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Vibration Study on Oak Wood and Aluminium Alloy Material and Their Combinations for Noise Attenuation

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ABSTRACT
Noise engineering is gaining an important research potential as the noise attenuation is a significant study in the field of noise and vibrations. Different studies have been under progress in the development of the design and analysis of vibrations to achieve the reduction in noise as per the statutory norms. Different methods have been put forward to fulfill the need for noise attenuation. Noise attenuation is based on the vibration characteristics of the materials. Hence it can be considered for the design of noise reduction techniques. The panels of vibro-acoustic materials as casings over the noise source can be considered for the investigation of vibration frequencies. Simulation studies are the best design methods for finding out the optimal thickness of the panels of vibro-acoustic materials and the frequency response of the selected thickness at selected frequency range. The computer aided simulation process provides the cost effective and reliable selection of the best noise attenuation materials based on thickness of the panels considering the different combinations of the materials. In the present work the vibration amplitudes of the combinations of the panels of Aluminium alloy and Oak Wood materials are considered. The analysis is carried out using ANSYS software. It is found from the results that there is a significant reduction of about 59% in the amplitude of vibration for the combination of materials (Aluminum alloy panel of 6mm and Oak wood panel of 10mm) as compared to the other panels of different thicknesses of Aluminium alloy and Oak wood considered for the present study.
Keywords - Noise Attenuation, vibro-acoustic material, amplitude of vibration, frequency response.

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I. INTRODUCTION

1.1 NOISE AND NOISE ENGINEERING:

Noise is unwanted sound originated by different sources such as a running engine, human vocal cord. A vibrating machine is unpleasant, noisy or disturbing to learning. Study the characteristics of the noise produced by different sources and vibration analysis by different numerical and experimental methods.

1.2 NOISE AND VIBRATIONS ANALYSIS

noise engineering the noise analysis is carried out using numerical and experimental methods. The Finite Element Method (FEM) is used in numerical analysis as this method has been extensively adopted by many researchers in the field of design and analysis. In the design of noise and vibration experimentation the sophisticated instrumentations are used. Hence it is apparent that the reduction in the cost and time of the experiments would lead to more appropriate outcomes with regard to the productivity and at the same time and the quality of the work.In the present life metals are used for the variety of applications like automobile, aerospace, daily using utilities and for other infrastructure. These metals have influenced the human life very much.

13 Noise Attenuation

attenuation is a term that related to the reduction of a strength of a sound signal. Attenuation can be analog or digital type of signal. It is measured in terms of the unit decibels .

Aabsorption coefficient:" This is the ratio of absorbed noise intensity in an actual material to the incident noise intensity". It is expressed as.

$\alpha = 1-(Ia/Ii)$.

α = Absorption coefficient.

Ia= Absorbed noise intensity in an actual material.

Ii= The incident noise intensity.

Porous materials: Sound force fluctuations at the surface which force the air into and out of the material will cause power dissipation. Examples of materials in this category are normal wood, fiberglass, open cell bubbles and carpet material.

1.4 Modal Analysis

Modal Analysis is the study of dynamic properties of the system in the frequency domain. It provides an overview of the limits of response of the

system. The designer can understand the natural vibration frequencies to make sure that they are not the same as operating or excitation frequencies.

1.5 Harmonic Analysis

Harmonic response analysis gives the dynamic performance of structures. Responses of steady state linear structure subjected to loads that vary sinusoidal (harmonically) are found by Harmonic Analysis. The aim is to calculate structure response at certain frequency range and finding a plot of some response quantities (displacements or acceleration) versus frequency.

II. OBJECTIVES

1. To model the combination of the Aluminum Alloy and Oak wood panel specimen for simulation using CATIA V5 R20 Software.
2. To carryout structural analysis for pre-stressed modal analysis to find out the fundamental natural frequency.
3. To carryout the pre-stressed harmonic analysis considering the different thickness combination of Oak wood and Aluminum Alloy specimen.
4. To propose the best suited thickness combination of the Oak wood and Aluminum Alloy materials for noise attenuation.

III. METHODOLOGY

3.1 Specimen modeling

The specimen for the simulation is modeled using CATIA V5 R20 Software

Fig- 3.1 shows the specimen of Aluminum Alloy model. The dimensions of the specimen are given in the table-3.1

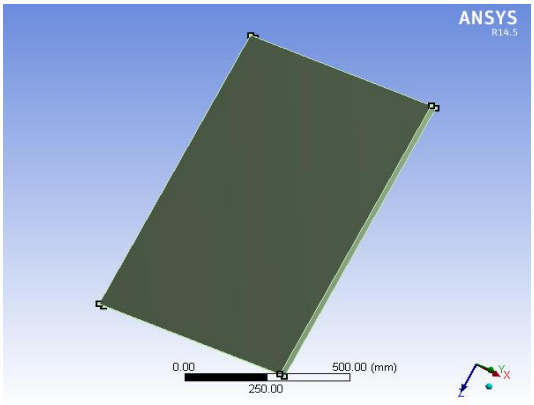

Fig-3.1 Aluminum Alloy Specimen Model

Table-3.1 The dimensions of the specimen

Model Material	Specimen Dimensions in mm	Thickness in mm
Aluminum Alloy	1000X1000	20
Oak_Wood	1000X1000	20
Aluminum Alloy +Oak_Wood	1000X1000	10+10
Aluminum Alloy +Oak_Wood	1000X1000	10+6
Aluminum Alloy +Oak_Wood	1000X1000	10+2
Aluminum Alloy +Oak_Wood	1000X1000	6+10
Aluminum Alloy +Oak_Wood	1000X1000	2+10

Update the material library for the selected acoustics materials viz., Oak wood and Aluminum Alloy materials as given below.

