Comparison of Vibration Characteristics of Synthetic, Natural and Hybrid Composite Laminate

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Abstract:- **In the growing aeronautical field, the composite materials are employed to enhance the strength of the structural components and to achieve high resistance to the stresses that are caused due to the exposure of those components to the high velocity air stream during flight. These components are often subjected to vibrational stresses which causes structural damage and degradation in physical properties of those components. Hence it is important to investigate the characteristics of the composite materials under vibrational stresses.**

INTRODUCTION

In this study, the vibration analysis on various laminates is carried out to determine the natural frequencies and damping ratios. Here, fiber glass epoxy laminates (synthetic), Jute epoxy (natural) and hybrid (combination of fiber glass and jute fibers) composite laminates were fabricated. Each laminates were fabricated by hand layup method with 12 layers of plies. The fabricated laminates were cut into specimens of required dimensions. Experimental vibration analysis is carried out on each specimen using FFT analyzer with fixed-free boundary conditions and results were discussed.

COMPOSITES

A composite is a structural material that consists of two or more constituent materials, with significantly different physical or chemical properties.

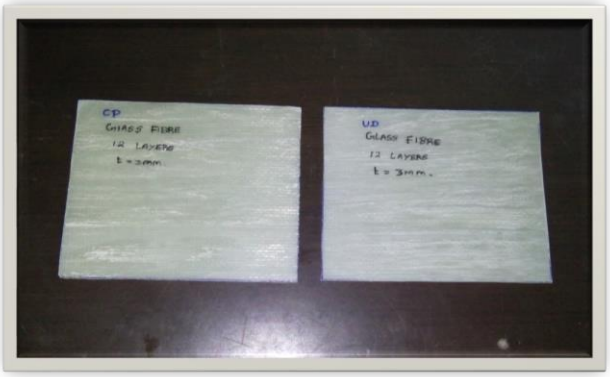
Composites are becoming an essential part of today's materials because they offer advantages such as low weight, corrosion resistance, high fatigue strength etc., .In airplane structures, the composite materials are employed to enhance the strength of the structural components and to achieve high resistance to the stresses that are caused due to the exposure of those components to the high velocity air stream during flight.

MATERIALS

The main constituents of composites are fibre(reinforcement material) and matrix. In this study, both the natural and synthetic fibres were used. For natural fiber, jute is taken and glass fiber for synthetic. Epoxy resin with hardener is used as matrix. In this experiment, four different laminates namely unidirectional fibre glass epoxy laminate, crossply fibre glass epoxy laminate, jute epoxy laminate and hybrid(combination of glass and jute fibres) laminate were fabricated with a dimension of 150 × 150 mm. Each laminates were fabricated with 12 layers of plies(fibres). Then the laminates were cut into specimens of dimension 100 × 100 mm.

FABRICATION

Composite laminates were fabricated using hand layup method. Required number of jute and glass plies were taken. A smooth and flat platform was selected and the nylon sheet was placed on it. Now, wax was applied on the sheet as a releasing agent. Then the gel coat(which is a mixture of resin and hardner in the ratio of 1:10) was applied over the layer of wax. Now, the first layer of reinforcement material was placed on the gel coat. The gel coat was again applied gently over this ply using brush. Then the next layer of ply was placed on it. Any air gaps (or voids) present were removed using roller. Also extra resins were extracted by this action. The same procedure is followed for all layers of plies.



SPECIMENS- GLASS EPOXY LAMINATES

SPECIMENS- HYBRID AND JUTE LAMINATES

TESTING

The test setup consists of accelerometer, Multichannel Analyzer (DEWE box), impact hammer, fixture, fixing tools, connecting cables, Adhesive, Computer system, Test specimen. The specimens were tested with fixed-free boundary condition.Vibration analysis is carried out using FFT analyzer. The test setup consists of Accelerometer, Analyzer (DEWE box), Fixture, Impact hammer, system. The specimen is fixed on the fixture with fixed- free end condition. Then the accelerometer (which measures the vibrations of the structure) is fixed on the surface of the specimen. The load is applied on the specimen using impact hammer to which load cell is attached to record the force.

Now, sensor (accelerometer) gets exited and the voltage corresponding to vibration of specimen is generated by it. The generated signal is given as input to the analyzer. ADC in the analyzer converts this analogue signal to a digital signal which is processed by DEWE software in the system and results are obtained in the graphical form.

RESULT

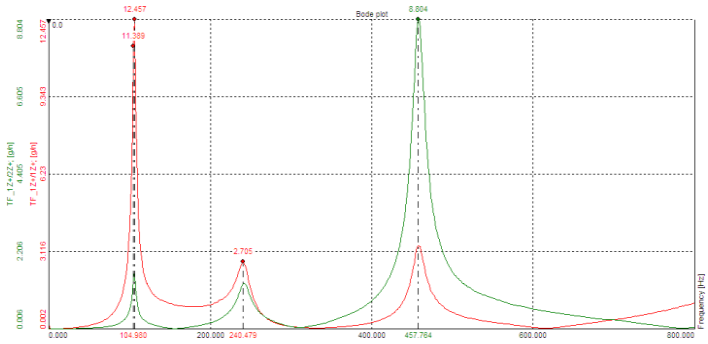
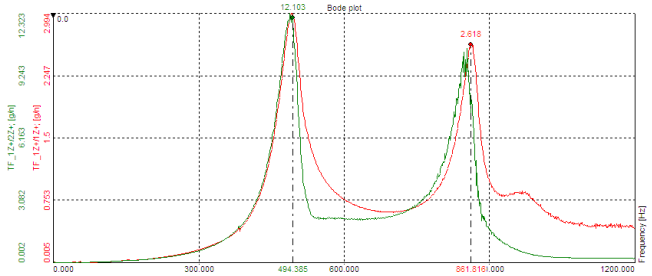


