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Experimental determination of structural damping of different materials

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Abstract

Estimating damping in structure composed of different materials (steel, brass, aluminum) and processes still remains as one of the most extremely vast challengers. The paper presents Structural damping effect on beam vibration by impact hammer. Structural damping contributes to about 10-15% of total system damping. The main objective of this work is to estimate the natural frequency and damping ratio of cantilever beams of Aluminum, Brass, and Steel by LabVIEW software and validate the result with vibration analysis and Harmonic analysis utilizing ANSYS. Free vibration analysis was carried out for identifying the natural frequencies and the harmonic analysis was carried out for obtaining frequency replication curves from which damping ratios were estimated utilizing Half- power Band Width Method. It is observed that damping ratio is higher for brass than steel than aluminum.

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Keywords: Structural Damping, LabVIEW, FFT, Half-Power Bandwidth Method, Harmonic analysis, Ansys

1. Introduction

The concept of damping within a structural system can have different meanings to the various trade branches. Damping is one of many different methods that have been proposed for allowing a structure to achieve optimal performance when it is subjected to seismic, wind storm or other types of transient shock and vibration disturbances. [5] Vibration is an element which is hard to avoid in practice. Excitation of resonant frequencies of some structural parts can occur with existence of vibration even it is only a small insignificant vibration. The number of times that a complete motion takes place during the period of one second is called frequency which is measured in Hertz (Hz).[10] Dynamic analysis aims at understanding, evaluating and modifying the structural dynamic behaviour which involves many terms such as natural frequencies, eigenvalues, eigenvectors, damping ratios, Frequency Response Functions (FRFs) etc. Modal analysis is an effective means for identifying, accepting and simulating dynamic behaviour and responses of structural elements. Modal analysis using ANSYS is an effective method of determining vibration characteristics [14]. Material

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damping of cantilever beams attracts a lot of work even though extensive literature exists in the area of vibrations of beams. Material damping has not been paid much attention [14]. In this paper the cantilever beam structure, as shown in Fig. 2, has been taken as a part because of its ease of practical ableness and also the ability to exemplify a variety of mechanical products such as wing of an aircraft, rotor blade of a helicopter, blade of a ceiling fan, needle of a clock, shelve of a civil structure, solar panel of a satellite etc. The dimensions of the cantilever beam structure are 370 x 25 x 10 mm, having a material of MS, Aluminium and Brass. The main aim of this project is to investigate highly damped structural material out of various materials of structural beams from finding damping ratio by half-power bandwidth method to reduce vibration level of the system for increase accuracy, safety and machine life.

2. Damping

Damping is the phenomenon by which mechanical energy is dissipated (usually converted into internal thermal energy) in dynamic systems. A knowledge of the level of damping in a dynamic system is important in utilization, analysis, and testing of the system. Damping is the energy dissipation of a material or system under cyclic stress. Several types of damping are inherently present in a mechanical system.
They are: 1. Internal (material) damping 2. Structural damping 3. . Fluid damping

Internal (material) damping results from mechanical-energy dissipation within the material due to various microscopic and macroscopic processes. Structural damping is caused by mechanical energy dissipation resulting from relative motions between components in a mechanical structure that has common points of contact, joints, or supports. Fluid damping arises from the mechanical energy dissipation resulting from drag forces and associated dynamic interactions when a mechanical system or its components move in a fluid

3. Measurement of damping

Damping can be represented by various parameters (such as specific damping capacity, loss factor, *Q*-factor, and damping ratio) and models (such as viscous, hysteretic, structural, and fluid). Before attempting to measure damping in a system, one should decide on a representation (model) that will adequately characterize the nature of mechanical-energy dissipation in the system. There are two general ways by which damping measurements can be made: time-response methods and frequency-response methods. The basic difference between the two types of measurements is that the first type uses a time-response record of the system to estimate damping, whereas the second type uses a frequency-response record

4. Half-power bandwidth method

This method is also based in the magnitude curve of the frequency-response function. Bandwidth ($\Delta\omega$) is defined as the width of the frequency response magnitude curve when the magnitude is $1/\sqrt{2}$ times the peak value. Then, damping ratio can be determined from bandwidth using the expression

$$\zeta = \frac{1}{2}\frac{\Delta\omega}{\omega_r} \quad (1)$$

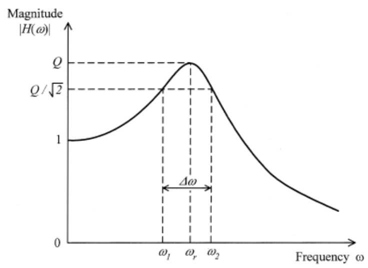

Fig. 1. Half Power bandwidth method