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EXPERIMENTAL AND FINITE ELEMENT ANALYSIS OF UNIDIRECTIONAL AND BIDIRECTIONAL FIBRE REINFORCED COMPOSITE CANTILEVER PLATES

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ABSTRACT

In vibration analysis mechanical resonance is a significant term. Resonance occurs when the frequency of its oscillations matches with the system's natural frequency of vibration. It may cause extreme swaying motion and the Structural failure in offensively constructed structures like bridges, buildings and airplane. This type of failure is known as resonance disaster. To avoid structural damage caused due to resonance, it is important to determine:

1. The natural frequencies to avoid resonance.
2. The mode shapes.

The generally steel components are corrosive in nature and difficult for loading due to heavy weight and transportation of heavy structures are also difficult so there is need to replace these materials by new materials.

INDEX TERMS: Natural frequency, Damping, etc.

INTRODUCTION

Composite material are well-defined as mixing of two or more than two materials (reinforcement, fillers, binder etc.) different in composition in small quantity. Composite materials are made from two or more than two constituent or materials with different chemical and physical properties, that when mixed make a material different from the individual components. There are many cases; the reinforcement is tougher, stronger, harder and stiffer than the matrix. The reinforcement is will be a fiber or a particulate. Particulate composites have almost same dimensions in all directions. Particulate composites are less stiff as compared continuous fiber composites and also they are less expensive. Particulate reinforced composites usually contain less reinforcement upto 40 to 50 percent. A composite has technologically advanced speedily in the earlier 30 years through the improvement of fibrous composites that is in glass fiber reinforced polymers (GFRP) and, more recently, carbon fiber reinforced polymers (CFRP). Their growing use in ground transport systems is an replacement of metals to increase usage which is still accelerating. It finds application in composite, Automotive, sport goods, medical equipment & packaging Industry.

The stiffness of the composite can be changed by stacking sequence and fiber orientation which allows for the altering of the material to achieve the desired natural frequencies and respective mode shapes without changing its geometry or increasing its weight. Their intrinsic anisotropy allows the designer to alter the material in order to achieve the desired performance requirements. Thus, it is an important to develop a tool that will allow the designer to obtain optimized designs considering the structural requirements and functional characteristics. This work considers the behaviour of components manufactured from fiber reinforced composite materials. To accomplish this, some plates are taken which are made by hand moulding process. Experimental tests are carried out using specimens with different thicknesses. From the results, the effect of the fibers orientations & number of layers on the natural frequencies and modal damping are investigated. These experiment results are used to validate the FEA results obtained from the ANSYS. The FEA and Experimental results are compared to analyze the composite plates.

Now a day's long fiber polymer are widely used in industries like aircraft and wind turbine components. Long fiber components are manufactured from carbon or glass fiber embedded in polymer like epoxy resin. Composite materials are ideal for structural application where ratio of high strength to weight and stiffness to weight are required. Aerospace applications are typical weight sensitive structures in which composite materials are cost effective. The study of composite materials involves many topics for example manufacturing processes, anisotropy, and elasticity strength of anisotropic materials. The main material properties for usual engineering mechanics applications are strength and stiffness. The fibers have high stiffness and have high strength and they carry the load to which the structure is submitted. The objective of this dissertation is to analyzer experimentally and by finite

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element analysis the mechanical behaviour of composite material used for cantilever applications.

FREQUENCIES OBTAINED BY FEA

Table: showing comparison of FEA results of natural frequency of glass fiber cantilever composite plates of various thicknesses and different orientation.

Below table shows that the comparison of natural frequencies obtained by the FEA of composite cantilever plates of Unidirectional fiber orientation and Bidirectional fiber orientation and the values of natural frequency are increasing as the plate thickness goes on increasing.

EXPERIMENTAL RESULTS

Experimentation is conducted to determine

i) Natural Frequency and
ii) Mode shapes of composite cantilever pates

Fig: Experimental Set…

- Equipment used to determine …tural Freq…y are
  1. Signal Analyser (F…
  2. Accelerometer
  3. Impact Ham…er
- Equipment for fi… …de shapes by …rimentation
  1. Signal Power Os…tor
  2. Ex…ter

Table: …ing comparison … …perimenta… results of natu… fre…cy of glass fiber ca…ver composite plates of various thi…ses and different o…ntation.

Modes .No	Unidirectiona… orientation(150…			…idirectional fiber orientation(150*80)		
	10mm	5mm	[illegible]	10mm	5mm	2mm
1	384.23	192.13	…4.03	704.65	384.38	128.1
5	2944.3	1792.6	704.4	3712.2	2432.1	1920.1
9	6144.2	3904.6	1856.1	9984.3	6656.5	4416.7

From above table natural frequency values for Bidirectional composite material are more as compared to unidirectional composite material. There is a difference in the values of natural frequency. Fundamental natural frequency of bidirectional composite is better than unidirectional composites.

RESULTS AND COMPARISONS

As Bidirectional fiber orientation composite cantilever plates shows higher range of natural frequencies we select Bidirectional fiber oriented composite plate as alternative material for steel components.

Table: shows that the …mparison of Bidirectional fiber orientation 80x150x…mm …late by FFT and FEA method.

Mode No.	Natural Frequency by FEA … Hz	…Frequ… by F… analyzer in Hz	%Difference	Average Difference
1	…1.8	704.65	7.5…	2.76%
5	6671.3	3712.2	0.399…	
9	10025.3	9984.3	0.4	

…able …ows the co…parison of 80x150x10mm plate by … and FEA metho… The average difference of …76% is o…ed for the sa… plate.

Mode …es are …ome closer with the respective f…uencies by ex… …method as well as FEA as shown i… …g below.

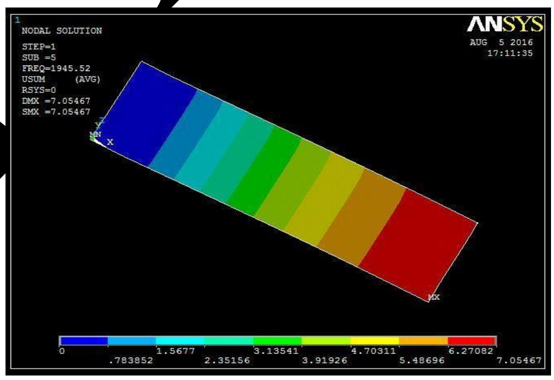

Fig: Mode shape using Exciter

Fig: Mode shape using FEA

Experimental results of natural frequencies determined experimentally are vary than those obtained by FEM analysis due to certain parameters are as follows
1. Weight of accelerometer mounted on plate.
2. Damping caused at fixed end.

3. Rotation of plates during flexural deformation.
4. Double hit of the hammer.
5. Manufacturing technique
6. Variation in the thickness
7. Non uniform surface finish
8. Bubbles

CONCLUSION

1. Natural frequency increases as thickness of plate increases.
2. Natural Frequency shows better result for Bi directional fiber orientation.
3. Experimental natural frequency of glass fiber rectangular cantilever composite plates matches with the ANSYS results with avg. 2.76% difference.
4. Experimental results are matching with the FEM results hence we can replace Bidirectional glass fiber composite cantilever plate in place of steel plates.

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