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FREE VIBRATION ANALYSIS ON CANTILEVER BEAM- A REVIEW

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Abstract - *A simple and unified approach is presented for the vibration analysis of a cantilever beam. Natural frequency and damping ratio are calculated with an experimental process. Estimating damping still remains as one of the biggest challenge in structure made of different materials like brass, stainless steel and aluminium. All materials or structures posses certain amount of internal damping, due to which energy is either dissipated into heat or radiated away from the system. Internal damping includes the 10-15% of the total damping in system. The primary objective of this thesis is the free vibration analysis of different materials under surface cracks to estimate the effect of cracks on damping ratio and natural frequency. All the values will find with the help of Vibscanner and Omnitrend software under a free vibration test.*

Key Words: *Cantilever Accelerometer sensor, Cantilever Beam, Natural Frequency, Clamp, Damping ratio, Free Vibration, Vibscanner, Omnitrend.*

1.INTRODUCTION

Vibration is the motion of a particle or a body or system of connected bodies displaced from a position of equilibrium. Most vibrations are undesirable in machines and structures because they produce increased stresses, energy losses, cause added wear, increase bearing loads, induce fatigue, create passenger discomfort in vehicles, and absorb energy from the system[1]. Vibration can be desirable: for example, the motion of a tuning fork, the reed in a woodwind instrument or harmonica, a mobile phone, or the cone of a loudspeaker[2]. Yet, most vibrations are undesirable in machines and structures since they deliver expanded burdens, vitality misfortunes, cause included wear, build bearing burdens, affect weakness, make traveler uneasiness in vehicles, and assimilate vitality from the system. Pivoting machine parts need watchful adjusting with a specific end goal to keep harm from vibrations.

Vibration analysis is one of important process in the field of mechanical engineering. The effect of vibration absorber on the rotating machineries, vehicle suspension system and the dynamic behavior of machine tool structures due to excitation are the important information that design engineer wants to obtain. This information is very helpful in designing the system so that to overcome the negative effects due to excessive amplitude of vibration.

A beam is a structural element that is capable of withstanding load primarily by resisting against bending. The bending force induced into the material of the beam as a result of the external loads, own weight, span and external reactions to these loads is called a bending moment[3]. In case of cantilever beams, a horizontal cantilever beam under a vertical load will bend downward and when this force is removed, the beam will return to its original shape; but the inertia of beam tends it into motion. Thus, the beam will vibrate at its characteristic frequencies as shown in Fig -1.

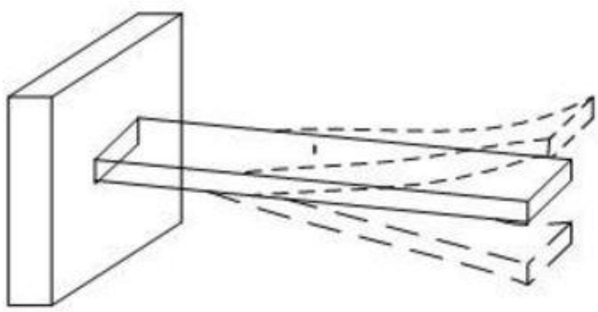

Fig -1: The beam under free vibration[4]

The cantilever beam movement stops after some time due to the resistance offered by a body to the movement of a vibratory system. This is called as Damping. The primary objective of our work is to find out the vibration characteristics of cantilever beam under different conditions.

2.LITERATURE SURVEY

A wealth of literature exists in the area of vibrations of beams but while going through the literature regarding material damping of cantilever beams it has been figured out that still a lot of work has to be done regarding it. Usually whenever study of various materials has been done the focus of researchers has been damping, mode shapes, resonant frequency, etc. but material damping has not been paid much attention. Some important literatures are given below:

Shibabrat Naik, Wrik Mallik[5] estimating the dynamic properties of a cantilever by using aluminium as a cantilever. All these values are analyzed on seven different patches which are designed at constant gap on aluminium beam. Accelerometer is connected to each patch one by one and Hammer is stroked on that patch to obtain the mode shapes, modal frequencies and the damping parameters. A fast Fourier transform analyzer, PULSE lab shop was used to obtain the frequency response functions and subsequent extraction of modal data was performed using ME's scope. These modal parameters were then checked using finite element analysis software, ANSYS which were found to comply with the experimental results. The range of applications for modal data is vast and includes checking modal frequencies, forming qualitative descriptions of the mode shapes as an aid to understanding dynamic structural behavior for trouble shooting, verifying and improving analytical models.

