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STRUCTURAL HEALTH MONITORING OF COMPOSITES

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ABSTRACT

Now a days Composite Materials are widely used in Automobile as well as Aerospace purpose due to their superior mechanical properties. The main composite plates are on the outer surface of Aerospace and Spacecraft i.e. (Laminated over an aluminum or other materials). So, these materials should possess very good vibrational and strength behaviours so as to sustain in different kinds of environments also these materials should be monitored on a micro level in service. It is a big challenge to monitor these composite plates in service. This research work is an approach for determining the defects in these materials in terms of vibration. An attempt is to be made to reduce the vibration by analysing different composite plates also for the different structures.

Key words: Composite, Laminated plates, Vibration

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I. INTRODUCTION

Composite material structures, like beam, plates, and shells are common place in many sectors of the automotive and aircraft industries. Use of such structures is now being considered for naval applications because of their improved strength to weight ratio and resistance to harsh environments. In this project work the prediction of vibration response and natural frequencies is to be done on the laminated composite materials. As composite materials are widely used in many fields, there is a need for accurate prediction of dynamic characteristics so that they can be designed against the failure due to various types of dynamic loads.

Composite: Two or more chemically different constituents combined macroscopically to yield a useful material. Composite materials are lighter, stronger, wear resistance, rust free, temperature resistance.

Smart materials are used because the smart materials possess the ability to change their physical properties in a specific manner in response to specific stimulus input on real time basis. They are light in weight, consume less power and have better reliability. In addition, they can be embedded in the structures without affecting the structural properties. With such features incorporated in a structure by embedding functional materials, it is feasible to achieve technological advances such as vibration and noise reduction, shape control with high pointing accuracy, damage detection, damage mitigation etc.

II. PROBLEM DEFINITION

The metals plates used in services today in more and more extent in automobile and aeronautical industries. These plates are usually made up of alluminium or mild steels sometimes these can be made up of stainless steels but stainless-steel plates are higher in cost. The plates of alluminium and mild steels are fails in service due to vibration, it ultimately results in generation of cracks, occurrence in residual stresses, these effects can be eliminated.

In this work the prediction of transient response and natural frequencies is to be done on the laminated composite materials. As composite materials are widely used in many fields, there is a need for accurate prediction of dynamic characteristics so that they can be designed against the failure due to various types of dynamic loads. It is important to eliminate or reduce the vibration. For this first do the analysis of vibration in analysis of vibration we can derive the equations of motion of a vibratory system and find out the response of vibration in the forms of natural frequencies and displacements.

III. OBJECTIVE

The main objective of the present research work is to develop an organized structure for different application where vibration is present using Finite Element Method and Experimental method technique. It is necessary that structures must safely work during its service life.

The present study mainly deals with the vibration characteristics of laminated composite plates. The effects of number of layers, on vibrational behaviour were examined. Tests were conducted to experimentally determine the influence of the above parameters and the obtained results were validated using finite element package i. e. ANSYS.

IV. METHODOLOGY

The phases of the process plan for the present investigation are as follows

- First Finite Element Analysis has been performed to obtain the relative values of first, second and third modal natural frequencies.
- After FEA, Experimental Analysis has been performed to obtain the relative values of first, second and third modal natural frequencies.
- Finally a comparative study has been made between Finite Element Method and Experimental method.

In this project We have considered different structures such as composite plate, square plate structure and the vibrational behaviour is to be seen for the same.

We have divided the methodology in three stages as below.

Stage 1. The general natural frequencies for aluminum, mild steel and Rubber materials are obtained.

Stage 2. The composite structures consisting of aluminum, mild steel and Rubber materials are constructed.

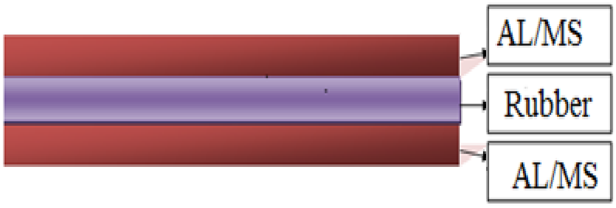

Figure 1: Composite Structure

The natural frequencies for these composite materials are found out. In this stage, the damping effect produced by these sandwich structures is measured.