Plate	Mode no	Natural frequency (HZ)	Damping ratio
Hybrid composite plate – glass and jute fibers	1	494.385	0.088631
	2	861.816	0.040176

Plate	Mode no	Natural frequency (HZ)	Damping ratio
Fiber glass epoxy plate – crossply(0/90)	1	104.98	0.035916
	2	240.47	0.065991
	3	457.7654	0.031407



CROSS PLY FIBRE GLASS EPOXY LAMINATE

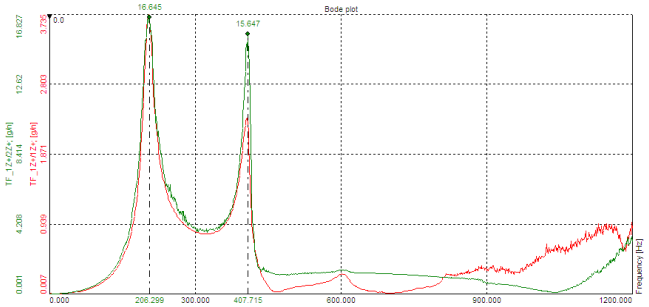


Plate	Mode no	Natural frequency (HZ)	Damping ratio
Fiber glass epoxy plate – unidirectional (0/0)	1	206.299	0.10601
	2	407.715	0.040086

UNIDIRECTIONAL FIBER GLASS EPOXY LAMINATE

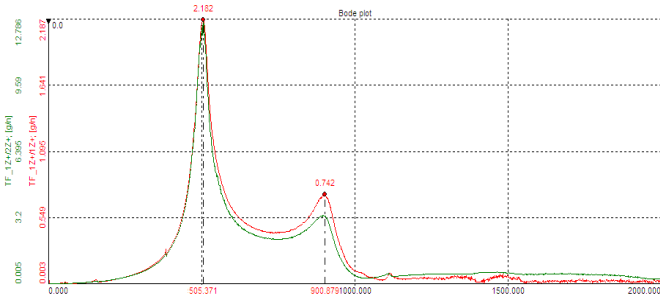
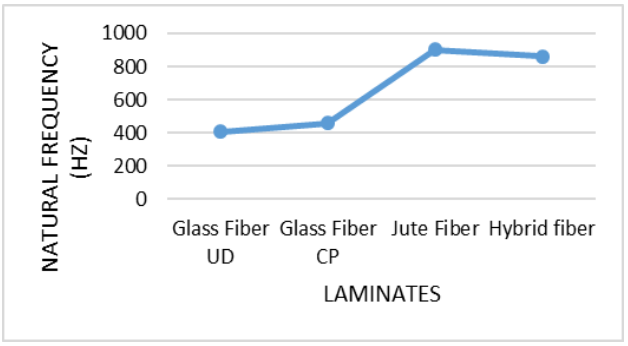


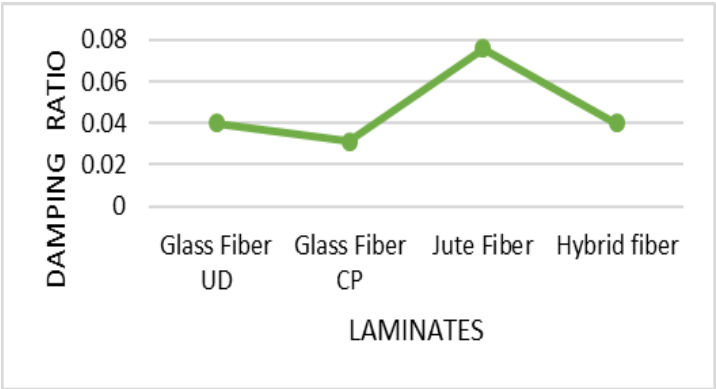
Plate	Mode no	Natural frequency (HZ)	Damping ratio
Jute epoxy plate	1	504.37	0.087132
	2	900.879	0.075882

HYBRID COMPOSITE LAMINATE



Natural frequencies of all laminates The above plot shows that the natural fiber jute epoxy laminate has greater natural frequency compared to other composite laminates. unidirectional glass epoxy laminate has lower natural frequency. However, the natural frequency of hybrid laminate is almost equal to jute lamin

DAMPING RATIOS OF ALL LAMINATES



Damping ratio relates actual damping to critical damping. Higher value of Damping ratio is obtained for jute epoxy laminate. Cross ply glass epoxy laminate has lower damping ratio than other laminates.

CONCLUSION

Composite laminates of different materials were fabricated by hand layup method and vibration analysis has been carried out using FFT analyzer, with fixed-free boundary condition and results are validated. The frequency response curves reveals that the natural frequency of natural fiber laminate is greater than the synthetic fiber and hybrid laminate. Damping ratio is high for jute laminate. However, the damping ratio values are lesser than 1, which represents the underdampes response of a system. Thus the natural fiber proves to be more effective than other materials which are subjected to vibrational stresses. Also natural fibers cause minimum health hazards during production and they are eco-friendly and renewable, which makes them effective replacement for synthetic fibres.

FUTURE WORKS

To fabricate composite laminates with different natural fibre materials and to conduct vibration analysis, to find the natural fibre laminate which has better vibration characteristics. To vary the orientations of various natural fibre laminates and to conduct vibration analysis to find better laminate orientation which has high vibration characteristics.

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