Pawar, R.S, Sawant, S.H[6] compare with previous old systems of vibration analysis of cantilever beam this method identifies the nonlinearities & effects on load deflection characteristics of cantilever. In this method Numerical verification of vibration analysis of cracked cantilever beam with non-linear parameters and evaluation of natural frequency and mode shapes with MATLAB/ANSYS software for both Free and Forced vibration are done & the Experimental validation of results obtained by theoretical and numerical method with the help of FFT Analyzer for both Free and Forced vibration of cracked cantilever beam with nonlinear parameters gives better result than previous old systems.

Hardeep Singh, Sanpreet Singh, Gurpreet Singh[7] investigated the vibration damping characteristics of mild steel, brass and aluminium of different lengths. Data is collected based on excitation frequency using free vibration technique and compare it theoretical results. Accelerometer is connected at its free end and cantilever beams have been subjected to impact hammer test. The objective of the study is to find out the natural frequency, damping ratio and vibration characteristics by using OMNITREND. Then these values compared with theoretical values obtained from ANSYS. It concluded that when the thickness decreases but length same then the natural frequency decreases and when the length decreases but thickness same then the natural frequency goes to increase.

Metin O Kaya[8] uses a semi-analytical technique called the differential transform method, applied to a rotating Timoshenko beam in a simple and accurate way. The natural frequencies are calculated and related graphics are plotted. The calculated results are compared with the ones in literature and great agreement is considered. The effects of the hub radius, rotary inertia, shear deformation and rotational speed are investigated. The numerical results indicate that the natural frequencies increase with the rotational speed and hub radius while they decrease with the rotary inertia (and shear deformation). The effect of the rotary inertia (and shear deformation) is more dominant on the higher modes.

D.Ravi Prasad[9] study the dynamic characteristics of structural materials steel, brass, copper and aluminium. These materials are used as a cantilever beam to analyze the modal analysis, natural frequency, damping, mode shape and free vibration. In this case, an accelerometer had a fixed position at middle of cantilever, while an instrumented impact hammer was roved along the excitation points. The force applied to the structure by an impact hammer excitation technique over the frequency range of interest, 0-2000 Hz and the corresponding response of the accelerometer attached to the specimen is measured by the OROS make dynamic analyzer. The obtained frequency response functions were processed to get the Modal Parameters (frequency, damping and mode shapes) using NV Solutions Smart Office software package. Theoretical values of the specimens were also calculated based on the free vibration analysis of distributed (continuous) systems and compared with experimental data. The dynamic parameters such as the natural frequency and inherent damping value of their components are very important in compliant structures. Modal testing is a non-destructive testing strategy based on vibration responses of the structural members. In this paper, the application of experimental modal testing to various beams based on the impact hammer excitation is attempted to assess the natural frequency, damping constant and associated mode shapes of these examples. The modal testing has proven to be an effective and nondestructive test method for estimation of dynamic characteristics of beams.

Vinay V. Kuppast, Vijay Kumar N. Chalwa, S. N. Kurbet, Aravind M. Yadawad[10] study the effect of vibration characteristics of aluminium alloys of different compositions. The modeling and analysis is carried out using ANSYS software. A modal analysis is carried out to understand the vibration behavior i.e., natural frequency and mode shapes, of the material considered. The harmonic analysis has been made to determine frequency characteristics. The analysis program reads the data from the input file processes the data and creates the output file containing the nodal displacements and nodal stress values of different stresses.

Rajwinder Singh, Mohit Sharma, V P Singh[11] analyzed the damping produced by the eddy current damper as applied to a cantilever beam. An aluminium specimen of 500 mm X 50 mm X 5 mm is used as a cantilever beam. Two electromagnets (Each consists of copper coil wound on a soft iron core.) were used in the experimental work with same poles facing each other. The electromagnets were simulated through computer software 'COMSOL'. The response of beam was checked with the help of a multimeter. The input to the multi-meter was provided through a sensing unit. The performance of the system was analyzed and it was found that the damping ratio comes out to be 58.1% more than that with the consideration of structure damping only. The damping ratio was computed from the logarithmic decrement for the two cases with structural damping and with combined effect of structural damping and eddy current damping.