Stage 3. The natural frequencies for the different structures are found out. The arrangement of structure is as shown in Figure 2.

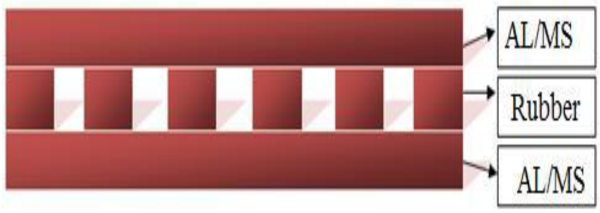

Figure 2: Arrangement of laminated structure

MATERIALS

I) Aluminum

II) Mild Steel

III) Rubber

In this stage also, I have found the natural frequencies for these structures. The damping effect produced by these sandwich structures have been measured.

- All these three stages are to be analyzed experimentally on FFT Analyzer by

Impact hammer

In this test the plates are hammered by impact hammer and the natural frequency for these structures by making input on structures by impact hammer are detected.

- Also, I have tested these structures for following boundary conditions.
- **Cantilever-** In this condition the beam is clamped from one side and free to move from other side.

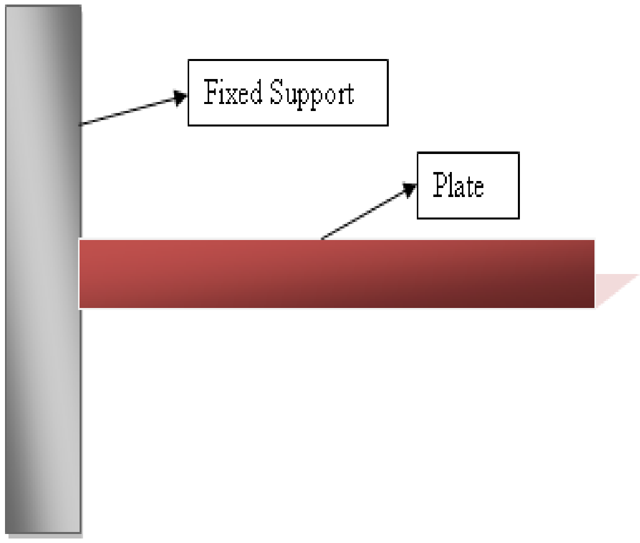

Figure 3: Cantilever Case

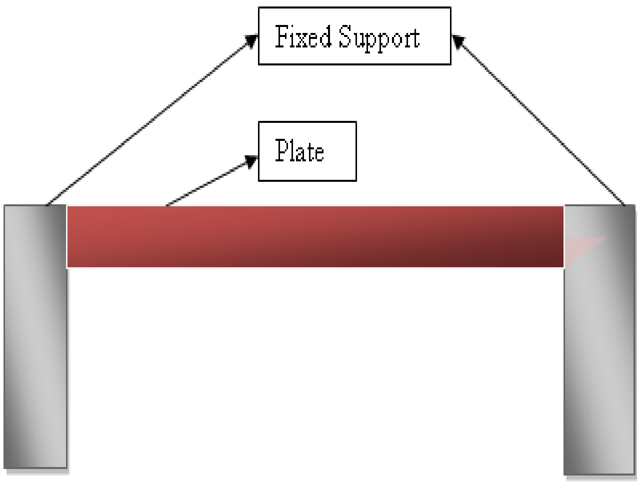

Figure 4: Simply Supported Case

V. SPECIFICATION OF PLATE

Plate dimension	
Materials For Plates	1) Aluminum 2) Mild Steel 3) Rubber
Length of Plate	270 mm.
Thickness (t)	6mm.
Width	150 mm