Table-3.2 Mechanical properties of Aluminum alloy

Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa	Density kg/mm3
71000	0.33	69608	26692	2.77e-006

Table-3.3 Mechanical properties of Oak_Wood

Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa	Density kg/mm3
11000	0.33	10784	4135.3	7.5e-007

3.2 Modal Analysis

Modal Analysis is carried out to find the natural frequency of the body for the given boundary conditions.

Steps in the Modal Analysis are

Step 1: Import the geometry in the workbench
Step 2 : Define material Properties
Step 3 : Meshing the model
Step 4 : Define the Boundary conditions
Step 5 : Solving to get the natural frequencies

3.3 Harmonic Analysis

The model is defined for its material properties. Then loads and boundary conditions are defined and also range of frequency is specified in the analysis settings and are shown in Table 3.4

Table 3.4 Frequency range for Harmonic Analysis

Material	Thickness (mm)	Fundamental frequency range. Hz
Aluminum Alloy	20	37900 to 37996
Oak_Wood	20	28669 to 28742
Aluminum Alloy +Oak_Wood	10+10	31475 to 35504
Aluminum Alloy +Oak_Wood	10+6	31544to 36815
Aluminum Alloy +Oak_Wood	10+2	28300 to 28721
Aluminum Alloy +Oak_Wood	6+10	**31500 to 35700**
Aluminum Alloy +Oak_Wood	2+10	31478 to 35873

First and Sixth mode from Modal Analysis are taken as t he maximum and minimum values for Harmonic analysis. Fixed support is same as defined in Modal Analysis, but the 100N force which acts on the fixed support of the specimen. Graph of Amplitude of Vibration in mm v/s frequency range is obtained from ANSYS workbench after carrying out the Harmonic analysis from which the maximum amplitude of vibration can b e obtained as shown in fig-3.3

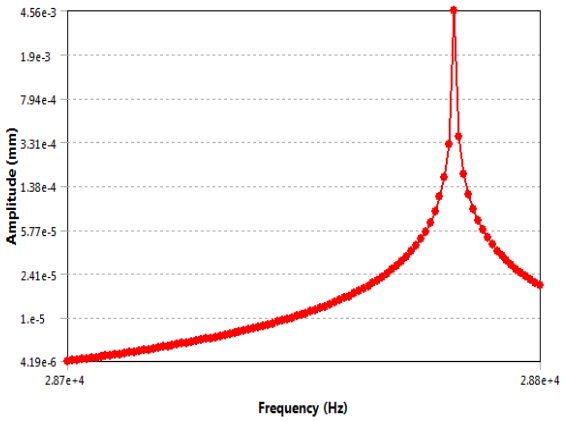

Fig-3.3 Frequency Response Curve for Harmonic Analysis

Then harmonic analysis is carried out to solve for frequency response and amplitude of vibration for the different combinations of the specimen modeled by giving 100N force for the excitation . The different thickness combinations are given in the Table -3.5

Material	Thickness (mm)
Aluminum Alloy	20
Oak_Wood	20
Aluminum Alloy +Oak_Wood	10+10
Aluminum Alloy +Oak_Wood	10+6
Aluminum Alloy +Oak_Wood	10+2
Aluminum Alloy +Oak_Wood	6+10
Aluminum Alloy +Oak_Wood	2+10

Table 3.5: Different thickness combinations

3.4 Comparison of Amplitude of Vibrations

From the frequency analysis the values of amplitude of vibrations and corresponding frequency of vibrations are shown in Table -4.1 and their behavior is shown in fig 3.4.

Material	Critical frequency Hz	Critical Amplitude (mm)
Aluminum Alloy	37995	9.19E-04
Oak_Wood	28741	4.56E-03
Aluminum Alloy +Oak_Wood	35460	1.31E-05
Aluminum Alloy +Oak_Wood	36082	2.56E-05
Aluminum Alloy +Oak_Wood	28342	2.11E-05
Aluminum Alloy +Oak_Wood	35658	1.04E-05
Aluminum Alloy +Oak_Wood	35865	1.40E-05

Table 4.1: Amplitude and frequency of vibration

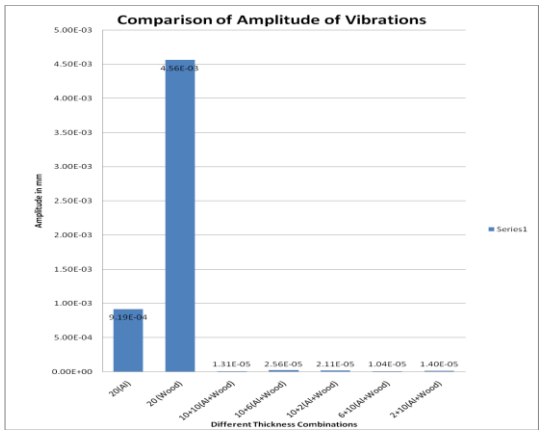

Fig 3.4 : comparison of amplitude of vibrations

IV. CONCLUSIONS

The computer aided simulation process is a best tool to select the best noise attenuation materials based on thickness of the panels of the combinations of the materials. Structural arrangement of materials for noise reduction can be studied for different material combinations. In the present study the vibration amplitudes of the combinations of the Aluminium alloy and Wood materials are considered. It is observed from this study that there is a significant reduction in the amplitude of vibration to 1.04E-5 mm for the combination of materials (Aluminium alloy(6mm) and Oak wood (10mm) as Compared to the other six cases of (Aluminium alloy and Oak wood) combinations. Hence noise attenuation based on the vibration characteristics of the materials can be considered for the design of noise reduction techniques.

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