Pragnesh K. Chaudhari, Dipal Patel, Vipul Patel[12] investigated the experimental modal analysis and theoretical natural frequency of the test specimens made of different material aluminium and mild steel. All the test specimens 950 mm, 850 mm, 750 mm with 3mm, 6 mm, and 10 mm were tested under free vibration condition. PCB impact hammer (MODEL 08CO3) was stroked on the cantilever beam in order to find the natural frequency and mode shape. FRF graphs are obtained with the help of software named DAQmx. The modal testing has effective and non-destructive test method for estimating of characteristics of beam. The natural frequency of both the beam is increase with increase in the modulus of elasticity and by decreasing the density of the material. It is observed that natural frequency is higher for aluminium than mild steel material beam of same geometry.

Sadettin Orhan[13] analyzes the free and forced vibrations of a cantilever beam having a V-shaped edge crack are studied. The length and cross-sectional area of the beam are 500 mm, and 29 x 20 mm2, respectively. Five types of cantilever beams are used with single crack and double crack at top and bottom of beam respectively. The ANSYS finite element program was used for free and forced vibration of the uncracked and cracked beams. When the crack location increases from free end, the natural frequency also increases. The natural frequency for a single crack on the bottom surface of the beam is greater than for a crack on the top surface of the beam. The natural frequency for two cracks on the top surface of the beam is greater than two cracks on the bottom surfaces. After analyzing the above past work, free vibration needs to be analyzed for cantilever beams of Brass, Stainless steel and Aluminium with surface cracks at constant dimensions of cantilever beam with varying the size of cracks with a experimental method.

Hamid Zabihi Ferezqi,Masoud Tahani,Hamid Ekhteraei Touss[14] investigate the free vibrations of a cracked Timoshenko beam made up of functionally graded materials (FGMs). It is assumed that the beam is constructed of FGM materials with a power law variation of metal-ceramic volume fraction. The perspective of wave method is adopted for the analysis. The method considers the nature of the propagation and reflection of the waves along the beam. Consequently, the propagation, transmission and reflection matrices for various discontinuities located on the beam are derived. Such discontinuities may include crack, boundaries or change in section. By combining these matrices a global frequency matrix is formed. In order to investigate the effect of the beam's structural synthesis, different natural frequencies are obtained and studied.

R. Lassoued, M. Guenfoud[15] dynamic behavior is analyzed using the orthotropic plate theory and modal superposition. A rectangular plate with its left and right edges simply supported and the other two opposite edges free is used. A computational procedure is used calculate natural frequency and amplitude. The plate can be excited by a convoy of constant or harmonic loads. The determination of the dynamic response of the structures considered requires knowledge of the free frequencies and the shape modes of vibrations. The formulation is based on the determination of the solution of the differential equations of vibrations. The boundary conditions corresponding to the shape modes permit to lead to a homogeneous system.

M.Gurgoze, H.Erol[16] determines the frequency response function of a viscously damped, cantilevered Bernoulli-Euler beam, which is simply supported in-span and carries a tip mass. The frequency response function is obtained through a formula, which was established for the receptance matrix of discrete systems subjected to linear constraint equations. The comparison of the numerical results obtained with those via a boundary value problem formulation justifies the approach used here.

3.METHODOLOGY

Brass, Stainless Steel and Aluminium beams of specified dimensions are used as a cantilever beam. These specimens are taken under a free vibration test. The results are obtained with the help of vibscanner and omnitrend software. Vibscanner is that mechanical instrument which is used to measure the vibrations and these vibrations are converted into displacement vs frequency graph with the help of omnitrend software. This graph is called Frequency Response Function (FRF graph). The values of natural frequency and damping ratio is calculated from these graphs with the help of Half-Bandwidth method. Then the values of different specimens are compared with each other to find a optimum solution.

4.CONCLUSION

The purpose of this experiment is to calculate the vibration characteristics of Brass, Stainless Steel and Aluminium as a cantilever beam with experimentally and analytical. The values of natural frequency and damping ratio will be obtained from the FRF graph (Frequency Response Function). The effect of cracks on the natural frequency and damping ratio will be observed. Thus the results of experimental data of different materials is compared.

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