MATERIAL		Aluminum	Steel	Rubber
Young's modulus (N/mm^2)		0.69×10^{11}	2.1×10^{11}	3×10^{6}
Poisson's Ratio		0.33	0.3	0.25
Density (kg/m^3)		2700	7850	1799
No. of Plates				
Simple Plate	Plate 1	Aluminum Plate		
	Plate 2	Mild Steel Plate		
	Plate 3	Rubber Plate		
Composite Plate	Plate 4	Al – Al – Al Plate		
	Plate 5	MS – MS – MS Plate		
	Plate 6	Rubber - Rubber - Rubber Plate		
	Plate 7	Al - Rubber - Al Plate		
	Plate 8	MS - Rubber - MS Plate		
Structured Plate	Plate 9	Al – Al – Al Plate		
	Plate 10	MS – MS – MS Plate		
	Plate 11	Rubber - Rubber - Rubber Plate		

SOFTWARE WORK

The analysis work is performed in ANSYS 17.0 software. The model is prepared in ANSYS only. The element used for meshing is 20 noded Solid 186. The cantilever Boundary Conditions is applied. The model is tested for Modal Vibrations and 10 Frequencies are obtained.

VI. RESULTS

Table2: Results for Al Plate and Laminated

Aluminum										
Condition			1st Nat.freq.		2nd Nat.freq.		3rd Nat.freq.		4th Nat.freq.	
			ANSYS Result	Exp. Result	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result
Simply Supported	6mm	Al	303.212	309.3	987.376	991.6	2067	2089.0	3539	3560.99
	Composite	Al-Al-Al	303.724	310.1	988.157	993.8	2066	2093.1	3532	3569.3
	Composite	Al-Ru-Al	65.165	68.61	203.478	209.1	392.961	399.06	617.339	647.91
	Structure	Al-Al-Al	167.093	169.9	661.163	668.5	1447	1458.2	2457	2498.86
Aluminium										
Cantilever	6mm	Al	69.055	72.81	429.48	439.1	1198	1220.3	2391	2401.55
	Composite	Al-Al-Al	69.069	72.99	429.519	440.8	1198	1228.5	2390	2411.96
	Composite	Al-Ru-Al	15.073	19.14	93.863	98.35	262.546	268.19	525.15	535.27
	Structure	Al-Al-Al	60.127	63.44	366.651	370.4	996.579	1004.1	1900	1948.37

In this above comparison table, the natural frequencies of aluminium material plates mean for all simple, composite and structured plates are shown for simply supported and cantilever conditions. it is clear that the natural frequencies for aluminium plates from ANSYS and experiment nearly about same.

Table 4: Results for Rubber Plate

Rubber										
Condition			1st Nat.freq.		2nd Nat.freq.		3rd Nat.freq.		4th Nat.freq.	
			ANSYS Result	Exp. Result	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result
Simply Supported	6mm	Ru	2.421	3.42	7.86	9.82	16.409	19.13	28.032	30.57
	Composite	Ru-Ru-Ru	2.421	3.99	7.859	10.09	16.401	19.97	28.01	31.73
	Structure	Ru-Ru-Ru	1.345	2.85	5.31	6.73	11.659	13.78	19.877	21.78
Cantilever	6mm	Ru	0.553	1.89	3.447	4.97	9.626	11.57	19.09	21.56
	Composite	Ru-Ru-Ru	0.553	1.99	3.447	5.01	9.625	12.03	19.081	24.13
	Structure	Ru-Ru-Ru	2.928	3.53	7.946	9.1	15.068	18.09	23.602	24.13

In this above comparison table, the natural frequencies of Rubber material plates means for all simple, composite and structured plates are shown for simply supported and cantilever conditions. From Table 9.3 it is clear that the natural frequencies for plates from ANSYS and experiment nearly about same.

VII. CONCLUSION

In this study the natural frequencies and amplitudes are determine for different material plates and different structures for the same materials. It is found that from amplitude graphs

1) For Aluminium Material

From Table3, it is clear that the composite structure means AL-RUBBER-Al plate is best in damping effect for both cases means in simply supported and in cantilever cases.

2) For RUBBER Material

From Table 4, it is clear that the Laminated Structure means RUBBER-RUBBER-RUBBER plate is best in damping effect for both cases means in simply supported and in cantilever cases.

From above experimental and software work, readings and result tables it is clear that the laminated structures are better in damping effect in cantilever condition.

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