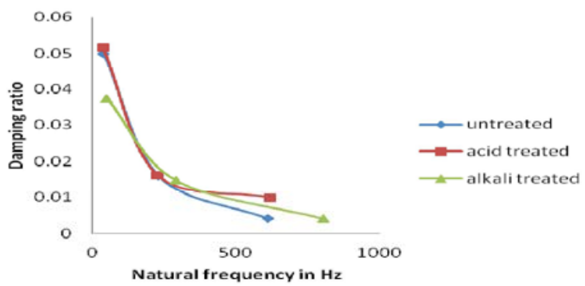

Fig. 3: Shows the damping ratio for corresponding natural frequency.

Damping coefficient factor for the first three modes has been calculated by half power method ($f= y_1- y_2/2y_n$). From the above graph it is clear that the damping ratio is high for acid treated glass fiber reinforced composite than the alkali treated and untreated conditions.

Comparison of Experimental Results with Theoretical Method: First three modes of natural frequencies for untreated, acid treated and alkali treated glass fiber reinforced composites are obtained using FEA method. The theoretical results are compared with the experimental values. Before go for theoretical analysis, flexural test has been conducted for all the specimens as per ASTM D 790 in order to determine the young's modulus and the density has been obtained as per ASTM D 792.

Table 4: Shows the value of young's modulus and density for glass fiber reinforced composite.

Condition	Young's modulus (gpa)	Density (kg/cm^3)
Untreated	5.04	1944.59
HCL treated	4.82	2141.03
NaoH treated	6.01	1784.30

Finite element analysis has been done using the software ANSYS. In that software, SOLID BRICK 8NODED 45 a linear structural element is used to model the beam. Young's modulus and density was determined experimentally which is used for finite element analysis. The experimental results have been compared with the FEA method and numerical method.

From the table it is clear that the there is small variation in the natural frequencies in the FEA method and it is due to the assumption of the material as quasi-isotropic.

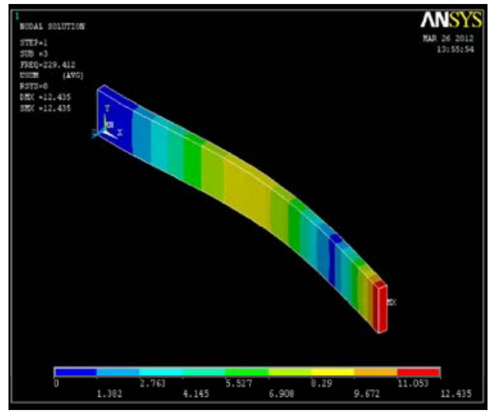

Fig. 3 shows the bending mode shape of the mode 2 natural frequency value for the untreated condition.

CONCLUSION

The untreated, acid treated and alkali treated glass fiber reinforced composite laminates are fabricated to study the effect of treatment of fibers on the characteristics of free vibration response. Natural frequencies of the glass fiber reinforced composite is found to be high for NaoH treated glass fiber reinforced composite than the HCL treated and untreated fiber reinforced composites. Natural frequency decreases after the acid treatment and increases after the alkali treatment of fibers. Experimental results of natural frequencies are compared with FEA results. Natural frequency and damping ratio of the glass fiber reinforced composites is investigated and is significantly influenced by the treatment of fibers. Natural frequency of the alkali treated glass fiber reinforced composites shows better results than the acid treated and untreated glass fiber reinforced composites. Damping ratio is found to be high for acid treated glass fiber reinforced composite when compared with untreated and alkali treated glass fiber reinforced composite.

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